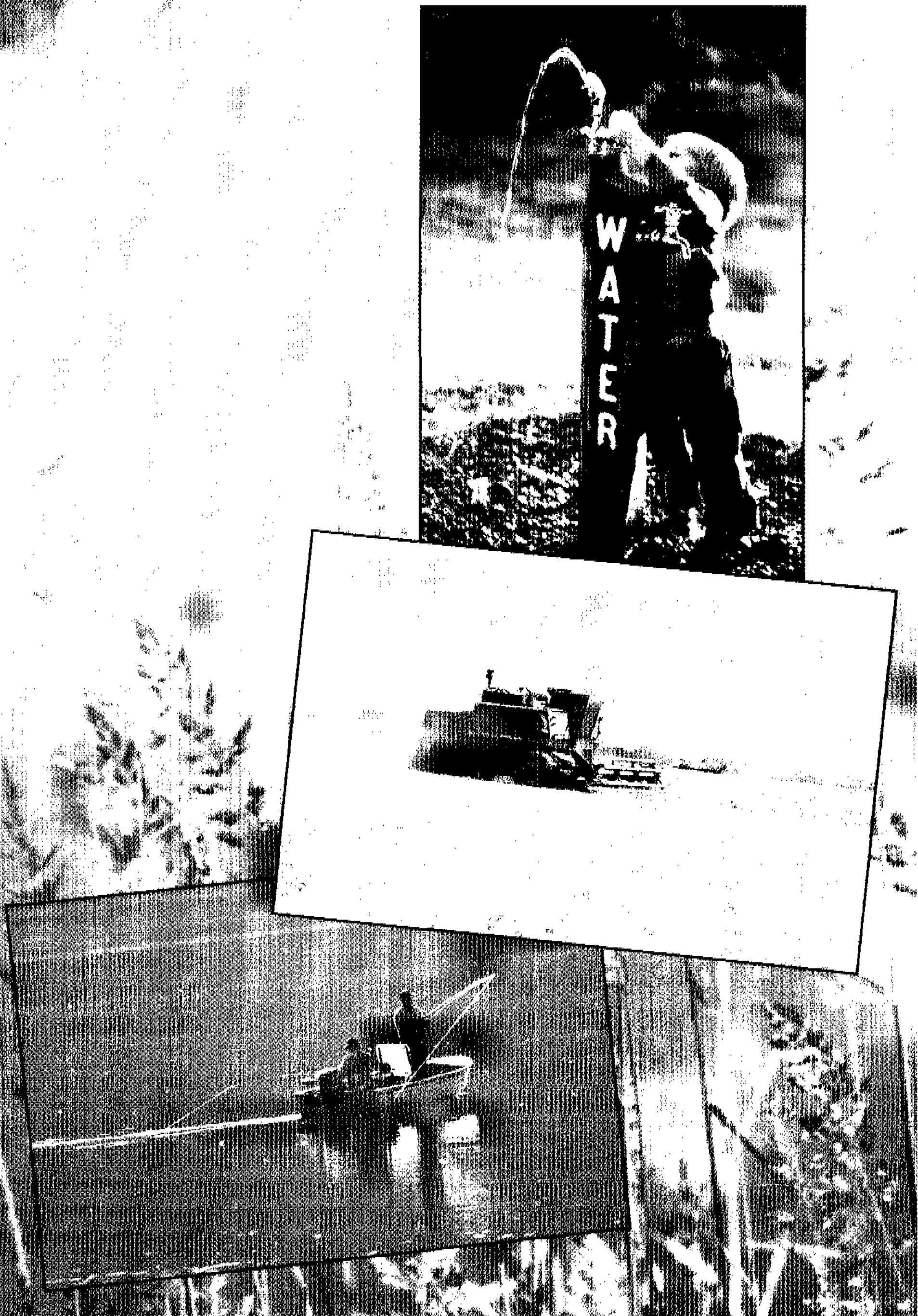
Sustainable Use of Water

California Success Stories



PACIFIC INSTITUTE
FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY

Sustainable Use of Water
California Success Stories

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About the Pacific Institute

The Pacific Institute for Studies in Development, Environment, and Security is an independent, non-profit center created in 1987 to pursue research and policy analysis in the areas of environment, sustainable development, and international security. Underlying all of the Institute's work is the recognition that the pressing problems of environmental degradation, regional and global poverty, and political tension and conflict are fundamentally interrelated, and that long-term solutions must consider these issues in an interdisciplinary manner. The Pacific Institute strives to improve policy through solid research and consistent dialogue with policymakers and action-oriented groups, both domestic and international.

The Institute has three broad goals: (1) to conduct policy-relevant research on the connections among environmental change, economic development, and international conflict; (2) to encourage and participate in similar research efforts by other organizations and individuals; and (3) to inform and learn from policymakers, activists, and the general public regarding the nature of these problems and the possible long-term strategies for mitigating them.

About the Authors

Arlene K. Wong is a Research Associate at the Institute. In addition to her work on the *Success Stories* project, she directs the Institute's program on Community Strategies for Sustainability and Justice. Her research focuses on the role of public participation in public policy and decision-making, environmental justice, and equity implications of natural resource and environmental policy. She received her Master's degree in Public Policy from Harvard University and a Bachelor of Arts degree in East Asian Studies from Yale University.

Lisa Owens-Viani is a freelance environmental and science writer specializing in California water issues. She has worked for the Institute on *Success Stories* for the past year while working toward completing her Master's degree in Geography at San Francisco State University. She is also an editor at *California Wild*, the magazine of the California Academy of Sciences.

Anna Steding is a doctoral student in Civil and Environmental Engineering at the University of California, Berkeley. She completed work on the *Success Stories* project during her two-year tenure as a Research Associate at the Institute. During that time, she also wrote extensively on the impacts of water transfers on social and economic equity in California. Her current research focuses on the design of wetlands and pond systems for wastewater treatment.

Peter H. Gleick is co-founder and President of the Pacific Institute. Dr. Gleick has written extensively on global freshwater resources, including the sustainable use of water, regional and international water conflicts, water planning and management, the hydrologic impacts of climate change, and the connections between water, population, and development. He serves on a variety of national and international environmental panels and has briefed the U.S. Congress, the Vice President, the Secretary of State, and other national and international policymakers on global and regional water problems. His new book, *The World's Water 1998–1999,* has just been published by Island Press.

Dana Haasz is a Research Associate at the Institute. Prior to her work on the *Success Stories* project she completed an analysis of the Water Use Efficiency Component of the CALFED Bay-Delta Program. She is also currently working on an analysis of the potential for demand-side management for the state of California. She received her Master's degree in Applied Geography from New Mexico State University and a Bachelor of Sciences Degree in Geography and Environmental Sciences from McGill University.

Robert Wilkinson is a Lecturer in the Environmental Studies Program at the University of California, Santa Barbara, and an Adjunct Senior Research Associate and Director of the Water Program at the Rocky Mountain Institute. His research and teaching includes water policy issues, climate impact analysis, and environmental policy. Wilkinson has extensive international environmental experience, including a tenure as Director of the Graduate Program in Environmental Science and Policy at the Central European University in Budapest, Hungary.

Megan Fidell worked on the *Success Stories* project as an Institute Research Assistant. Fidell received a Master's in Water Engineering from California Polytechnic State University, San Luis Obispo in 1998, and a Bachelor of Arts degree in Environmental Sciences from the University of California, Berkeley. She intends to purse a doctorate degree, but in the meantime has spent her time conducting on-farm evaluations for the U.S. Bureau of Reclamation.

Santos Gomez is a directing attorney with California Rural Legal Assistance. Prior to his current position, Mr. Gomez was a Senior Research Associate at the Pacific Institute, where he directed the Community Strategies for Sustainability and Justice Program. He has studied and written extensively on sustainability and sustainable communities, environmental justice, population, immigration, and the environment, and his work has been published in such journals as the *Journal of Race, Poverty and the Environment* and *The Urban Ecologist: The Journal of Urban Ecology*. Mr. Gomez received his Bachelor of Arts degree in Mathematical Economics from Pomona College, and his J.D. from King Hall School of Law at the University of California at Davis.

The Advisory Committee and the Peer Review Process

Early in the Success Stories project an Advisory Committee representing governmental, agricultural, urban, and environmental interests was formed. Members of this committee generously helped select case studies, collected data and information, reviewed cases and sustainability criteria, participated in roundtable discussions, and assisted in project outreach. We are saddened that one member of this Committee, Carla Bard, was tragically killed in an accident in late 1997. She was a tireless advocate for combining good environmental science with good public policy, and we will miss her efforts on behalf of all Californians. We would also especially like to thank Jim Mayer, a participant on the Advisory Committee and an Institute Board member, who early on suggested identifying and analyzing California success stories as a way of moving the California water debate forward.

Many other people were involved in offering valuable feedback, data, and suggestions. We made a special effort to solicit comprehensive and broad peer review for every one of the case studies. Individual experts in each area were identified, and every case study received at least two independent outside reviews; many case studies received four or more separate reviews, and we thank all of the individuals involved in this process. It has made our final product much stronger.

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* Organizations are listed for identification purposes only.

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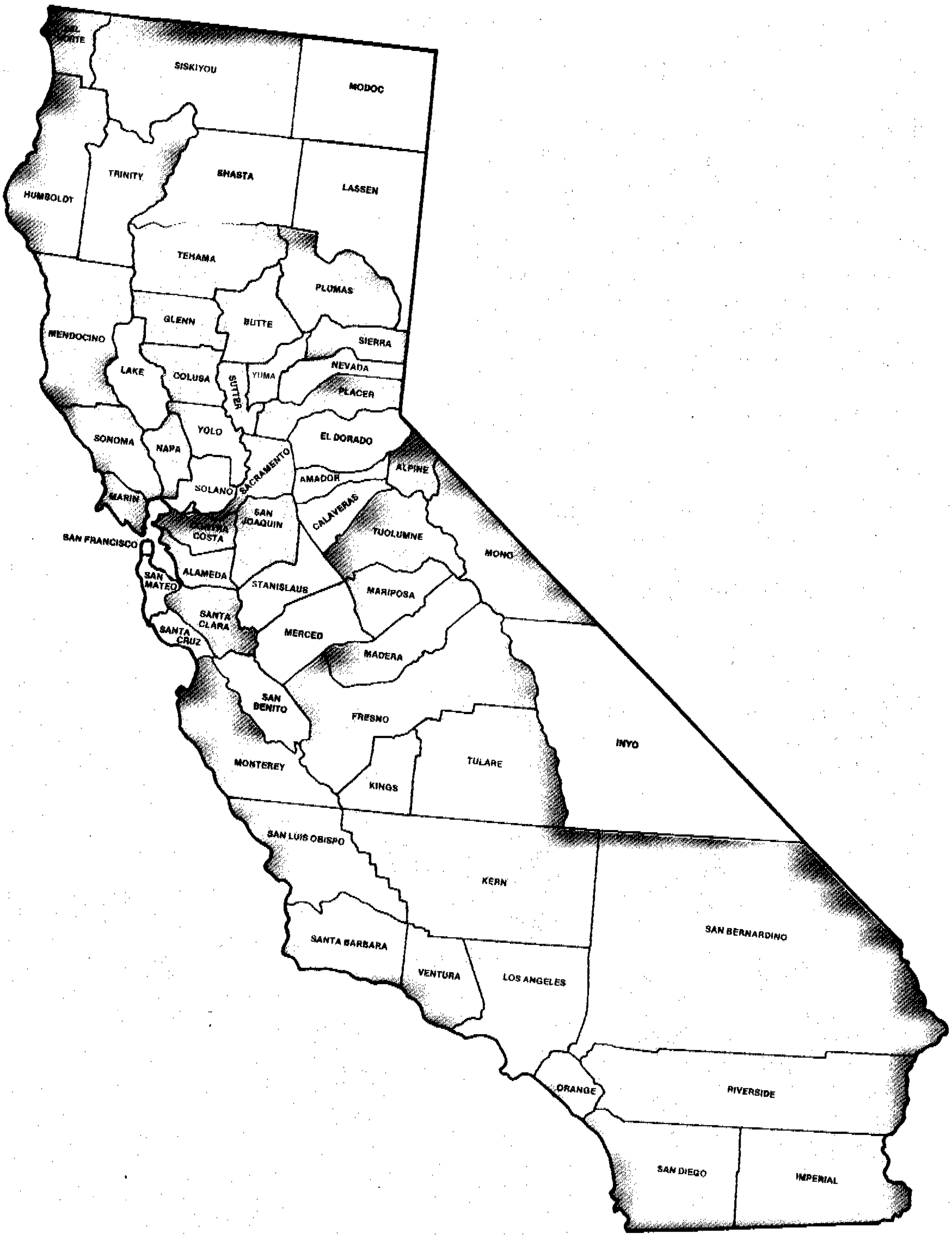
Figure ES-1

Counties in California Covered by the 28 Success Stories



Sustainable Use of Water
California Success Stories

Executive Summary

The intense political and legal battles that have characterized California water policy throughout the 20th century have not ended—nor are they likely to end in the near future. But unexpectedly, with little fanfare or attention, California is moving toward more sustainable water management and use. In 1995, the Pacific Institute published *California Water 2020: A Sustainable Vision,*[1] which presented a positive vision of where California water resources could be in the year 2020 and a detailed analysis of how to get there using existing and proven economic incentives, efficient water technologies, and innovative governmental and non-governmental management practices. That analysis offered compelling support for the argument that alternative approaches to water planning and use can be—and have been—very successful.

As a follow-up to the 1995 report, the Pacific Institute now offers *Sustainable Use of Water: California Success Stories:* 28 successful, informative, and educational examples of collaborative water planning, effective institutional and governance structures, intelligent use of technology or economic incentives, and environmental protection and restoration in areas where deadlock and litigation used to be the norm.

These "success stories" identify, describe, and analyze examples of sustainable water policies and practices in the state (see Figure ES-1 for county locations of case studies) and show water managers, policymakers, and the public how to move California toward more equitable and efficient water management and use. As we stated in our 1995 report, long-term sustainable use of water does not require drastic advances in technology or heroic or extraordinary actions. Instead it requires an ethic of sustainability and the will to continue expanding positive trends that are already underway. These "success stories" offer lessons for the rest of us—lessons about what works and why, and how we might begin to solve our other water problems.

The intense political and legal battles that have characterized California water policy throughout the 20th century have not ended—nor are they likely to end in the near future. But unexpectedly, with little fanfare or attention, California is moving toward more sustainable water management and use.

The 28 success stories described here are the tip of the iceberg. In communities around the state, smart and committed individuals and groups are getting together to take water policy into their own hands. The result is a growing movement away from state or federally sponsored programs and policies and toward regional and local watershed and community actions, though several successful state and national activities are also described here. As a result, official state water policies now often lag behind—rather than define—the state-of-the-art. The official California Water Plan, for example, fails to acknowledge these many successful activities or to incorporate them into its projections for California's water future. Integrating the lessons learned from these success stories into long-term policy and planning could lead to a very different California—one where efficient, equitable, and sustainable water uses are the norm, rather than the dream.

In compiling these 28 stories, several common themes and factors for success became clear. We describe these lessons and offer some common-sense recommendations for others interested in emulating the successes described here.

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[1] Gleick, P., Loh, P., Gomez, S., and Morrison, J. 1995. *California Water 2020: A Sustainable Vision.* Pacific Institute Report, Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.

Lessons and Recommendations

The most successful water projects have individuals and groups with different agendas working together to meet common goals.

Almost all successful water projects brought competing and conflicting stakeholders together in cooperative arrangements. Cooperation, rather than confrontation, led to an understanding of different points of view and a willingness to explore compromises and creative solutions that benefited all parties. Nearly every successful partnership had an individual or individuals strongly committed to the project. In many cases this leadership was vital for managing any stakeholder conflicts that did arise and keeping the project alive.

Official state water policies now often lag behind—rather than define—the state-of-the-art. The official California Water Plan, for example, fails to acknowledge these many successful activities or to incorporate them into its projections for California's water future. Integrating the lessons learned from these success stories into long-term policy and planning could lead to a very different California—one where efficient, equitable, and sustainable water uses are the norm, rather than the dream.

☐ **The effort to split water stakeholders into "special interest groups" should be resisted.**

☐ **All critical water planning and decision-making efforts need to invest sufficient time and effort into assuring that all stakeholders are identified and brought into the process as early as possible.**

Existing technologies for improving water-use efficiency and for cleaning wastewater have enormous untapped potential. Smart water policies will unleash this potential.

With little notice, a wide range of new technologies has been developed and made available for using water more efficiently, for reducing overall water needs, or for cleaning contaminated water to permit its reuse. These technologies, including low-flow toilets, faucets, and showerheads, efficient washing machines, drip and precision sprinkler irrigation, reverse osmosis water purification systems, and others, are changing the face of California water. As a result, per-capita water use in California has begun to drop and appears likely to continue to decrease, even as our economy grows.

☐ **Industry, public agencies, and governments need to continue to invest in and support research and development of water-efficient and water-treatment technologies.**

☐ **Demonstration programs, technical assistance, and education programs that introduce water users to existing technologies and their effective application should be adequately funded and expanded.**

☐ **Financial incentive programs should be implemented to assist with conversion to and adoption of new technologies.**

Regulatory incentives and motivation are effective tools. Smart regulation is more effective than no regulation.

Despite recent anti-government rhetoric, even among government officials and agencies, there is a critical role for federal, state, and local regulatory actions in helping move toward sustainable water management and use. Many of the success stories described here were encouraged by regulations that protect drinking water or groundwater quality, or reduce threats to remaining natural ecosystems.

☐ **Regulations and standards should be considered important components of water policy reform.**

☐ **Policymakers and the public should continue to look for effective regulatory tools in the water area. Such tools should be designed with flexibility in approach.**

The power of the proper pricing of water in California is underestimated.

The old sayings "there is no free lunch" and "you get what you pay for" apply to California's water situation. Inexpensive water only appears inexpensive. It often carries high or hidden costs for the citizens of California. Many of the following success stories repeatedly show that prices of water and water services play a major role in decisions about water use, investment, and behavior. Experience also shows that implementing proper pricing policies takes careful thought, preparation, and consumer education.

☐ **Water providers should adopt prices that better reflect the costs of service, including capital costs and environmental costs.**

☐ **Water retailers should adopt pricing structures that encourage efficient use of water.**

Economic innovation leads to cost-effective changes.

In addition to effective regulatory tools, a new set of economic tools can influence California water management and use. Several cases studies described here were successful because they used new approaches to water pricing, low-interest loans, smart rebates, and appropriate cost sharing. In general, sending the right price signals to water users leads to more efficient water allocation, use, and management, while making funds available for capital investments can lead to the rapid adoption of new technologies. Most successful projects secured funding from a broad array of sources—federal, state, and other public and private sources.

☐ **Water agencies should adopt strategies that reduce economic risks associated with sustainable water projects.**

☐ **Governments and others need to be willing to fund and share in the economic risks of projects with multiple benefits.**

In the water area, ignorance is not bliss. The more water users know about their own water use and the options and alternatives available to them, the better decisions they make.

As in most areas of public policy and interest, lack of information (or failure to disseminate that information), hinders rational and effective action. In case after case reviewed here, the availability of good information was critical to making good decisions. The more individuals and groups know about water, including the nature of supplies and demands, water quality, water laws and prices, and so on, the better are their choices and decisions. When farmers or landscape managers know how much water is in their soils, what the weather may do, and how effective their irrigation systems are, their use of water becomes much more efficient. When water districts or industries know how much water they use, where wasteful uses are occurring, and what new technologies are available, water-use efficiency rises dramatically.

☐ **Gaps in water data and information must be filled by more active water information programs.**

☐ **Available water data and information should be made more widely available. Existing cost-effective programs, such as CIMIS, should be expanded.**

"Waste not, want not." The potential for improving the efficiency of water use is greatly underestimated.

Growers are producing more crops, or generating more income for every acre-foot of water consumed by installing precision irrigation equipment. Industry is increasing economic output while decreasing total water use by auditing and modifying production processes. Water use in the home is dropping, even while income and populations are growing, through new technology and proper home water management. In the classic cartoon, trying to put more water into a bucket with thousands of tiny holes doesn't make as much sense as trying to plug the holes. Efforts to patch those holes are beginning to pay off, although there is still plenty of patching to be done.

☐ **Comprehensive water-use efficiency programs are needed for all sectors, as fundamental components of water policy efforts.**

☐ **Existing voluntary conservation programs should be expanded in scope and their implementation accelerated.**

Environmental and economic goals are increasingly being recognized as compatible rather than conflicting.

For some water policymakers, meeting ecological water needs is thought of as a "win-lose" situation: water used to protect the environment or fisheries must be "taken" from another user. Growing experience—as shown in many of the stories here—shows that this doesn't have to be the case. We are finally realizing that if we do not protect California's natural resources, such as our fisheries, our economy suffers as well. Among the most interesting examples in this report are "win-win" situations, where environmental and other water needs are simultaneously being met. Cleaning and recycling wastewater to meet clean water goals is increasingly meeting environmental water needs. Agricultural goals and environmental goals can also be effectively integrated.

☐ **Manage agricultural lands to improve wildlife habitat, reduce agricultural water requirements, and improve air and water quality.**

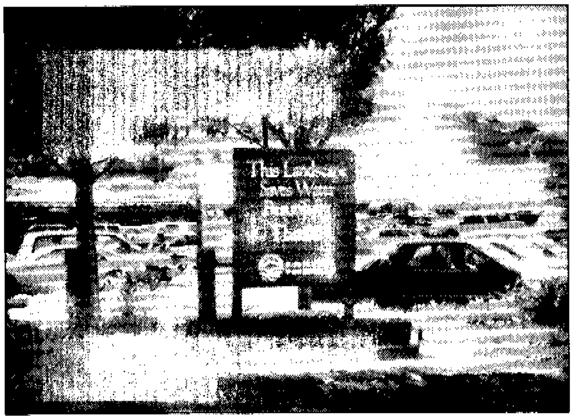
☐ **Include agricultural values in environmental restoration efforts. This will work most effectively when environmentalists and growers work together.**

☐ **Urban water agencies must also consider the upstream and downstream environmental impacts of their activities. Cooperative actions with other users can increase environmental benefits.**

In sum, many in California are moving toward a more sustainable water future, with little fanfare or notice. One of the reasons so many successful activities are underway in California is the serious pressure that exists on the state's water resources and the great competition among different users for limited water supplies. These pressures, as unwanted as they may be, serve to stimulate innovation and new thinking. In the end, therefore, we can take some consolation from the old adage "out of adversity, comes strength" and add the observation that out of competition and disputes over California water can come innovation and progress.

The Success Stories

Chapter 1:
Marin Municipal Water District's Innovative Integrated Resource Management Program



The Marin Municipal Water District has implemented a comprehensive integrated resource management plan that links phased development of new water supply to a sophisticated demand management program. Through its conservation and water recycling programs, the District has stabilized demand at close to 1980 levels (despite a substantial increase in population), and has not yet had to implement the third phase of its supply plan, which includes building a major new pipeline. By tying new supply to demand management, the District relies first on the proven conservation capabilities of its customers, and avoids incurring the financial and environmental costs of new supply until such development can no longer be avoided.

Chapter 2:
Promoting Conservation with Irvine Ranch Water District's Ascending Block Rate Structure

Experience is showing that creative thinking about water rates and prices can have a major effect on water use and efficiency. In 1991, Irvine Ranch Water District (IRWD) replaced its flat rate-per-unit charge with an innovative ascending block rate structure. IRWD's rate structure represents an aggressive approach to promoting conservation, has formed the foundation of a larger water conservation program, and is regarded as a long-term water management tool. As a result of its programs, IRWD has seen a significant drop in per capita water use.

Chapter 3:
Effective Public Participation in the Rate Setting Process: LADWP Blue Ribbon Committee on Rates

Most people think that water rates are solely designed to serve the revenue needs of a water agency. We now understand, however, that such rates also have implications for equity (who pays and how much) and water conservation (sending signals regarding water use and reflecting the true cost of delivering water). Despite the often technical nature of designing a water rate structure, the Los Angeles Department of Water and Power acknowledged these other issues and formed a citizens' committee to design a new rate structure. This successful community–agency collaboration brought a far greater section of the public into the process than ever before, helped address issues of fairness and equity, and produced a rate structure that was eventually approved.

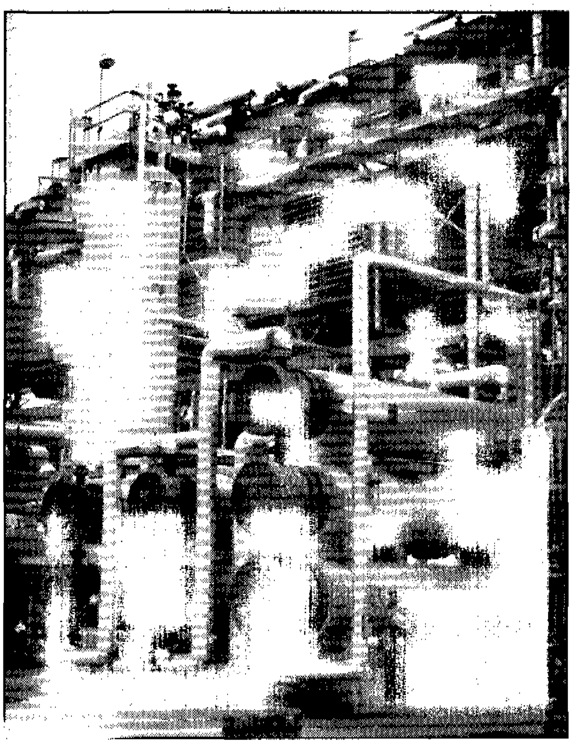
Chapter 4:
Reducing Water Use in Residential, Industrial, and Municipal Landscapes

Urban landscapes consume a significant amount of water in California. Yet too little attention has been given to different ways of promoting efficient landscape practices and the potential for these practices to reduce water use. Three separate district programs show what can be accomplished if water developers and users are informed and if proper incentives for efficient water use are provided. The North Marin Water District's landscape water reduction program targets developers with incentives in the form of credits and rebates. A successful voluntary audit program at

the Santa Clara Valley Water District is aimed at teaching large landscape customers proper irrigation scheduling and careful maintenance. And the Irvine Ranch Water District reaches both large and residential landscapes with a combination of a progressive rate structure and outreach programs. All three districts have seen remarkable decreases in landscape water use.

Chapter 5:
Community-Agency Partnerships Save Water and Revitalize Communities through ULFT Programs

Over the past decade, water agencies have formed highly successful partnerships with community groups to distribute ultra-low-flush toilets (ULFTs) in cities throughout the state. As of August 1998, these programs had saved an estimated annual 13,000 acre-feet of water. Agencies hire local, unemployed residents to run their ULFT programs and invest revenues from the programs in community activities. Participation in these programs has been greater than in similar programs run by agencies alone, since residents are eager to support programs managed by—and benefiting—their communities. Agencies benefit from improved public relations and the ability to better meet their conservation goals.



Chapter 6:
An Overview of Water-Efficiency Potential in the CII Sector

Commercial, industrial, and institutional (CII) water users account for approximately 30 percent of urban water use in California. While some CII users have installed water-efficient technologies, the enormous potential for significant water savings in this sector remains largely untapped. This case study reviews this potential and describes some of the actual savings that have been achieved through municipal and water agency programs targeting the CII sector. It also discusses some of the issues and motivating factors involved in implementing and maintaining successful CII conservation programs.

Chapter 7:
Assessing Commercial, Industrial, and Institutional Water-Efficiency Potential: The MWD Audit Program

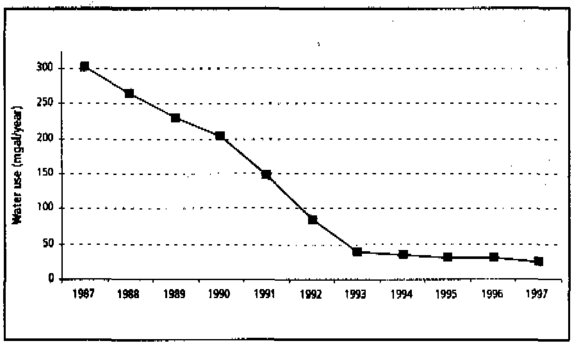
In 1991, the Metropolitan Water District of Southern California (MWD), in conjunction with its member agencies, initiated a major water-efficiency improvement program in the commercial, industrial, and institutional (CII) sector involving water audit support, analysis, and recommendations. During its five-year life, the program audited over 900 commercial, industrial, and institutional water users in MWD's service area. Results from these surveys are believed to represent the largest and most extensive database on this sector developed to date, providing valuable information on water use, water-savings potential, and implementation of conservation programs.

Chapter 8:
Increasing Institutional Water-Use Efficiencies: University of California, Santa Barbara Program

The University of California, Santa Barbara campus provides an outstanding institutional example of a comprehensive water-efficiency program leading to significant water and cost savings. Through a wide variety of cost-effective indoor and outdoor conservation efforts, total campus water use was reduced by nearly 50 percent between 1987 and 1994, even as the campus population increased. Total cost savings to the campus for the years 1989 through 1996 from efficiency improvements were on the order of $3.7 million, excluding energy and maintenance savings.

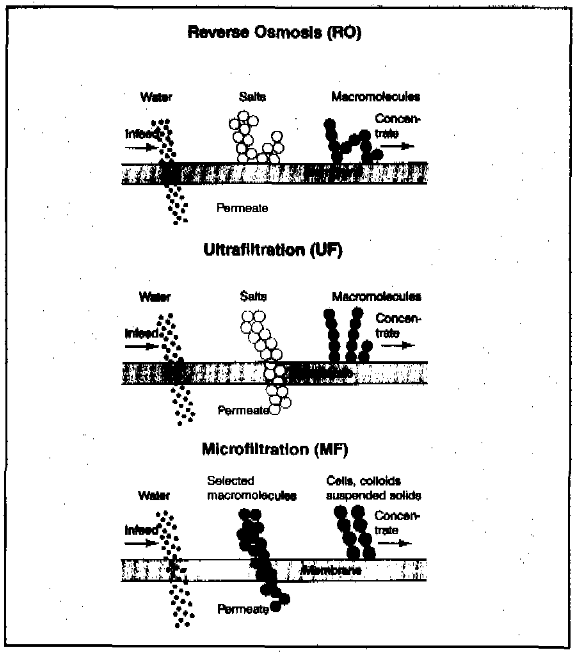
Chapter 9:
Increasing Industrial Water-Use Efficiencies: Naval Aviation Depot, North Island

The North Island Naval Aviation Depot is an excellent example of the potential for water savings in industrial processes. Between 1987 and 1997, due to new local regulations, higher wastewater treatment costs, and explicit military directives, the Depot reduced its water use by over 90 percent, from 305 million gallons to under 27 million gallons per year. Many of the dramatic improvements were accomplished with low-tech, operational changes that simply reduced water use and prevented waste.



Chapter 10:
Reducing Water Use and Solving Wastewater Problems with Membrane Filtration: Oberti Olives

Most food-processing plants use large quantities of fresh water and dispose of considerable volumes of wastewater each year. In response to environmental regulations and concerns, some companies have looked for technical innovations that reduce water needs and wastewater volumes while offering substantial economic and environmental benefits. One example is the water-saving membrane filtration and byproduct-recovery system operating at Oberti Olives in Madera since September 1997. By reusing 80 percent of the olive plant's processing water, this technology has reduced Oberti's daily groundwater pumping requirements by 91 percent and solved environmental concerns by eliminating wastewater discharges.



Chapter 11:
An Overview to Water Recycling in California

While early water-recycling projects were largely motivated by the need to find alternatives to wastewater disposal, recycled water continues to grow in importance as a source of water that can replace the need for potable water supplies for certain kinds of uses. This section provides an overview of water recycling in California, its regulation, its increased use, and challenges in implementing projects.

Chapter 12:
Using Recycled Water in Urban Settings: West Basin Recycling Project and South Bay Water Recycling Program

Recycled water can reduce wastewater volumes, provide water supply, and generate environmental benefits. These advantages are leading to a surge in interest in the production and use of

recycled water throughout California. A significant amount of growth in its use has taken place in urban areas, and these trends are likely to continue. The West Basin Water Recycling project in Los Angeles County and the South Bay Water Recycling Program in Santa Clara County provide two examples of the current trend in urban recycling projects. The West Basin Water Recycling project will ultimately provide 100,000 acre-feet of new water annually (approximately one-half of demand) for its 17-city service area. The South Bay Water Recycling Program will serve the cities of San Jose, Santa Clara, and Milpitas. The first two phases are expected to provide over 16,000 acre-feet each year.

Chapter 13:
Using Recycled Water for Agricultural Irrigation: City of Visalia and City of Santa Rosa

California agriculture, under growing pressure for water, is beginning to explore innovative uses of recycled water. Some growers already use reclaimed wastewater in different ways, depending on the level of treatment the water receives. Most common is the use of secondary-treated wastewater on fodder and fiber crops. Increasingly, however, growers are irrigating fruits and vegetables with tertiary-treated water, producing high quality crops and high yields. The city of Santa Rosa uses tertiary-treated water to irrigate about 6,000 acres of land in and around Santa Rosa. The city of Visalia has developed a project to irrigate a walnut orchard with secondary-treated wastewater. Though each project was primarily designed to reduce wastewater discharge, both cities have gained from the water-supply benefits recycled water offers.

Chapter 14:
Crop Shifting in California: Increasing Farmer Revenue, Decreasing Farm Water Use

With little fanfare or attention, the mix of California crops and planting patterns has been changing. These changes are the result of decisions made by large numbers of individuals, rather than any intentional actions by state policymakers. California farmers are planting more and more high-valued fruit and vegetable crops, which have lower water requirements than the field and grain crops they are replacing. They can also be irrigated with more accurate and efficient precision irrigation technologies. As a result, California is slowly increasing the water productivity of its agricultural sector—increasing the revenue or yield of crops per unit water consumed. Over time, these changes have the potential to dramatically change the face of California agriculture, making it even more productive and efficient than it is today, while saving vast quantities of water.

Chapter 15:
Converting to Efficient Drip Irrigation: Underwood Ranches and High Rise Farms

In the past two decades, California farmers have made considerable progress converting appropriate cropland and crops to water-efficient drip irrigation. Much of this effort has focused on orchard, vineyard, and berry crops. Recent innovative efforts now suggest that row crops not previously irrigated with drip systems can be successfully and economically converted as well. This case provides the example of two farmers converting bell pepper row crops to drip irrigation with great success. Subsurface drip irrigation substantially increased pepper yields, decreased water consumption, and greatly improved profits. In these cases, initial capital costs were supported by state loans that were promptly repaid. The growers made subsequent investments themselves.

Chapter 16:
The Power of Good Information: The California Irrigation Management Information System (CIMIS)

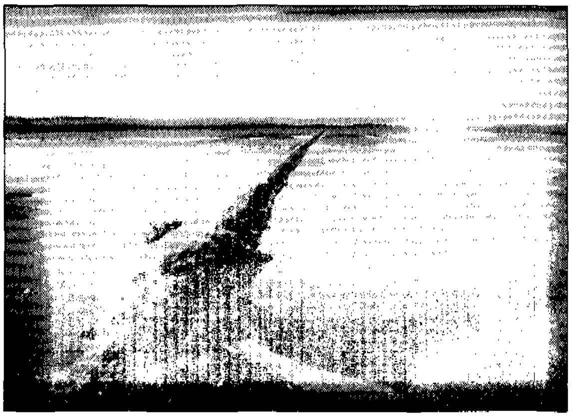
Experience has shown over and over that the availability of timely, good information makes an enormous difference in decisions about water use and management. The California Irrigation Management Information System (CIMIS) is an example of an inexpensive system set up to provide timely information to growers and landscape irrigators about the water demands of their plants and the likely climatic conditions facing them. With this information, growers can make smart decisions about when, where, and how much to irrigate, reducing overall irrigation water needs, increasing crop water productivity, and saving money. A recent independent assessment of the program suggested that growers using CIMIS have reduced applied water use on their lands by an average of 13 percent, and increased yields by eight percent. The costs to state and local agencies of operating the system are approximately $850,000 per year, while estimated benefits exceed $30 million per year—a hugely successful project.

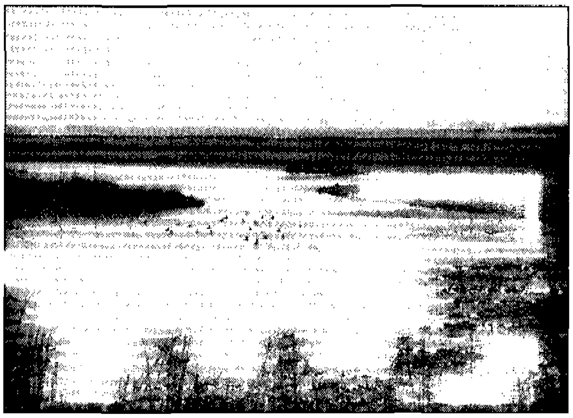
Chapter 17:
Improving Water Quality Through Reducing the Use of Herbicides on Rice: An Effective Collaboration Between Growers and Public Agencies

In the early 1980s, rice herbicides were implicated in fish kills and the contamination of drinking water in the Sacramento Valley. Through smart regulations and a strong collaborative effort, rice growers, state agencies, agricultural extension services, and local organizations developed and adopted new approaches to permit rice farmers to continue the necessary use of herbicides while greatly reducing the risks these chemicals have for humans and wildlife. A combination of innovative technological changes in the way water is held on rice lands and careful monitoring and education has reduced the concentrations of chemicals to below legal limits and, sometimes, below detectable limits.

Chapter 18:
Winter-Flooded Fields Benefit Farmers and Wildlife

As the Central Valley's open lands and farms are increasingly threatened by conversion to residential subdivisions and commercial developments, agricultural lands that also act as wildlife habitat will become even more crucial for many wildlife species. This case study describes how a growing number of California farmers are flooding their fields to shallow depths each winter, both to decompose crop stubble and to provide habitat for the hundreds of thousands of waterfowl and shorebirds migrating through the Valley on the Pacific Flyway. In the Sacramento Valley, this practice also offers one solution to the air-quality problem caused when rice stubble is burned.



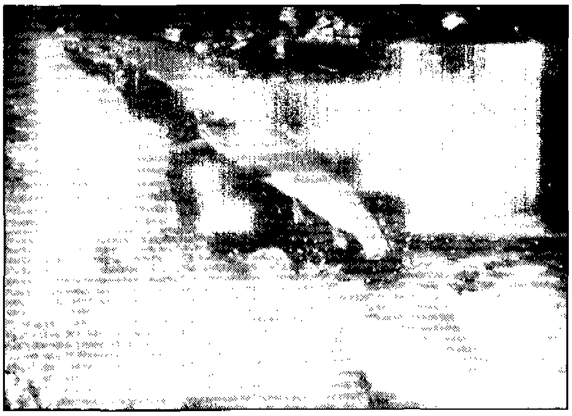


Chapter 19:
Reviving Central Valley Wetlands: Upper Beach Lake Wildlife Enhancement and the Beach Lake Mitigation Bank

With only 10 percent of the Central Valley's original wetlands remaining, much wetland restoration is needed in the region. The lessons offered by the two projects in this case study will be invaluable for guiding future restoration efforts. Although different in approach and scope, both projects demonstrate that a combination of agency initiative, creative funding, and reliance on sound restoration principles can yield good restoration results. Both illustrate the linkage between good water management and wetland restoration and both have multiple benefits. Finally, both will be important complements to the planned 18,000-acre Stone Lakes National Wildlife Refuge.

Chapter 20:
Restoring Riparian Forests and Natural Flood Regimes: The Cosumnes River Preserve

Conventional wisdom tells us that humans, floods, and riparian forests should not be mixed. The Nature Conservancy has successfully challenged this wisdom by working with other organizations to establish and maintain 14,000 acres of seasonal and permanent wetlands, grazing, and agricultural lands on the Cosumnes River Preserve. They have taken steps to restore natural flood regimes in the interest of promoting the restoration of riparian forests on the Preserve. They have also taken steps to "floodproof" their farming operation, illustrating that human uses in floodplains can be compatible with periodic inundation and that riparian forests and floods are good for each other.



Chapter 21:
Improving Passage for Spring-Run Salmon: Cooperative Efforts on Deer, Mill, and Butte Creeks

California's declining fisheries are at the forefront of conflicts over the need to reallocate water for environmental benefits while at the same time satisfactorily operate existing water supply systems. This case describes innovative actions taken by local landowners on Mill, Deer, and Butte Creeks, in cooperation with regulatory and resource agencies, to improve conditions for spring-run Chinook salmon, and to prevent possible challenges to the landowners' water rights and existing water use. In each case, local residents took the initiative in finding ways to better manage resources to meet all stakeholders' needs. Each community was able to find alternatives that flexibly accommodated both human and environmental needs.

Chapter 22:
Collaborative Watershed Management "Above the Dams": Feather River Coordinated Resource Management

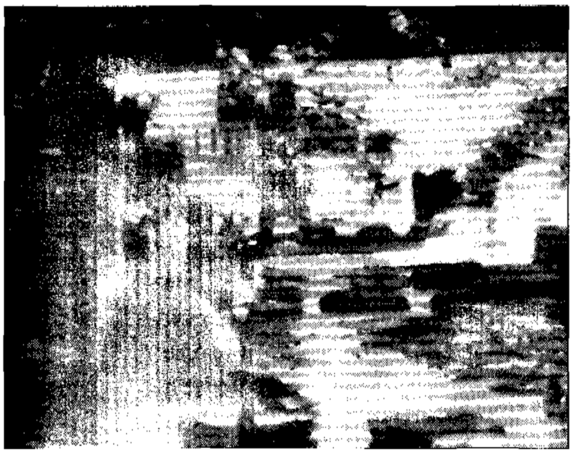
Watershed management is being implemented in a wide range of settings around California, with varying degrees of success. The Feather River Coordinated Resource Management project provides a positive example of watershed management in a rural, higher-elevation region of the Sierra Nevada. Since its inception in 1985, 21 member agencies have worked to implement 45 projects in the roughly 3,200 square-mile program area, including an array of plans, education efforts, and on-the-ground projects. These efforts have been instrumental in restoring meadows, wetlands, and streams, as well as expanding regional understanding of what does and doesn't work for restoring hydrologic systems.

Chapter 23:
Working for Healthy Urban Watershed Communities: Santa Ana River Basin and Napa River Watershed

The two cases discussed here illustrate two different approaches for successfully anticipating and managing watershed problems in urban areas. The first is the Santa Ana Watershed Project Authority, a regional planning and project management agency that has worked to ameliorate the worst water-quality problem in the Santa Ana River basin: the build-up of salts in groundwater and surface water. The second is from the Napa River watershed, where the Napa County Resource Conservation District has facilitated a number of innovative projects, including a demonstration of sustainable vineyard practices, watershed-wide volunteer monitoring, the development of a watershed management plan, and educational programs in local schools.

Chapter 24:
Restoring Urban Streams Offers Social, Environmental, and Economic Benefits

This case study offers three examples of stream restoration projects that resulted in social, economic, and environmental benefits in urban communities. The restoration of San Luis Obispo Creek helped revive the city's failing downtown by highlighting the creek as the focal point of a pedestrian plaza and retail hub. The Wildcat Creek restoration demonstrates how flood problems can be solved with more attractive, environmentally benign methods than concrete channels or culverts. And the unearthing—or "daylighting"—of long-buried Strawberry Creek created new riparian habitat in a blighted area and jobs for local youth hired to maintain the project.



Chapter 25:
Finding Mono Basin Replacement Water: Mono Lake Committee and Los Angeles Department of Water and Power

The struggle to "save" Mono Lake reached a milestone in 1994 when California amended LADWP's licenses to divert Mono Basin water. With amended licenses, LADWP would necessarily take less water from the Mono Basin and would need to find a way to replace "lost" supplies. The Mono Lake Committee, concerned that LADWP would seek water from other environmentally sensitive sources, worked with it to develop replacement water through recycling and conservation projects. The projects currently produce more than 50,000 acre-feet of water per year, and, with additional funding, will yield as much as 88,000 acre-feet per year by 2015—enough to make up for lost Mono Lake supplies.

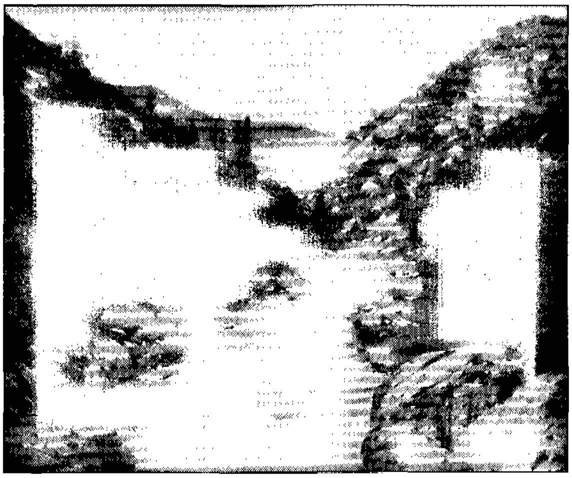
Chapter 26:
Improving Water Management through Groundwater Banking: Bakersfield 2800 Acre Recharge Facility and Semitropic Groundwater Banking Program

Increasingly, localities are recognizing the importance of supporting groundwater management to ensure the productivity and future protection of their basins. By taking advantage of groundwater storage options, groundwater banking offers a valuable supply-side management tool. In addition to supply benefits, banking programs also provide a management tool to help a district better coordinate groundwater and surface water activities to improve basin conditions. The city of Bakersfield's 2800 Acre Recharge Project and Semitropic's Water Banking Project offer two examples of successful banking projects undertaken in Kern County.

Chapter 27:

Comprehensive Groundwater Management: Orange County Water District and West and Central Basins

Much of California's groundwater use is not monitored or managed, leading to serious problems in some regions. Two Southern California examples provide different models for successful groundwater management. The Central and West Coast Basins offer examples of basins where groundwater extractions have been adjudicated and are now being effectively managed and monitored, and where collaborative efforts among multiple agencies are successfully addressing the basins' problems. Orange County Basin offers the case of a non-adjudicated basin where groundwater pumping is not limited and a supply-side strategy is pursued.



Chapter 28:

Legal Protection for Rivers: the State and Federal Wild and Scenic Rivers Acts

Over the past three decades, public interest in restoring and preserving rivers and streams has blossomed. This case describes two important legal "tools" for protecting California's unique rivers: the National Wild and Scenic Rivers Act of 1968 and the State Wild and Scenic Rivers Act of 1972. In large part due to these legal remedies, California still possesses many free-flowing river sections: over 95 percent of the state's dams were built prior to 1968, the year the federal Act was passed. This story also describes several recent legal decisions under the federal Act that can protect rivers from the impacts of grazing and logging.

Introduction

Background and Project Description

In 1995, the Pacific Institute published *California Water 2020: A Sustainable Vision,*[1] which presented a positive vision of where California water resources could be in the year 2020 and a detailed analysis of how to get there using existing and proven economic incentives, efficient water technologies, and innovative governmental and non-governmental management practices. That analysis offered compelling support for the argument that alternative approaches to water planning and use can be—and have been—very successful. Despite mounting evidence of the applicability and effectiveness of many of the report's suggestions, some water policymakers and managers remain skeptical about new ways of tackling California's water problems. This skepticism is in part due to lack of information, incomplete data, and poor communication among the many different actors in the water community. The most recent version of the official California Water Plan—Bulletin 160-98—shows that the agencies in charge of state water planning still don't understand either the benefits of rethinking California's water future, or the real opportunities for moving in a new and productive direction. It also indicates that there are sizable institutional obstacles to the development and implementation of the new and innovative approaches described in this report.

As stated in our 1995 report, long-term sustainable use of water does not require drastic advances in technology or heroic or extraordinary actions. Instead it requires a commitment to an ethic of sustainability and the will to continue expanding positive trends that are already underway. As a follow-up to that first study, the Pacific Institute initiated the *Sustainable Use of Water: California Success Stories* project to identify, describe, and analyze successful examples of sustainable water policies and practices in the state. The goal of this new project is to show water managers, policymakers, and the public how to move California toward more equitable and efficient water management and use.

Nearly 100 case studies were reviewed in the context of the Institute's sustainability criteria and guidelines. Ultimately, 28 were chosen as successful, informative, and educational examples of collaborative water planning, effective institutional and governance structures, innovative use of technology or economic incentives, and environmental protection and restoration. As examples of successful practices already in use, these cases offer viable alternatives to the traditional approaches to meeting today's water management challenges. In each case we identify the key factors that led to success, with the objectives of highlighting smart practices for individual managers and actors and identifying those policy levers that can promote such practices.

For agriculture, we selected activities that have resulted in more efficient applied water use, increased crop yields, or enhanced water quality, and practices that produced multiple benefits for other sectors, such as the environment. We looked at practices that have been implemented by both large and small farms, as well as by irrigation districts. Successful examples of planning and management practices, technological improvements, information dissemination, use of reclaimed water, and incentive and assistance programs are all included.

Successful urban case studies presented here include the innovative use of reclaimed water, the substitution of recycled water for potable supplies, improvements in institutional water management, and environmental restoration. Several cases highlight successful demand management programs, such as design of efficient outdoor gardens, industrial and commercial

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[1] Gleick, P., Loh, P., Gomez, S., and Morrison, J. 1995. *California Water 2020: A Sustainable Vision.* Pacific Institute Report, Pacific Institute for Studies in Development, Environment, and Security. Oakland, California.

Criteria for Evaluating "Success"

Overall criteria

The project or activity contributes to long-term economic, environmental, and social well-being.

General characteristics

The project or activity should be

- Replicable
- Durable
- Socially, environmentally, and economically affordable
- Acceptable to multiple stakeholders
- Adequately monitored and documented

Criteria with respect to resource management or use

The project should do at least one, and preferably more, of the following:

- Meet or assure a basic human or ecosystem need for water
- Result in more efficient use of water
- Result in a more equitable distribution of costs and benefits of water use
- Reduce or eliminate an unsustainable use of water
- Improve water quality
- Promote a better match between water quality and end use

Criteria with respect to institutional management

The project should do at least one, and preferably more, of the following:

- Promote stakeholder and community participation in decision making and management
- Promote planning and management coordination among government agencies
- Promote flexibility and adaptability in decision making and management
- Develop a mechanism for avoiding and resolving water disputes

efficiency improvements, and residential conservation programs such as ultra-low-flush toilet rebates/installation. Successful management practices, including integrated resource planning, groundwater management, and conjunctive use, are also described.

Environmental successes presented here encompass innovative management of floodplains and watersheds, river and wetland restoration, and collaborations with farmers to preserve or expand natural habitat in agricultural areas. The cases selected demonstrate the potential for simultaneously achieving ecological and human goals.

A final set of cases focuses on institutional and governance mechanisms that have broadly affected and improved water management and use. These include legal mandates such as the federal and state Wild and Scenic Rivers Acts as well as successful consensus-based processes and the forums and institutional activities that were developed to promote them.

The Case Studies: What Makes Success?

What makes a program a success? Achieving a specified goal? Learning something unexpected? Exceeding an expectation? In our study and review of California water activities, we sought to identify programs that did all of the above while teaching lessons about ways of solving California's complex water problems. Many individuals, organizations, and institutions are involved in California water issues, and while this mix sometimes produces rancorous debates and disagreements, it also can produce unusual collaborations and innovations.

As we evaluated many different possible stories we developed criteria for evaluating the "success" of a project. Ultimately, we followed a strict set of guidelines for selecting success stories, shown in the sidebar. These guidelines are standards by which projects and activities could be measured. Each case we studied was different—with a unique set of actors, characteristics, and approaches. In the end, we chose examples that met our criteria and seemed to hold the most promise for teaching us how to think about water management and planning. This chapter identifies five themes that capture the common lessons learned from these many examples.

1. Cooperative Partnerships Among Stakeholders Lead to Successful Programs

State and local water administrators and a small number of powerful agricultural and urban interest groups seeking reliable agricultural and urban water supplies have long dominated water policy and planning in California. Recently, interest groups representing the environment have also come to play an important role in water policy. These three groups represent important constituents, but they do not fully represent all the interests with a stake in the outcome of water policy debates. Even when broader public participation is permitted, it is often limited to a public hearing process held after major decisions have been made, or a public election where input is reduced to simple approval or rejection of a complex proposition or bond issue.

Without broader and earlier public participation, water policy and management will continue to fail to recognize the needs of many of California's increasingly diverse communities, particularly rural, low-income, or communities of color that have historically been poorly represented. Many people and organizations involved in water policy or planning are beginning to acknowledge this problem. A wide variety of recent activities, including the important CALFED process, have tried to broaden public participation in water policy decisions and to include members of the public in discussions of water problems. In almost every successful project, we found that a wide range of stakeholders came together to work out their differences and to explore collaborative solutions. Some of the most successful projects included groups that have traditionally been left out of water policy discussions.

A set of successful collaborations has developed between growers and environmentalists. Environmentalists often criticize California farmers for using too much water and too many chemicals, and for the impacts of agriculture on water quality and wildlife habitat. In turn, farmers often criticize environmentalists for failing to understand or acknowledge the importance of farming to the economy and land preservation. Since 1991, an unusual combination of stakeholders, including California rice growers and the rice industry association, The Nature Conservancy, Ducks Unlimited, and the California Waterfowl Association, has worked to develop winter habitat for migrating waterfowl while simultaneously helping the state reduce air quality problems and rice growers dispose of rice straw. This collaboration, known as the "Ricelands Habitat Partnership," effectively integrates agricultural needs with ecological and environmental values (see Chapter 18).

In almost every successful project, we found that a wide range of stakeholders came together to work out their differences and to explore collaborative solutions.

Rice cultivation in California has also led to problems with water quality. By the early 1980s it was apparent that large quantities of rice herbicides were entering rivers and streams, killing fish and adversely affecting drinking water quality in downstream communities, including the state capital, Sacramento. Public concern over these problems led to the creation of a joint government–industry group that worked to lessen these impacts without harming rice growers (see Chapter 17). This working group effectively reduced herbicide concentrations in public waterways through a combination of regulatory actions, innovations in farming techniques, and education of growers. For more than a decade, the concentrations of rice pesticides in water have been below legal limits, despite the regular tightening of those limits.

The South Bay Water Recycling Program case study (Chapter 12) offers a more urban example of increased agency cooperation and coordination among cities, agencies, and the local community. The program is a joint effort to increase the use of recycled water to solve local water supply and discharge problems. Participating in the program are three large cities (San Jose, Santa Clara, and Milpitas), five sanitation agencies, the San Jose Water Company, Great Oaks Water Company, the Santa Clara Valley Water District, U.S. Bureau of Reclamation, and a 27-member Citizens Advisory Committee. The committee includes representation from environmental groups such as CLEAN South Bay, the Silicon Valley Toxics Coalition, stream preservation interests, local universities, and the League of Women Voters.

Another successful citizen advisory committee was the Los Angeles Blue Ribbon Committee on Water Rates (described in Chapter 3). This committee successfully involved citizens in the water policy and rate-setting process in the early 1990s and included individuals drawn from outside traditional water policy circles. During the process the members became engaged in both educating and representing their own constituencies throughout the city. The process allowed Los Angeles Department of Water and Power staff to engage in open discussions with members of the communities they serve, and lent credibility to the idea that complex and often contentious issues can be worked out with community involvement.

In many different parts of the state, coalitions of local grassroots groups, city planners, municipal agencies, environmental non-profits, and even the U.S. Army Corps of Engineers are working to restore long degraded urban streams. These efforts are reversing decades of policies that eliminated or hid waterways in urban areas. Today, close to 100 "friends of creeks" groups work to preserve and protect urban streams throughout California. Three examples are presented in Chapter 24 that improved the quality of riparian habitat or even created habitat where none existed. All of the projects led to increased community awareness and involvement in local watersheds and the formation of both formal and informal environmental education programs. Two of the projects improved water quality by decreasing erosion and by identifying and eliminating serious sources of pollution. All three projects led to economic benefits by boosting local business or employing local residents to maintain the restoration sites and monitor water quality. And one of the projects provided flood-control benefits to the local community.

The restoration and protection of streams outside of cities is also gathering momentum, particularly with efforts to provide better instream flows for fish. Like the cases described above, the most successful projects are those that include the participation of all affected parties. Three such success stories are offered here: Deer, Mill, and Butte Creeks in Northern California (see Chapter 21). Each project succeeded when the Department of Fish and Game, Department of Water Resources, and local landowners came together to fashion an agreement to provide better conditions for spring-run Chinook salmon while maintaining reliable water deliveries to local users and protecting landowners' water rights. The Butte Creek siphon project, in conjunction with several other separately funded projects, improved conditions for salmon by opening up 18 miles of stream for their migration; Deer and Mill Creeks now have better year-round flows to aid migrating salmon.

Recent collaborations between non-governmental organizations and state and local officials have simultaneously restored wetlands and reduced flooding risks, while allowing agricultural and grazing activities to continue. One such example has been the partnership among The Nature Conservancy and local, state, federal, and private organizations, including the California Department of Water Resources and the California Department of Fish and Game, and local landowners in creating the Consumnes River Preserve (see Chapter 20). This partnership has led to an environmentally affordable solution to floodplain management without the use of new structural approaches. Additional examples can be found at the Beach Lake site in the Stone Lake National Wildlife Refuge, where state and federal agencies came together with a local sanitation district to restore a tract of wetlands that will ultimately link with other wetland habitat in the Central Valley (see Chapter 19). A third example is the Feather River Coordinated Resource Management project

(Chapter 22) that has involved 21 different stakeholder groups and implemented 45 projects since 1985 to restore meadows, wetlands, and streams. This project has also expanded our understanding of what does and doesn't work in protecting the 3,200 square-mile Feather River watershed and other portions of the Sierra Nevada. These projects demonstrate that creative, collaborative funding and management can lead to environmental restoration that offers multiple benefits to multiple stakeholders.

2. *Existing Technologies Have Enormous Untapped Potential*

Water disputes cannot be solved with technology alone. California's problems include a complex mix of economic, political, social, and geophysical characteristics. Yet many technologies that are already available can play a vitally important role in conserving water, protecting water quality, providing recycled water for different uses, monitoring and measuring water availability and use, or managing complex demand and supply situations. In the positive "vision" for water described in our report *California Water 2020: A Sustainable Vision,* we noted that:

> "To realize this positive vision *no significant new supply infrastructures need be built, nor are any drastic advances in technology necessary."* (Italics in original)

This conclusion is even more true today, as shown by the intelligent application of existing technologies in several of the case studies included here. The continued penetration of the best new technologies will have a long-term beneficial effect on California water policy by reducing demand and increasing available supply through improvements in water quality and management.

In recent years California farmers have made progress converting appropriate cropland and crops to water-efficient drip irrigation systems, significantly reducing applied water requirements for many growers. By the mid-1990s, approximately 13 percent of California farmland was irrigated with drip systems, up from five percent in the mid-1980s. Much of this conversion has happened on land planted with vine and orchard crops, and with high-valued fruit and vegetable crops. Recently, however, innovative efforts have shown that row crops not previously irrigated with drip systems can be successfully and economically converted as well, reducing applied water needs and increasing crop yield and quality (see Chapter 15). These examples show that existing drip technology has far greater potential than has yet been realized. Furthermore, the trend statewide toward more valuable, permanent crops (see Chapter 14) is leading to even more acres of crops suitable for efficient drip systems, further increasing the water productivity of California agriculture.

Many technologies that are already available can play a vitally important role in conserving water, protecting water quality, providing recycled water for different uses, monitoring and measuring water availability and use, or managing complex demand and supply situations.

In the commercial and industrial sectors, dramatic improvements in water-use efficiency have been achieved by company after company, without new technology (see Chapter 6). Careful review of processes, innovative use of existing technology, and smart water management have repeatedly been shown to be effective at cutting industrial water use, industrial wastewater generation, and production costs. One such success story is the Naval Aviation Depot in San Diego, which reduced water use between 1987 and 1997 by over 90 percent, from 305 million gallons to fewer than 27 million gallons each year, largely through careful water management and the wise use of existing technology (see Chapter 9).

Similar improvements are materializing in the residential and institutional sectors. Existing low-flow toilet technology, efficient showerheads and faucets, and new washers all can reduce household water use by 20 to 30 percent, or more. Over the past decade, water agencies have explored ways to get these existing technologies to residents, including highly successful partnerships with community groups to distribute ultra-low-flow toilets (see Chapter 5) in cities throughout the state. As of August 1998, these programs alone have saved an estimated annual 13,000 acre-feet of water, and they have only begun to scratch the surface. Institutions can also use existing technologies wisely to save water. The University of California, Santa Barbara implemented a comprehensive water-efficiency program between 1987 and 1994 that reduced total campus water use by nearly 50 percent, while the campus population increased (see Chapter 8). Application of existing technology and more careful attention to water management was the key to this program's success.

Technological innovation also plays a role in reducing water-quality problems. The food-processing industry, for example, often generates wastewater with high concentrations of pollutants such as salts. Many plants have traditionally discharged their wastewater into evaporation ponds—an inexpensive option. This approach, however, can lead to groundwater contamination and other environmental problems. As a result of increasingly strict state and federal regulations, the food-processing industry has begun to look for alternative approaches to both reduce wastewater volumes and treat remaining effluent. Oberti Olives, one of only four olive processors in California, studied the possibility of modifying state-of-the-art water-treatment technologies usually used for other purposes and eventually installed a membrane filtration/water-recycling system in its own plant. This innovative application of technology, driven by the need to meet a regulatory requirement, has cut Oberti's groundwater use by 90 percent and completely eliminated wastewater discharges, at a cost far below the other options available for meeting wastewater discharge requirements (see Chapter 10).

The technology for cleaning wastewater has long existed. Only recently, however, has this resource been considered a potential source of new supply, as water managers have come to realize that not all water demands require the supply of potable water. The West Basin Water Recycling project is an example of an effort that will ultimately provide 100,000 acre-feet of water that can be used for a wide variety of demands in its 17-city service area (see Chapter 12). Next door to the West Basin Water District, the Santa Ana Watershed Project Authority has helped implement a number of successful projects for cleaning wastewater to reduce the inflow of salts to the Santa Ana River and to reuse water for a wide range of uses in the basin (Chapter 23). Similarly, the cities of Santa Rosa and Visalia are already using recycled wastewater for several agricultural projects, reducing wastewater discharges and meeting a local water need to grow fodder, fiber, fruits, and vegetables (see Chapter 13). The Marin Municipal Water District has long been an advocate for new uses for recycled wastewater, supplying a laundry facility, a car wash, and a prison (for flushing toilets), as well as large landscape customers (see Chapter 1).

3. *Regulatory Incentives and Motivation Are Effective Tools*

The recent upsurge in anti-government, anti-regulatory sentiment nationwide has stimulated a search for new approaches for meeting resource needs, including market-based mechanisms and devolution of responsibility to local levels. At the same time, despite the reluctance to look to governments for solutions, it is increasingly apparent that federal, state, and local regulatory oversight, management, and standards can be highly effective tools for achieving water policy objectives. Several of the successful case studies analyzed in this project highlight the value of regulatory incentives and motivation. Federal clean water legislation helped stimulate the development of new technology for wastewater treatment; state recycled water guidelines helped define where and how recycled water could be used. National and state laws protecting undeveloped rivers or endangered species have stimulated local and regional communities to work together on river basin management. And consistent national standards for water-use efficiency technology have eliminated conflicting and contradictory state standards, reducing costs to industry and the public.

The goal of protecting and restoring rivers and riparian habitats has long had public support. This public support led to explicit and formal legislative actions, both nationally and in California, with the passing of the National Wild and Scenic Rivers Act in 1968 and the California Wild and Scenic Rivers Act in 1972. Many of the nation's Wild and Scenic rivers are in California and Oregon. While most free-flowing river systems in California were altered in the early part of this century, California still possesses many sections of rivers that have not been dammed or altered. As of 1998, over 1,900 miles of California rivers and streams were protected under the federal Act and 1,344 miles under the state Act. Millions of California residents and visitors from around the country and world treasure these rivers for their scenic value, recreational opportunities, and superb fishing (see Chapter 28). Without this protective legislation, these rivers would probably not flow freely today.

Despite many concerns over the federal Endangered Species Act, this law has stimulated a wide range of innovative state and local programs to meet the needs of species that are on the verge of extinction. The South Bay Water Recycling program (see Chapter 12) was undertaken in response to federal mandates to protect a salt water marsh that provides habitat for two federally-listed endangered species. In addition to meeting this regulatory mandate, the project now provides multiple benefits for humans as well. It provides a new source of water to meet growing demands, reduces sensitivity to decreased quantities of local and imported water during drought years, and prevents over-exploitation of groundwater and potential subsequent ground subsidence, by providing alternative supplies. The Deer, Mill, and Butte Creek projects to enhance and improve habitat for salmon were spurred on by the federal Endangered Species Act and Wild and Scenic Rivers legislation (see Chapter 21).

Federal and military mandates to reduce water and energy use helped stimulate an enormous improvement in water-use efficiency at the San Diego Naval Aviation Depot. These regulatory and legal incentives led to a reduction in water use of 90 percent between 1987 and 1990 (see Chapter 9). While the water-efficiency measures implemented were highly cost-effective, they had long been ignored as unimportant or unnecessary.

Legislation at the state level to protect human health by reducing the serious air pollution caused by burning rice fields at the end of the growing season provided a strong incentive to rice farmers to identify new approaches for disposing of unwanted rice straw. This regulatory requirement, in turn, led to the innovative use of flooding during winter, which has multiple benefits for farmers and waterfowl (see Chapter 18).

Despite the reluctance to look to governments for solutions, it is increasingly apparent that federal, state, and local regulatory oversight, management, and standards can be highly effective tools for achieving water policy objectives.

Many Californians are familiar with the battle to save Mono Lake, which succeeded in large part because of a legal decision supporting the Public Trust Doctrine. Yet these legal victories are merely one side of the story. Once the Los Angeles Department of Water and Power was required to reduce water withdrawals from the Mono Basin, the question arose as to how it would find an equivalent amount of water elsewhere. In order to avoid simply redirecting adverse impacts to the Owens Valley or the San Francisco Bay–Delta, the Mono Lake Committee worked with LADWP to fund alternative projects to develop "replacement water" for Mono Lake supplies. These efforts led to funding for recycling and conservation programs that are expected to ultimately yield enough water to completely make up for the water formerly obtained from Mono Basin (see Chapter 25).

State regulations limiting wastewater discharges encouraged Oberti Olives to eliminate wastewater discharges and contamination of underground aquifers (see Chapter 10). Without this regulatory incentive, wastewater use and discharge in the food-processing industry would be a more severe problem than it is today—indeed other olive processors continue to discharge wastewaters that could, and should, be treated or eliminated. Similar concerns about groundwater quality and meeting new state regulations led the city of Visalia to look for ways local customers could use treated recycled wastewater (see Chapter 13). Mandates by the Santa Ana Regional Water Quality Control Board to reduce salt discharges to the Santa Ana River encouraged the member agencies of the Santa Ana Watershed Project Authority to design and construct advanced technologies for wastewater cleaning and recycling (Chapter 23).

4. Economic Innovation Leads to Cost-Effective Changes

The international water community is increasingly trying to treat water as an economic good, with a value and a price. While many uses of water cannot be properly measured in purely economic terms, such as environmental uses, a whole range of new approaches for including economic costs and benefits in water policy decisions is slowly but surely changing California's water picture for the better. Environmental costs are being internalized in the form of mitigation funds. Efforts to better value environmental costs and benefits have allowed for better economic comparisons of water-supply alternatives. Low-interest loans from government agencies stimulate adoption of new approaches or technologies. Higher prices for wastewater treatment have stimulated technological innovation and waste reduction. Urban and agricultural rate structures are being designed to send useful price signals to different kinds of users to change water use patterns. Joint funding programs are helping bring multiple interests together on collaborative projects and are spreading the burdens and benefits of different activities.

While many uses of water cannot be properly measured in purely economic terms, such as environmental uses, a whole range of new approaches for including economic costs and benefits in water policy decisions is slowly but surely changing California's water picture for the better.

The drought of 1987–1992 brought many water agencies face-to-face with the problem of implementing water conservation programs while maintaining revenue streams and economic viability. To avoid having to raise rates after asking customers to conserve, the Irvine Ranch Water District (IRWD) replaced its flat rate-per-unit charge with an innovative ascending block rate structure in 1991 (see Chapter 2). At the same time it offered its customers the support, education, and information needed to help them fully understand and accept the ascending rate structure and to respond to the conservation incentives. IRWD's rate structure represents part of an aggressive but cost-effective approach to promoting water-use efficiency improvements, and it has proven very successful at reducing demand in all customer classes.

Innovative rate structures have also helped support and encourage the use of recycled water. In the West Basin Municipal Water District and the San Jose area (see Chapter 12) discounted rates were implemented that encouraged users to identify where recycled water could be used and to develop programs to use that water, reducing pressure on the water agencies to find expensive new supplies. The Marin Municipal Water District has also developed a range of rate structures to encourage improvements in water-use efficiency and the use of recycled water wherever possible (see Chapter 1). These conservation and recycling programs have permitted Marin Municipal to avoid developing new sources of water, at higher cost.

Orange County Water District (OCWD) developed a different kind of economic mechanism to signal groundwater users about the desired amount of pumping each year (Chapter 27). OCWD developed a basin production percentage and a basin equity assessment that creates a disincentive to pump above a particular level. This has proven highly effective as a management tool.

Experience in the agricultural sector also shows the importance of proper water pricing, as well as the value of offering growers ways to share the economic risks of implementing nontraditional water management programs. State programs that share the economic risks of the initial capital costs have accelerated the innovative use of drip irrigation technology, as shown in Chapter 15. For the two farms described in the drip irrigation case study, initial capital cost barriers were overcome through low-interest loans offered by the California Energy Commission. The initial costs were quickly recovered by increased crop yields, and by decreases in the cost of water, chemicals, and labor. As a result, the loans were repaid: one of the two growers even repaid the loan a year early and then installed another 200 acres of drip systems, using private financing. State or federal loans also played a role in encouraging water recycling in West Basin and the South Bay (Chapter 12), and both programs also offer financial assistance to help customers retrofit their water systems to use recycled water. Agencies also offer rebates to customers for landscaping retrofits, installation of efficient toilets and appliances, and audits and retrofits in commercial, industrial, and institutional settings (see Chapters 4, 5, 6, and 7). Increasing prices for water in some irrigation districts are encouraging growers to think about using new water-management approaches and planting different crop types (see Chapter 14). As a result, the productivity of water used in agriculture, measured by farmer revenue per acre-foot of water applied or other comparable indicators, is going up statewide.

Higher prices also play a role in driving technological change and innovation in the urban and industrial sector. The high cost of wastewater treatment has proven enormously effective in pushing industrial water users to reevaluate internal water use and improve their water-use productivity. For the Naval Aviation Depot North Island, San Diego, wastewater costs were 15 to 200 times higher than the simple costs of water supply. This offered a great incentive—and stimulated successful efforts—to reduce water use and disposal (see Chapter 9).

5. *The Value of Information Is High*

The lack of good or complete information on water use or quality and on the availability, applicability, and cost of new technologies greatly inhibits changes in water policy. Numerous examples show that collecting and disseminating proper data and information permits individuals, organizations, or even government agencies to make fast and successful changes in water management and use. Several of the case studies described in this report show the value of information in encouraging and accelerating water policy changes.

When proper data and information are collected and made available, individuals, organizations, or even government agencies can make fast and successful changes in water management and use.

One of the great uncertainties in the water arena is the potential for water-use efficiency in various sectors of the economy. Limited and inconsistent information is collected by state water agencies on actual water use at the industry, household, or commercial levels. As a result, many local and regional water suppliers are beginning to collect and analyze their own water use data. For example, the Metropolitan Water District of Southern California (MWD), in conjunction with its member agencies, initiated a major program in 1991 to gather information on the potential for improvements in water use in the commercial, industrial, and institutional sectors (see Chapter 7). During a five-year period, MWD provided water audits, analyses, and recommendations for actions to companies in these sectors. The program audited over 900 commercial, industrial, and institutional water users, providing valuable information on water use, water savings potential, and implementation of conservation programs.

Good information on water supply and demand at the field level is also critical to farmers interested in carefully managing water resources. In 1982, the California Department of Water Resources and the University of California created the California Irrigation Management Information System (CIMIS) to encourage farmers and other water users to include weather information in irrigation decisions (see Chapter 16). If growers have available—and use—actual data on evaporation and transpiration rates in a region, they can irrigate in a more accurate and timely manner and replace only the water actually used by crops. This approach can increase water-use efficiency and crop yields and decrease costs to growers. By 1998, CIMIS consisted of more than 100 computerized weather stations collecting weather data throughout the state and converting those data into estimates of water needs for different purposes. CIMIS is used to help determine water needs on more than 370,000 acres of farmland and urban and municipal landscaping, and the information it provides has reduced applied water use on these lands by an average of 13 percent. At the same time, agricultural yields on these lands have increased eight percent. The costs to state and local agencies of operating the system are approximately $850,000 per year, while estimated benefits exceed $30 million per year—a hugely successful project.

In the case studies of successful groundwater management, groundwater banking, and watershed management, a premium was placed on data gathering and monitoring. Designing and adapting groundwater management strategies (see Chapter 27) requires that agencies better understand and monitor basin hydrology, water quality, and actual use. Both the Water Replenishment District of Southern California and the Orange County Water District devote substantial resources to maintaining and improving information on their basins. Similarly, the information requirements for successful groundwater banking programs (Chapter 26) showed that such programs are best implemented in conjunction with broader groundwater management or monitoring programs. The two case studies on watershed management (Chapters 22 and 23) also illustrate the value of information in successful restoration efforts. Emphasis was placed on carefully monitoring the activities undertaken in the three watersheds (the Feather, Napa, and Santa Ana Rivers) to provide for program evaluation and adaptive management.

Water-use efficiency programs also benefit from good information on customer water use and behavior. After conducting detailed studies of water use in their service areas, both Irvine Ranch Water District and the Marin Municipal Water District were able to tailor effective water-conservation programs to customers' needs. The rate structures designed by Irvine Ranch (Chapter 2) and MMWD (Chapter 1) were designed to provide customers with clear signals about appropriate water use, to provide incentives for conservation. The landscape efficiency programs described in Chapter 4 also rely on providing customers with adequate information so they can adopt better management practices. Similarly, audit programs for residential, commercial, and industrial customers provide water users with information about efficient water use, available technologies, improved practices, and assistance programs.

Making information available to the general public, and involving the public in collecting that information, can facilitate citizen involvement in the management of water resources. The Napa River Watershed Management project is a case in point. Here, the Napa County Resource Conservation District and its citizen collaborators have established a program of consistent citizen-led watershed monitoring. The compilation of monitoring results, combined with publishing watershed management goals, has helped increase the number of citizen groups involved in active stewardship of various sections of the Napa River.

The 28 success stories described here are the tip of the iceberg. In communities around the state, smart and committed individuals and groups are getting together to take water policy into their own hands. The result is a growing movement away from state or federally sponsored programs and policies toward regional and local watershed and community actions, though several successful state and national activities are also described here. As a result, official state water policies now often lag behind—rather than define—the state-of-the-art. The official California Water Plan, for example, fails to acknowledge these many successful activities or to incorporate them into its projections for California's water future. Integrating the lessons learned from these success stories into long-term policy and planning could lead to a very different California—one where efficient, equitable, and sustainable water uses are the norm, rather than the dream.

Chapter 1

Marin Municipal Water District's Innovative Integrated Resource Management Program

Lisa Owens-Viani

Introduction

In 1992, concerned about being able to meet existing and future demand in its service area, the Marin Municipal Water District (MMWD, or the District) developed a four-pronged integrated resource management plan (IRMP) that allowed it to stabilize demand by linking the phased development of new water supply to a sophisticated demand management (water conservation) program. Because its conservation and water-recycling programs have held demand close to 1980 levels even with a population increase of 13,500 (see Figure 1-1), the District has not yet had to implement the third phase of its supply plan, which includes building a new pipeline to import additional Russian River water. A crucial player in this success is the committee that regularly monitors and evaluates MMWD's supply and demand and the programs designed to manage them.

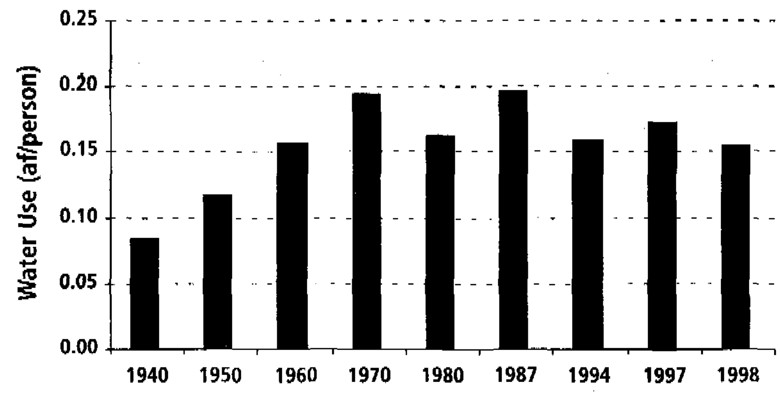
MMWD's IRMP not only closely ties supply to demand but also saves MMWD from incurring the financial and environmental costs of developing new supply unless and until such development can no longer be avoided. According to James Fryer, MMWD's Conservation Coordinator, this more flexible, conservation-based strategy has replaced MMWD's former way of thinking about supply, in which supply systems were built with no regard for demand management. Recognizing that some level of rationing will always be necessary during severe droughts, MMWD's new goals for supply reliability are to maximize ongoing conservation and avoid having to ask customers to reduce water consumption by more than 25 percent (the level set by MMWD's citizen ad hoc committee) more often than every 20 to 25 years (Fryer 1998).

Background

MMWD serves the eastern corridor of Marin County, from the Golden Gate Bridge northward to the site of the former Hamilton Air Base, and from the San Francisco Bay west to the San Geronimo Valley (see Figure 1-2).

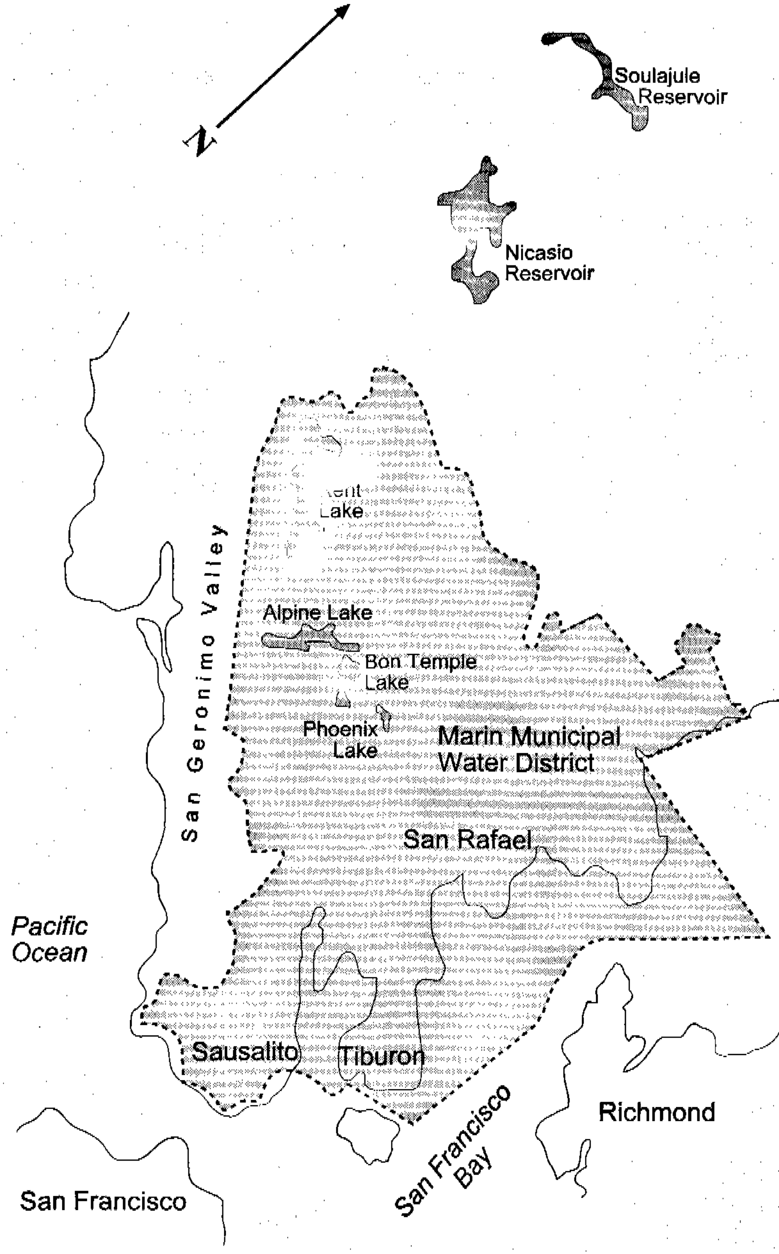
The District encompasses approximately 147 square miles and services a population of about 180,500. Its primary water sources are Lagunitas Creek and tributaries Nicasio and Walker Creeks, which are impounded in seven reservoirs operated and maintained by MMWD (see Figure 1-2). The amount of water MMWD is able to supply from these reservoirs is limited in part by California Department of Fish and Game requirements for instream flows for anadromous fish. In addition to the approximately 80,000 acre-feet of water stored in these reservoirs, MMWD imports about 25 percent of

Figure 1-1
Water Consumption Per Capita*
in the MMWD Service Area for Selected Years



** Includes all uses and sectors*
Source: MMWD

Figure 1-2
MMWD's Service Area



Source: Adapted from Boyle Engineering

its yearly water supply (depending on demand) from the Russian River. Water recycled at the Las Gallinas recycling facility accounts for a small (approximately three percent) but growing portion of MMWD's supply.

Prior to implementing the IRMP, the District had developed its water supplies in "leap-frog" fashion: as demand reached or exceeded available supply, the District would build a new water supply project estimated to satisfy demand for the next 15 to 20 years. In 1989, a consultant hired by the District identified a 5,000 acre-foot per year (afy) supply deficit for existing services (the District had enacted a moratorium on new or increased service connections for existing customers) (see sidebar), plus a future supply deficit of 5,000 afy based on expected growth in the area.

During the time of the consultant's study, MMWD based its definition of adequate supply on "net safe yield": it wanted to have enough water to supply the District through the worst drought of record without any cutbacks or rationing. The 5,000 afy supply deficit identified for existing customers was also based on the fact that reservoirs cannot be completely drained to zero. MMWD has since changed its definition of adequate supply to one based on "operational yield," which acknowledges that customers can significantly reduce consumption during drought periods (Fryer 1998).

In response to these findings, and having experienced two major droughts within the previous couple of decades, the District placed a bond measure on the ballot that proposed importing additional water from the Russian River. Local environmental groups opposed the bond measure, citing the District's lack of conservation efforts, and the voters defeated it. With that message from its customers, and with no practical options for hooking into either of the state's two major water supply systems,[1] the District found itself seriously considering recycled water and demand management as viable alternatives to developing new supply. MMWD knew, based on the response of its customers to requests for conservation during periods of drought, that the potential for substantial water savings existed within the District. In 1977, for example, the District's worst drought year, consumption was reduced by 62 percent, exceeding the 57 percent requested by the District (*Water Use Monitoring and Evaluation Program* 1993).

In 1993, MMWD hired a consultant to perform a baseline study on water end uses, the market penetration level of water-conserving fixtures, water consumption levels, customer knowledge and attitudes toward conservation, demographics, and projected future demand. That study found that many of MMWD's customers supported and had implemented water-conserving measures but that the potential for additional conservation was large.

An ad hoc committee of interested citizens, MMWD staff, and members of the District's board of directors was formed and met over a seven-month period to develop a comprehensive water management program for the District. The committee's recommendations, which were presented to the public in a series of eight public workshops, and the findings of the baseline study, formed the basis of the IRMP. The IRMP called for a comprehensive water conservation program, increased use of recycled water, a monitoring program, and the phased implementation of new supply projects. Phased implementation would enable the District to import water from the Russian River if water savings from improved efficiency and conservation measures were insufficient to help the District meet its water supply reliability goals (i.e. to not exceed 20–25 percent rationing every 20–25 years) and future needs. Motivated by the desire to limit the amount of rationing or moratoriums on new hookups it would have to impose in the future, constrained by limited supply options, and encouraged by a supportive public, staff, and board of directors, MMWD developed an innovative and comprehensive IRMP. The IRMP includes conservation programs geared toward all types of customers and uses, a successful recycled water program, and an effective self-monitoring program that ensures that the conservation programs are cost-effective and achieve the ad hoc committee's goals.

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[1] In 1976–1977, in one of the worst periods of drought for the agency, a pipeline was built to carry water from Hetch-Hetchy via the East Bay Municipal Utility District across the Richmond-San Rafael Bridge to MMWD, as an emergency stop-gap measure. After the drought, however, the District was unable to secure permanent supply from the East Bay or the Delta, and Caltrans required MMWD to remove the pipeline. For MMWD to tap into one of the large water projects as a long-term solution would be prohibitively expensive.

Some of the Driving Forces Behind MMWD's Conservation-Oriented IRMP

- Scarce local water supply/high cost of developing new supply
- Customer interest in minimizing water bills and the District's costs
- Customer interest in and support for conservation and environmental preservation
- Strong staff interest in and support for conservation, leading to the board's adoption of Policy 16 setting forth water conservation as "an integral part of the District's long-term resource planning"
- Measure V, passed in 1992, which funded the IRMP
- The Water Efficiency and Conservation Master Plan (CMP), which reviewed existing and identified potential new conservation programs
- California's Memorandum of Understanding on Urban Water Conservation (to which MMWD is a charter signatory), which identified best management practices (BMPs)

The Four-Pronged IRMP

1. Phased Supply

In developing its phased plan, MMWD's goal was to reduce demand, through conservation and efficiency measures, by an additional 10 to 15 percent beyond the 11 percent reduction estimated to have been achieved through both voluntary and state-mandated measures between 1970 and 1987 (such as 3.5 gallon ULFTs and low-flow showerheads). At the same time, by adopting a phased supply plan, MMWD wanted to be able to meet a higher demand scenario, if necessary.

The first phase of the supply plan included expanding MMWD's recycled water distribution system, implementing the conservation master plan, and signing a new contract with the Sonoma County Water Agency (SCWA) and its contractors to purchase 10,000 afy of Russian River water, in addition to the 4,300 afy provided under the original contract.

Phase 2 included improving existing infrastructure, further expanding the Las Gallinas water-recycling facility, acquiring rights-of-way for the new SCWA pipeline, designing Phase 3 pipeline facilities, and continuing conservation and water efficiency measures. These first two phases solved the 10,000 acre-foot deficit problem identified by the consultant.

Phase 3, which would include building a pipeline to carry Russian River water from Kastania (Petaluma) to Novato, as well as further expansion of the Las Gallinas recycling facility, has not yet been implemented, due to the success of MMWD's conservation and water-recycling programs—and abundant rainfall. If and when the monitoring committee's evaluation shows that existing demand is approaching supply capability (the current operational yield), and that projected near-term increases in demand will exceed supply, the third supply phase will be triggered.

Phase 4 would involve building a new water-recycling facility, expanding the Russian River pipeline of Phase 3, and continuing conservation and efficiency programs.

In Phase 5, the Monitoring Committee would reevaluate all of MMWD's long-range water resources options, improve recycling facilities, and build new infrastructure from the Russian River.

Cost

MMWD issued $37.5 million in bonds to pay for the IRMP. The bonds cover all elements of the plan—conservation programs, the recycled water program, and new supply—and spread the cost of building new supply infrastructure over an 18-year period, factoring in inflation. The supply phases are implemented as needed, which enables MMWD to adopt more of a "pay as you go" financing approach. Funds collected through connection fees and water rates are held in reserve until needed, and along with other revenues, help pay back the bonds. The financial analysis behind the bonds assumed a consistent growth rate of 300 single-family residences per year in the District. If actual growth—and more importantly, demand—is lower, the reserves are not tapped into and the phases are postponed. If the growth rate is higher or demand rebounds to pre-drought levels (i.e. before many basic conservation measures were implemented), funds will be made available for implementing the next supply phase.

2. Monitoring and Evaluating Water Use

In developing the IRMP, the District determined that it needed to fine-tune its monitoring and projections of water use in order to cost-effectively manage supply and demand. A nine-member citizens' committee,[2] the Water Conservation and Monitoring Advisory Committee (the monitoring committee), was appointed to monitor and evaluate the IRMP. Through formal, yearly evaluations and more frequent, less formal meetings, the monitoring committee ensures that the initial ad hoc committee's recommendations are met, evaluates MMWD's supply and demand, and determines if and when new phases of the supply plan need to be implemented. Using the baseline study, census data, the District's water service database, water production data, and weather information, the monitoring committee evaluates the effectiveness of the District's conservation programs and determines actual water savings as well as potential additional water savings. The monitoring committee helped develop and implement the ultra-low-flush toilet programs, the baseline study, the Conservation Master Plan (CMP), and the board's water conservation policies, as well as the monitoring program itself. Prior to developing the CMP, MMWD had evaluated water use and developed use projections using gross per capita figures, since many of its customers were in the single-family residential category. In the CMP, MMWD refined its projections by delineating user categories and service areas. The District has since begun factoring in variables such as rainfall, temperature, and population growth.

As part of the evaluation process, District staff members work with city, town, and county planning departments within the District to determine whether growth and development trends vary from adopted general plans, and apprise the monitoring committee of their findings. The monitoring committee also evaluates the "decay" of MMWD's access to the pipeline capacity of the North Marin Water District (which delivers the Russian River water MMWD purchases from the SCWA to MMWD): as demands within North Marin's own service area increase over time, MMWD loses access to pipeline capacity.

The primary cost of the monitoring program is the time MMWD staff spends preparing for and attending monthly or bi-monthly meetings, according to James Fryer. The monitoring program does not have a budget per se but is paid for out of the general fund. Citizen members volunteer their time.

3. Water Conservation and Efficiency Programs

The goal of MMWD's conservation programs and activities is to cost-effectively improve the reliability of the District's water supply by conserving as much water as possible. Specifically, the CMP recommended reducing total demand by 22 to 32 percent below 1987 levels through customer-friendly, incentive-based programs that are less costly than developing new supply options (*Urban Water Management Plan* (UWMP) 1995). The year 1987 was used as the "target," since it was the highest consumption year on record, even though consumption reflected savings from conservation measures implemented after the 1976–1977 drought (which were estimated to have reduced 1987 consumption by 11.5 percent) (UWMP 1995). The District is on track in achieving its goal—halfway through the 10-year implementation of its CMP, it has reduced demand by approximately 15 percent, despite a 7.5 percent increase in population. This reduction in demand has largely been achieved through the District's wide array of innovative conservation programs and an

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[2] Two members of the committee also serve on MMWD's board of directors.

aggressive water-recycling program. Conservation measures include the implementation of ordinances and policies, tiered rate structures, audits and incentives, budgets and entitlements, and a multi-faceted educational effort targeting the general public through demonstration gardens, school programs, billboards and advertisements, and water-efficient landscape contests. Some of MMWD's most successful water conservation and efficiency programs are described in more detail below.

Ordinance 326

In 1991, MMWD's board passed Ordinance 326, which requires customers applying for new, increased, or modified service to implement stringent indoor and outdoor water-conserving technologies. It also requires all new landscape designs (with the exception of those for single-family residences) to undergo a very thorough pre-installation plan review by MMWD and to be inspected by licensed landscape architects. MMWD staff members frequently inspect the sites as well (Fryer 1998). According to James Fryer, many water-inefficient designs are caught in this pre-installation plan review process, and corrected before installation. Although to date MMWD has performed landscape plan reviews free of charge, it is considering charging landscape architects for any subsequent reviews necessary to correct inadequate designs (Theisen 1998). MMWD has also developed a workbook for landscape architects, to help them comply with the ordinance.

Required indoor efficiency measures include pressure-regulating valves, ultra-low-flush toilets (1.6 gallons-per-flush), low-flow shower heads and kitchen and bathroom faucets, and (for non-residential facilities) self-closing valves on faucets and showerheads.

Some of the outdoor requirements include limiting lawns and swimming pools using potable water to 25 percent of the total developed landscape area and lawns using reclaimed water to 40 percent of the total developed landscaped area; planting all other areas with low-water-use plants (unless the site is a ball field or public park, etc.); using specified amounts of mulch; and installing automatic irrigation systems that meet stringent standards for overspray, runoff, and distribution uniformity.

MMWD estimated in the CMP that the ordinance would save at least 69 afy; however, the agency believes that actual savings due to the focus on landscape efficiencies is much greater (Fryer 1998). James Fryer says the program has other, less quantifiable benefits as well. Once landscape architects have undergone three or four plan reviews, they are more likely to incorporate what they have learned, not only in future projects requiring plan reviews, but also in projects that do not require reviews, such as single-family residences. Fryer believes the ordinance has been particularly successful in regard to landscape water savings because it encourages a three-pronged effort by the agency, the customer, and the landscape architect that helps the agency meet its water conservation goals and saves the customer and the landscaper money.

Ultra-Low-Flush Toilet Programs

To date, these programs have resulted in over 30,000 toilets being retrofitted in Marin County (Fryer 1998). In August 1994, the District implemented a program offering customers a $100 rebate or a $150 no-interest loan to replace their old toilets (which use 3.5 to 7 gallons per flush), with ultra-low-flush (1.6 gallons per flush) toilets. The District has since begun working with community-based organizations to distribute ultra-low-flush toilets (see *Community-Agency Partnerships Save Water and Revitalize Communities,* Chapter 5) and also works with individual schools interested in replacing their old water-consumptive toilets. MMWD is now installing ULFTs and infra-red sensors on water faucets in area movie theaters in exchange for pre-movie screen space advertising MMWD's ULFT program. One clever question-and-answer-type ad asks the audience how many movies they could attend with the money they would save from installing a ULFT.[3]

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[3] With the ULFT rebate, a customer can see at least 10 movies, and with the money saved on an average water bill from installing a ULFT, a customer can see five movies each year.

Table 1-1
MMWD's ULFT Installations 1994–1998

Ultra-Low-Flush Toilets Retrofitted	Fiscal Year 1994–95	Fiscal Year 1995–96	Fiscal Year 1996–97	Fiscal Year 1997–98 (as of 6/30/98)
Through Rebate Program	12,000	4,490	2,923	3,500
Through CBOs	Not implemented	2,605	2,773	4,000
Schools	Not implemented	Not implemented	180	38
TOTAL:	12,000	7,095	5,876	7,538

Source: Fryer 1998

To date, MMWD's ULFT programs have saved an estimated 8,000 acre-feet of water; by the year 2002, that figure is expected to be close to 24,000 acre-feet (Fryer 1998).

"Water Budget/Entitlement" Program for Non-Residential Customers

The water budget/entitlement program was designed to indicate the maximum amount of water MMWD is committed to supplying *new* non-residential customers, to check existing non-residential customers whose use is increasing, and to indicate the quantity of water the District is committed to supplying *all* of its non-residential customers. In 1989, MMWD began assigning water budgets to all new non-residential services and in 1991, to existing non-residential customers. (Non-residential customers make up approximately 40 percent of MMWD's customer base.) While water *budgets* represent MMWD's determination of the customer's *actual* consumption requirements, *entitlements* represent the maximum amount of water MMWD is committed to supplying the customer on an annual basis. The water budget may be less than or equal to the entitlement, but cannot exceed the entitlement.

The water budget serves as a tool to implement the District's inverted block billing structure for non-residential customers (residential customers pay the same tiered rates, but the rates are based on fixed break points rather than budgets). The annual water budget, divided over six bi-monthly billing periods, serves as the billing baseline. The amount of water allocated to any two-month billing period defines how much water can be used before second- and third-tier water rates are triggered. The water budget also serves as the water allocation basis for the District's rationing program in the event of a drought. Because customers have different water needs (an office building versus a restaurant for example), the break points triggering the next tier are based on each customer's individual needs, as defined in their water budget.

MMWD staff review the annual water use of all non-residential accounts every January to determine which customers have exceeded their entitlements; MMWD then notifies those customers. If the excess use was caused by a leak that has since been repaired, customers are not considered in excess of their entitlement. New customers who exceed their entitlement for three consecutive years or customers who change their service to more intensive-water use must purchase additional entitlement to come into accord with their increased demand. As can be seen in the table below summarizing 1995 entitlements, while some users did exceed their entitlements, most used less, resulting in a net water savings, and showing that most customers seem to be responsive to the budget/entitlement program.

Table 1-2
MMWD's 1995 Entitlement Review

	No. of Accounts	Total Entitlement (AFY)	Total 1995 Use (AFY)	Amount Over/Under (AFY)
Accounts Over Entitlement	285	424.87	663.63	+238.76
Accounts Under Entitlement	4,059	9,381.32	6,285.87	-3,095.45
Total	**4,344**	**9,806.19**	**6,949.50**	**-2,856.69**

Source: Water Conservation Action Plan for 1997, MMWD

Conservation Rate Structure

In 1993, MMWD established a three-tiered rate structure that applies to all customer classes and reflects the marginal (and some operational) costs of its three supply sources—local reservoirs, the Russian River, and the Las Gallinas recycled water system. For non-residential customers, the tier is determined by the budget/entitlement system, as described above; residential tiers are based on fixed break points determined by consumption (there is also a fixed service charge based on meter size). Because marginal costs reflect MMWD's actual cost of obtaining and delivering additional water to meet customer demand, a tiered structure based primarily on those costs offers a rationale that can be easily explained to and understood by customers; it also provides them with a price signal that encourages conservation.

MMWD's third-tier potable rate reflects the cost (capital, pumping, and treatment) to MMWD of delivering *recycled* water. Potable customers do not actually receive recycled water but are charged third-tier rates when they exceed a specified level of consumption. In this way, the third-tier rate helps pay back the capital costs incurred by MMWD in building its recycled water distribution system.

MMWD has also established a tiered rate system for recycled water users. Although the marginal cost of delivering recycled water is higher than that for Russian River or local reservoir water, to encourage its use, MMWD charges only (approximately) one-half the cost of first-tier potable water—$1.24/ccf—for first-tier recycled water. Like potable users, recycled water users (who tend to be commercial or large landscape users) are billed based on how much water they use: the second-tier rate ($2.21/ccf) is triggered when customers use 100 to 150 percent of their entitlements; the third tier ($4.08/ccf) when customers exceed 150 percent of their entitlements.

Table 1-3

The Cost of MMWD's Water by Source in $ Per Acre-Foot Delivered

SOURCE	(1) Pumping	(2) Treatment	(3) Amortized Capital Costs	(4) Purchase	Variable*	TOTAL (1–4)
Reservoirs	65	65	335	0	130	465
Russian River	55	15	385	320	195	775
Las Gallinas Recycling System	45	200	1,900	0	245	2,145

**Reflects the sum of pumping and treatment costs, with a portion of the purchase cost for the initial 5,000 acre-feet of Russian River water.*

Source: Fryer 1998

Table 1-4

MMWD's Three Pricing Tiers for Potable Water in $ Per Acre-Foot

Tier 1	Tier 2	Tier 3
$963	$1,779	$3,410
Based on the true cost* of delivering reservoir water	Based on the true cost of delivering Russian River water	Based on the true cost of delivering recycled water.

**True cost is primarily MMWD's marginal cost of supply plus some other associated operating costs.*

Source: MMWD, converted from ccf

The Conservation Assistance Program (CAP)

This audit program targets and tries to eliminate inefficient water use among the highest water users in each customer class. Although Best Management Practices (BMPs) require water agencies to target the top 20 percent of users, MMWD targets more than just the top 20 percent. Since 1995, when the CAP was established, MMWD has conducted 800 audits of single-family units; 73 audits of multi-family units, 70 audits of large landscaped areas, and 137 audits of commercial institutions (Pelletier 1998). Prospective participants are sent hand-signed letters in handwritten envelopes inviting them to participate in the program. If the agency does not receive a response to the initial letter, it sends second and third follow-up letters. MMWD employees perform the audits themselves and try to conduct careful, thorough audits rather than performing large numbers of less detailed audits.

Each audit consists of an inventory of water fixtures inside the home or building and an evaluation of the customer's landscape and irrigation system and his or her general water use. Auditors identify water-saving measures, perform benefit-cost analyses, and propose incentives for retrofits. The customer receives a water-use profile, a list of recommended actions, an analysis of his or her water bill, and rebate information if applicable.

Participants receive a follow-up letter as well as annual updates on their water usage. MMWD customers can also sign up to receive weekly "weather faxes" from MMWD, which contain CIMIS information about evapotranspiration rates and water replacement needs (Fryer 1998) (see *The Power of Good Information,* Chapter 16). MMWD is currently developing a method of sending this information out via e-mail. Follow-up efforts like these tend to increase implementation of conservation measures identified in the audits, according to James Fryer. MMWD has also learned that customers are more likely to respond to an invitation to have their water use audited and potential cost savings identified through a "water use consultation" than they are to participate in a more vague-sounding "survey." Table 1-5 shows estimated water and avoided cost savings from the CAP program.

Landscape Seminars

In 1995, MMWD began offering landscape seminars for "do-it-yourself" homeowners as well as landscape professionals and institutional groundskeepers. Although geared somewhat differently for these different users, the seminars include topics such as local water supply constraints, soil types, climate, plant selection, irrigation techniques, hydrozones, water pressure regulation, irrigation system maintenance, CIMIS information, and MMWD's weather faxes and call-in tip line. Landscape professionals who attend and pass tests on the seminars receive MMWD's WEL ("Water-Efficient Landscaping") logo, which they can use in advertisements. As of mid-1998, MMWD has also held nine seminars on efficient irrigation techniques and 10 on water management for homeowners' associations.

Other seminars are offered on improving efficient use in hotels and motels, swimming pools, and cooling towers.

Demonstration Water Conservation Garden and Water-Conserving Garden Contests

In 1994, MMWD installed a demonstration Water Conservation Garden in Corte Madera. The garden showcases 42 native plant species on a 2,850 square-foot site that demonstrates how low-water-use plants and efficient irrigation can be used to create an attractive garden in Marin's Mediterranean-type climate. Plants in the garden, most of which are California natives, are labeled with their common and botanical names. Brochures explaining how to

Table 1-5
MMWD's Estimated Savings from CAP

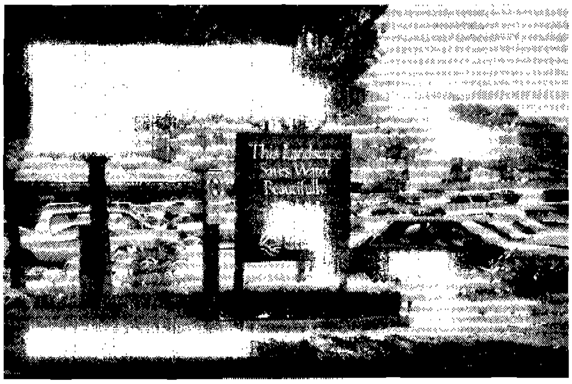
CAP Weighted Cost per Acre-Foot of Water Saved	$357
Avoided Cost of New Supply per Acre-Foot	$1,241
Estimated Cumulative CAP Savings:	431 to 638 acre-feet per year

Source: Water Conservation Action Plan for 1997, MMWD design low-water-use gardens and lists of low-water-use species are available for visitors to take home. The District recently installed a second demonstration garden in San Rafael.

Since 1994, the District has held annual water-conserving landscape contests for the public. Contest categories range from single-family home landscapes to established commercial landscapes; winning landscapes (along with water-conserving gardening tips), are featured in MMWD newsletters, displays at the county fair, and local shopping malls. MMWD is currently developing a documentary about the landscape winners, in which these customers will encourage others to install water-conserving gardens.

Rebate Program for "Tumble-Action" Washing Machines

In 1996, in conjunction with Pacific Gas and Electric, the District began offering rebates to customers who install tumble- or horizontal-action washing machines. By July 1998, 550 machines had been installed. These washing machines save between 25 and 50 percent of the amount of water used by traditional top-loading type washing machines, and they save on energy costs. Assuming an average single-family household washes four loads of clothes per week (an average water use of 28 gallons per day), those 550 new washing machines are already saving the District at least 8.6 acre-feet of water per year. MMWD estimates in the CMP that savings from this 10-year program will total between 68 afy (with low-participation in the rebate program) and 184 afy (with high participation), and that if the use of horizontal-axis machines is mandated after the year 2000, savings could be as high as 614 afy (assuming 4,000 new participants per year over 10 years) (Barakat & Chamberlin, Inc. 1994). So far, this program has been very well-received, according to James Fryer, and MMWD believes actual water savings will be even greater than predicted.



MMWD's presence and message are visible year-round (Photo by author).

Public Information Campaign/School Education Program

MMWD's public information campaign is handled through its Public Information Department, with support from the Water Conservation Office, ensuring that MMWD's water conservation message is prominent in the public eye. MMWD uses news releases and interviews, brochures, bill inserts, billboards, and special events like county fairs and other community events to promote its programs and urge conservation; these efforts are increased during the warm summer months when water use surges upward although MMWD's presence—and conservation message—is highly visible year-round. Billboards, for instance, are placed near high traffic areas and, when appropriate, call attention to attractive water-conserving landscapes nearby.

MMWD is currently developing a series of videos to be aired on public access channels describing MMWD's WEL logo/training program for landscapers, as well as videos teaching homeowners how to install efficient drip irrigation systems and how to create gardens that act as a continuation of the natural Marin County landscape, instead of gardens unsuited to the local climate and native wildlife (Fryer 1998). The public can also borrow these videos free of charge from MMWD, local libraries, and video stores. MMWD is also working with local movie theaters to air pre-movie segments about the landscape contest winners, using images of the winning gardens.

In 1993, MMWD developed a water education workbook for distribution to grades K–12, and works with PTAs, school superintendents and principals, and other environmental education groups in its service area to distribute the mate-

Table 1-6
The Cost of MMWD's Conservation Programs

Fiscal Year	Conservation Program Expenditures	Operating Budget	Capital Budget	Percent of Total Expenditures (Operating and Capital) Represented by Conservation Costs
1991–92	$252,882	Not available	Not available	0.6
1992–93	$414,896	Not available	Not available	0.8
1993–94	$479,829	Not available	Not available	0.8
1994–95	$1,601,304	Not available	Not available	2.4
1995–96	$1,903,501	$37,097,420	$26,931,279	2.9
1996–97	$1,048,698	$37,226,362	$15,347,409	1.9
1997–98	$1,400,000	$38,438,738	$15,421,390	2.6

Source: MMWD

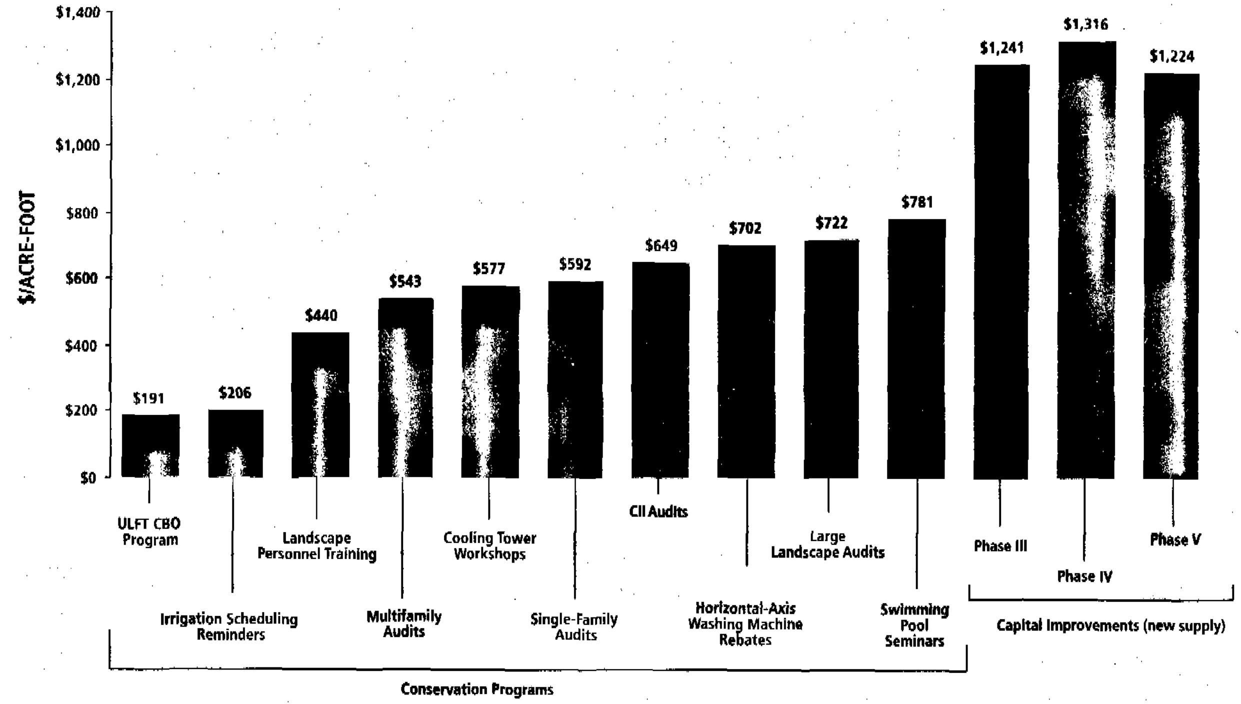
rials. It also holds teacher training workshops and has developed a newsletter for teachers.

Cost of Conservation Programs

Although its conservation budget has reached as high as $1.9 million (in its 1995–1996 fiscal year), conservation remains a small component of the District's overall expenditures, as shown in Table 1-6.

Perhaps most importantly, MMWD's conservation programs are highly cost-effective when compared to the cost of new supply, as shown in Figure 1-3.

Figure 1-3
The Cost of Conservation Programs vs. the Cost of New Supply



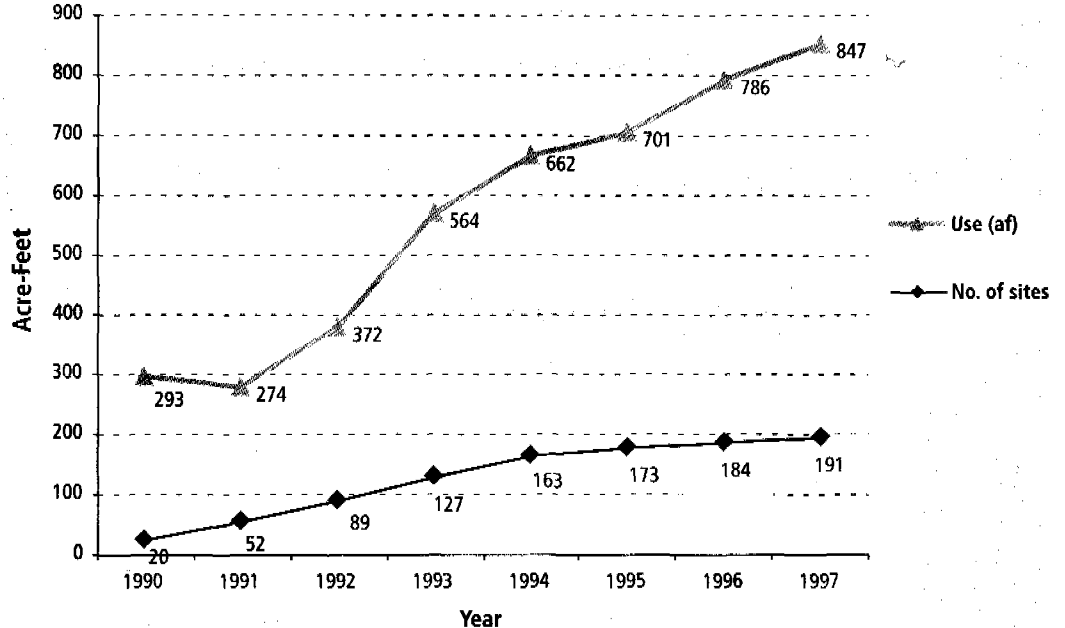
Source: UWMP 1995

4. *Recycled Water*

MMWD began using recycled water with a pilot recycling plant during the drought of 1976–1977, successfully demonstrating that recycled water could be used when other sources were not available. Concern about the future availability of potable water led MMWD, working with the Las Gallinas Valley Sanitary District, to build a permanent facility. In 1981, a one million gallon per day (mgd) filtration plant was completed, but when state regulations on recycled water use became more stringent, the plant's water quality was no longer considered adequate for irrigating parks, playgrounds, or greenbelts. MMWD then upgraded both the plant's water quality treatment capabilities and its capacity, to a two mgd advanced tertiary treatment plant. With these improvements MMWD was able to expand its market for recycled water, and between 1990 and 1994, expanded its distribution system and built 25 miles of recycled pipeline. Today, MMWD recycled water customers (over 250 connections, 95 percent of which are irrigated landscape customers who formerly used potable water) use approximately 850 acre-feet of recycled water each year. During peak irrigation season, the Las Gallinas plant is operating close to its two mgd capacity.

As an incentive for customers to use recycled water, MMWD does not charge *existing* customers to convert to recycled water[4] but absorbs the costs of distribution and service installation and recoups some of those costs through new service connection fees and its third-tier potable rate. To further promote recycled water use, MMWD requires new, non-residential customers to use recycled water for landscaping as a condition of potable service. Roger Waters, MMWD's Recycled Water Coordinator, mentions that the droughts of 1976–1977 and 1991–1994, which necessitated rationing and resulted in damage to customers' planted landscapes, also encouraged customers to use recycled water since, unlike

Figure 1- 4
Growth of Recycled Water Use in MMWD



Source: MMWD

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[4] New recycled water customers pay the same connection fees as potable users.

potable water, it is not subject to cutbacks during droughts. Many customers have begun to view recycled water use as a way to protect their landscape investments.

MMWD has promoted as many new uses for recycled water as possible within state health department restrictions. In 1993, after several regulatory hurdles were overcome, the first car wash in the state to use recycled water went on-line. Although customers initially complained about spotting (from the higher dissolved solids in recycled water—1,000 ppm versus 100 ppm in potable water), that problem was resolved with the installation of a reverse osmosis system. Washed cars are now spot-free, and the car wash has saved money by using recycled water.

In 1995, after overcoming more regulatory concerns, MMWD began supplying a heating, venting, and air conditioning (HVAC) cooling tower with recycled water. The cooling tower has successfully used recycled water since then, and MMWD offers a technical paper for others interested in replicating such a system.

In 1998, MMWD installed a recycled water laundry facility in a retirement home, the first time recycled water has been used in California inside a facility classified as "medical."

MMWD has been a pioneer in advocating the use of recycled water for flushing toilets and initiated AB 1698, which empowers public agencies to require dual plumbing systems in non-residential buildings (so that recycled water can be used to flush toilets). MMWD also initiated legislation creating a revolving low-interest loan fund for water recycling projects, and legislation that expands the categories of buildings in which recycled water can be used to include all facilities except single-family dwellings. Those facilities include stores, offices, theaters, auditoriums, schools, hotels, apartments, barracks, dormitories, jails, and prisons. The new 320-bed Marin County Jail is the first penal institution to use recycled water for toilet flushing, in accordance with standards of the new Uniform Plumbing Code that address dual plumbing design and installation (Castle 1998).

Cost of Recycled Water Infrastructure

Between 1978 and 1995, MMWD spent approximately $17 million ($5 million of which came from the low-interest state revolving fund loan program) to develop the Las Gallinas water-recycling system, which consists of a two mgd advanced tertiary treatment plant, 25 miles of pipeline, five storage tanks with a total capacity of 1.7 million gallons, and four pumping stations (UWMP 1995).

MMWD is now examining the potential for expanding its recycled water system again. Although it had considered developing a recycled water system with the Central Marin Sanitary District, widespread saltwater intrusion in that district has increased the cost and decreased the feasibility of the project. MMWD is now considering a further expansion of its Las Gallinas facility.

Recycled Water Study Garden

In 1994, in conjunction with the University of California, MMWD established a 25,000 square-foot demonstration garden in Terra Linda designed to compare the performance—using recycled and potable water—of various trees, shrubs, and ground cover plants (both native and exotic) commonly used in Marin County landscaping. One of the reasons for the study was to see if complaints of poor plant performance attributed to recycled water had any validity. Half of the garden was watered with potable water; half with recycled. Each half was watered using both overhead spray and drip irrigation. No fertilizers were used, and the soil was not amended before being planted. Tensiometers indicated when the soil was dry and the plants needed watering. After four years of data collection, researchers could find no appreciable difference in the growth or health of the plants, regardless of the type of water applied.

Because the study plants were watered only when they truly needed to be and performed so well, Roger Waters suspects that the true cause of any plant damage is customers watering their plants too frequently using too much water—rather than recycled water. The demonstration garden has been turned into a water management training facility where seminars on landscaping using recycled water will be taught.

Conclusions/Lessons Learned

Marin Municipal Water District's Integrated Water Resources Management Plan reflects the innovative thinking the agency engaged in when it realized that its options for developing new water supply were limited and that its customers both supported its efforts to conserve water and and expected it to lead in those efforts. MMWD had come close to exhausting its local water supply sources, and, as James Fryer puts it, "We knew we weren't going to be bailed out by the CVP or the State Water Project." At the same time, based on the amount of water conserved by its customers during several droughts, MMWD knew the potential for enormous water savings existed, if demand could be better managed. When local groups defeated a bond proposal in 1991 to obtain new supply from the Russian River, MMWD realized it had little choice but to better manage supply—by better managing demand.

MMWD took the first step in developing a more balanced water supply plan by conducting its water conservation baseline study. The results of that study showed strong customer support for conservation and gave the District hard numbers upon which to base proposals for conservation programs. Fryer believes agencies that haven't collected such data might be surprised if they polled their customers. Because MMWD researched and understood its customers' patterns of water use and attitudes toward conservation, it was able to tailor its programs to the different sectors within its service area and to develop strong rapport with its customers. And because it administers the programs in-house, MMWD continues to learn about and better understand its customers. As a result, MMWD's conservation programs have helped it successfully manage demand, stabilizing it at close to 1980 levels, despite a population increase of 13,500 in the agency's service area.

Although the success of some of MMWD's conservation programs in saving water cannot be precisely quantified, MMWD's presence and water conservation message are highly visible. Billboards urging conservation are not suddenly erected when a drought begins but can be seen at all times as can the television announcements about more natural, water-conserving landscapes and the documentaries on landscape contest winners (to name just a few of the agency's public information efforts). These ongoing, persistent efforts are undoubtedly having a cumulative impact upon customers in MMWD's service area.

Another key to the success of MMWD's conservation programs is the fact that MMWD compares their cost to the marginal cost of new supply—approximately $1,241 per acre-foot—and only chooses those that can be implemented for less. MMWD's marginal cost estimate takes into account the true costs of developing new supply—the new infrastructure that would need to be built, the estimated life span of that infrastructure, the energy costs to pump the water, and the cost of acquiring water from an outside source and treating it. By basing implementation of its conservation programs—particularly its rate structure—on this complete measure of cost-effectiveness, MMWD can also justify and explain its conservation policies and rates to its customers.

Not all of the proposed conservation programs MMWD originally thought most promising turned out to be economically or otherwise feasible. A pre-pilot study performed on graywater use, for example, indicated that such a program would not be cost-effective for single-family units. The study found that the cost for an average homeowner to implement a graywater system would range between $1,500 and $2,000, and that the payback period would not be rapid enough to act as an incentive for most consumers (Waters 1998). Despite the cost, some MMWD customers are interested in graywater systems, but permit problems with the State Health Department have prevented their implementation (Waters 1998).

For other utility districts interested in implementing conservation-oriented integrated resource plans, James Fryer recommends focusing on demand management and developing programs to support it—and making sure staff believe in demand-side management. Although not every utility district is faced with the constraints MMWD was and continues to be confronted with, MMWD's experience shows that a successful integrated resource plan can and should be based on the link between demand management and supply. MMWD's experience also highlights the importance of establishing a mechanism for monitoring supply and demand and performing baseline research on water use and conservation in a district's service area. That research can bolster efforts to establish conservation programs by showing that many customers value—and even expect—their service providers to lead efforts to conserve water.

MMWD's ad hoc and formal monitoring committees are important components of the IRMP and critical in supporting and ensuring reasonable funding for conservation programs. These citizen-based committees countered MMWD's prior tendency to jump ahead with new supply projects by offering a more conservative approach—of cautiously phasing in new supply while creatively managing demand. As part of this new approach, MMWD, through the efforts of these committees, developed a number of innovative ways to manage demand and encourage conservation, such as giving price breaks to recycled water customers while recouping the cost of building the recycled water distribution system through its tiered rate structure. As Roger Waters puts it, MMWD's recycled water program is part of its "commitment to proving that water is an even more valuable recyclable resource than bottles, cans, and other commodities." Waters, and many others at MMWD, hope their IRMP will help them manage the demand for water and encourage its stewardship within their service area, which ultimately benefits the agency, its customers, and the environment. At the September 8, 1998 meeting of the monitoring committee, MMWD staff and board members agreed that, based on the success to date of its demand management program, the agency may even be able to defer implementing Phase 3 of the supply plan long enough to render it unnecessary. The general consensus, says James Fryer, is that the longer the agency can postpone new supply the better. The agency believes that if it can defer Phase 3 long enough, a whole new range of conservation options—such as changes in regulations that would make recycled water use more viable and improved efficiency technologies will become available, further helping the District avoid the costs of new supply.

Contacts

James Fryer, Water Conservation Coordinator, MMWD
Robert Castle, Water Quality Manager, MMWD
Roger Waters, Recycled Water Coordinator, MMWD

References

Castle, R. 1998. Marin Municipal Water District. Corte Madera, CA. Personal communications.

Fryer, J. 1998. Marin Municipal Water District. Corte Madera, CA. Personal communications.

Marin Municipal Water District Water Efficiency and Conservation Master Plan. 1994. Barakat & Chamberlin, Inc. June 29.

Pelletier, M. 1998. Marin Municipal Water District. Corte Madera, CA. Personal communications.

Theisen, R. 1998. Marin Municipal Water District. Corte Madera, CA. Written communications.

Urban Water Management Plan. 1995. Marin Municipal Water District. Corte Madera, CA.

Water Conservation Baseline Study Final Report. 1994. Marin Municipal Water District. Corte Madera, CA. The Demand Management Company, Oakland, CA, with Planning and Management Consultants, Ltd., Carbondale, IL. April 4.

Water Conservation Action Plan for 1997. Marin Municipal Water District, Water Conservation Section. Corte Madera, CA.

Water Use Monitoring and Evaluation Program/A Guide to Conducting Biennial Reviews. Undated. Marin Municipal Water District. Corte Madera, CA.

Waters, R. 1998. Marin Municipal Water District. Corte Madera, CA. Personal communications.

Promoting Conservation with Irvine Ranch Water District's Ascending Block Rate Structure

Arlene K. Wong

Introduction

Droughts can often create a rather perverse cycle for a water agency: the agency will request water conservation or even water rationing; customer response will be strong, often exceeding conservation requests; in response to the decreased water use, and therefore decreased revenue, the water agency will require a rate increase. The drought of 1987–1993 brought many water agencies face-to-face with this dilemma, as California customers became increasingly aware of the need to use water efficiently. To avoid the cycle of raising rates after asking customers to conserve, Irvine Ranch Water District (IRWD or District) replaced its flat rate-per-unit charge with an innovative ascending block rate structure in 1991. With the end of the drought, IRWD recognized that customers would need support, education, and monitoring to fully understand changes in the rate structure, to accept the ascending rate structure, and to appropriately respond to the conservation incentives. IRWD's rate structure represents an aggressive approach to promoting conservation, and has formed the foundation of a larger water conservation program that, linked with an existing water recycling program, has expanded to include landscape conservation and other conservation incentive and education programs covering all customer classes.

Background

Irvine Ranch Water District serves a 76,000-acre area (one-fifth the area of the county) located in southern central Orange County. The District serves the city of Irvine, the unincorporated areas of Foothill Ranch and Newport Coast, as well as portions of Tustin, Santa Ana, Newport Beach, Costa Mesa, Orange, and Portola Hills. The service area includes about 18,000 acres of developed land, 1,200 acres of agricultural land, and a population of about 150,000. In 1997 IRWD delivered 69,858 acre-feet of water, including over 14,600 acre-feet of reclaimed water. IRWD relies on groundwater (managed by the Orange County Water District) for about one-half of its supply and imports water from Metropolitan Water District (MWD) for the remainder. Groundwater supplies are constrained by basinwide efforts to properly manage the basin and prevent long-term overdraft. Thus, any increases in water demand that cannot be reduced through water-use efficiency improvements or conservation must primarily be met with increased imported water.

During the drought, IRWD was concerned about the possibility of asking customers to reduce water use and then having to raise rates to cover the revenue shortfalls from the reduced use. All agencies in the area were increasingly concerned that MWD rates would skyrocket because of the cost of procuring new supplies to meet demand. IRWD's board of directors wanted to "do the right thing" for customers and the District during a time of impending water restrictions and rising wholesale costs. Asking people to conserve while raising rates to offset a revenue decrease was not viewed as a positive option. With leadership and commitment from the board, staff were directed to develop a system that would meet the practical needs of the District, meet the political needs of maintaining fair and low rates for customers, keep District revenue stable, and build a water conservation ethic across customer groups. The board established several priorities for the new design. The rate structure design needed to:

- Reward conservation;
- Penalize water waste;
- Provide an equitable distribution of costs such that all customer types feel they are being treated fairly;
- Provide revenue stability; and
- Present a credible basis for a design based on science and historical use that will be defensible to the public.

The Program

Rate Structure Design

District staff took approximately six months to design the rate structure and another six months to gather the appropriate data to implement the structure. To address the issue of revenue stability, staff quickly agreed on the need to separate fixed and variable costs. Fixed costs were covered in part through a fixed monthly service charge. Water use would be charged as a separate commodity.

An ascending block rate structure for water use was determined to be an appropriate mechanism to provide incentives for water conservation and to penalize water waste. The rate structure adopted is based on five blocks of water use, each with an increasing charge for the volume of water used within that block. The break point between each block is based on a percentage of a base allocation provided each customer. The rate structure differentiates between three customer classes: residential; non-residential landscape and agriculture; and commercial, industrial, and public authority. As illustrated in Table 2-1, for residential customers, conservation is rewarded by offering a discounted rate applied to the first 40 percent of the base allocation used and the base rate for the remainder of the base allocation. Rates for water usage above 100 percent of the base allocation were set to send severe price signals for wasteful use, doubling in price for each ascending block, with a maximum charge of eight times the base rate for water use exceeding 200 percent of the base allocation. The structure is similar for non-residential landscape/agriculture and commercial, industrial, and public authority customers, but the percent of water use above the base allocation for triggering the penalty tier rates is stricter (Table 2-2), and the low-volume subsidy is available only to landscape irrigation customers.

A key part of the rate design was determining the base allocation for customers. IRWD developed criteria for determining the base allocation for each customer class based on use and demand factors as well as the variances that would be considered to adjust the allocation.

Residential

The base allocation for residential customers is based on number of household residents, landscape square footage, and actual daily weather and evapotranspiration (ET) data for the area. IRWD analyzed local zoning and tract maps and used the type of residential structure to develop the following assumptions about household size and landscaped area:

- Detached homes were assumed to have four persons per household and 1,200 square feet of landscape.
- Attached homes were assumed to have three

Table 2-1
Summary of Ascending Block Rate Structure for Residential Customers

Tier	Water Use (as Percent of Base Allocation)	Price per Unit Used in Each Tier
Low Volume Discount	0–40%	3/4 Base Rate
Conservation Base Rate	41–100%	Base Rate
Inefficient	101–150%	2x Base Rate
Excessive	151–200%	4x Base Rate
Wasteful	201 and above	8x Base Rate

Source: IRWD

Table 2-2
Summary of Ascending Block Rate Structure for Landscape/Agriculture and Commercial, Industrial, and Public Authority Customers

Tier	Water Use (as Percent of Base Allocation)	Price per Unit Used in Each Tier
Low Volume Discount *	0–40%	3/4 Base Rate
Conservation Base Rate	41–100%	Base Rate
Inefficient	101–110%	2x Base Rate
Excessive	111–120%	4x Base Rate
Wasteful	121 and above	8x Base Rate

** The low volume discount rate applies to non-residential landscape customers only. The other customers are charged at the conservation base rate for water use up to 100 percent of their base allocation.*

Source: IRWD

persons per household and 300 square feet of landscape.

- Apartments were assumed to have two persons per household, no landscape.

Customers receive a fixed allotment for indoor usage based on number of people in the household (75 gallons per person per day). The landscape allotment varies based on ET for cool season turf and landscape area. This reference ET is a measure of the volume of water per unit area that cool season grass consumes for its necessary physiological functions, such as transpiration of water through plant leaves and evaporation of water from surrounding soil. The calculation for the landscape allotment is:

Landscape allotment = [Landscape area (sq. feet)] x [ET(cool season turf grasses) x K_c(crop coefficient)] x [1/irrigation efficiency]

Landscape area was originally estimated by type of home designation. If a customer later called in to complain that his or her lot was bigger, he or she could submit a new square footage to apply for a larger allotment. For allotments, IRWD uses the ET for cool season turf grass, the highest water-using plant in the landscape. Crop coefficients (K_c) are used with ET to estimate specific crop evapotranspiration rates. Crop coefficients vary by crop, stage of growth of the crop, and cultural practices. Thus, for cool season turf grass, K_c can change from month to month as the turf goes through its growth cycle. Climate conditions and calculation of ET were provided by a state-operated CIMIS weather station in the service area (see *The Power of Good Information*, Chapter 16). In May 1997, IRWD established three of its own weather stations to more precisely measure the service area's microclimates. Irrigation efficiency is assumed to be 80 percent (i.e. 20 percent of the water applied is lost to runoff, overspray, or misting). Allotments were first based on historical, monthly ET data, but since billing periods range from 28 to 32 days and may cross months, IRWD later switched to daily weather measurements for calculating ET so that the allotments would more precisely match the customer billing periods.

Customers could apply for an increase in monthly allocation or an adjustment in their bills based on the following:

- Number of persons in a household;
- Larger landscape area;
- Medical reasons for increased water use (i.e. hydroponics equipment); and
- Other special reasons, such as an increase in the number of "non-permanent" people served in a household, such as households involved in daycare or homecare activities.

Landscape and Agricultural Irrigation

All non-residential landscapes in the district are metered separately. Similar to the base allotments for residential landscaping, non-residential landscape allotments are determined by the square footage of the metered area for each individual site, and the daily ET. The same assumptions of ET for cool season turf grass and irrigation efficiency of 80 percent apply. Allotments for agriculture are determined by crop type (each crop has a different crop coefficient to adjust the reference ET), acreage of crop, number of crop rotations, local ET, and irrigation efficiency (80 percent).

Commercial, Industrial, and Public Authority

Baselines for commercial, industrial, and public institutions are difficult to set because each customer can differ in terms of size and type of water use. Water use can also vary according to production cycles or business cycles. When establishing its rate structure in 1991, IRWD used the customer's 1989 water-use figure (a drought year) as a base allocation. Customers could request changes in their allotment based on changes in their business status, such as changes in number of employees or change in production volume.

IRWD is currently working on establishing baselines for industry sectors based on standards of wise use. While formulas for industrial production can be difficult, IRWD already regularly applies standards for sanitary use based on a customer's current equipment (i.e. 3.5 or 1.6 gallon toilets or whatever is on site). By setting such simple baselines, a customer will quickly be alerted to leaks or other changes in water use.

Implementation

In addition to designing the rate structure and gathering the necessary data to help implement it, IRWD also put in place new administrative practices, including reprogramming the computer system to accommodate a new database, and other staff training. Customer service staff received additional training so they could provide explanations of the new structure, help customers navigate through the variances, and help customers identify why they might be in a penalty block and what actions they could take to get themselves out of it. Customers were notified through billing inserts about the new structure. Since the District was in the midst of a severe drought, consumers were very amenable to a rate structure designed to reward conservation and penalize waste. Several public meetings were held during the rate design period, though they were lightly attended.

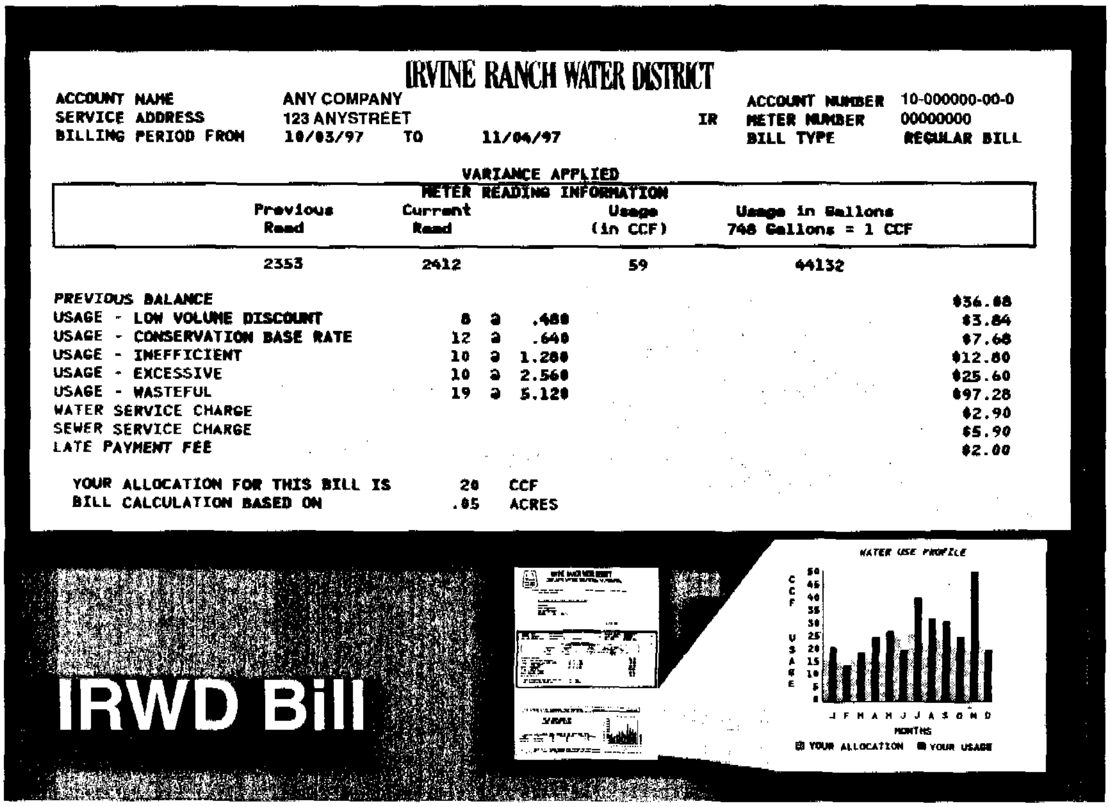
The new structure was rolled out incrementally in 1991. The rate structure was first introduced to non-residential landscape customers in February 1991. By June, all other customers were brought under the new structure. Within the first few months, customer service received over 6,000 calls. The first six months were largely spent responding to customer inquiries about the base allocation. All customers who qualified for variances in their base allocations were rebilled to accurately reflect the charges with their new allocation in place. To date, IRWD has issued about 15,000 variances for its residential customers (about 45,000 residential customers total). Residential variances most often are for changes in landscape area, followed by number of people in the household. Commercial and industrial customers have also been fairly active in seeking adjustments to their base allocations, with about 50 percent of customers (about 1,500) seeking adjustments up or down as business cycles dictate.

The new bills clearly indicated amounts billed at the different water rates: low volume discount, conservation base rate, inefficient, excessive, and wasteful (see Figure 2-1). They also included a monthly graphic profile showing the base allocation and actual usage.

With a baseline, or water budget, customers are quickly alerted when water use extends into one of the penalty blocks and can call the agency to identify the cause of the excessive usage. Often customers with sudden changes in water use are alerted to slow growing leaks that otherwise went unnoticed under the old rate structure. Customers who fix such equipment failures are rebated the difference between the penalty rate and the base rate once the correction is made.

The new rate structure also allows IRWD to easily identify which customers are regularly in the penalty blocks as well as when such events regularly occur. It became clear that landscape customers were most often in the largest penalty use group, and that water use did not ade-

Figure 2-1
Sample IRWD Bill



IRVINE RANCH WATER DISTRICT

ACCOUNT NAME ANY COMPANY
SERVICE ADDRESS 123 ANYSTREET
BILLING PERIOD FROM 10/03/97 TO 11/04/97

IR
ACCOUNT NUMBER 10-000000-00-0
METER NUMBER 00000000
BILL TYPE REGULAR BILL

VARIANCE APPLIED

METER READING INFORMATION

Previous Read	Current Read	Usage (in CCF)	Usage in Gallons 748 Gallons = 1 CCF
2353	2412	59	44132

PREVIOUS BALANCE		$36.08
USAGE - LOW VOLUME DISCOUNT	8 @ .480	$3.84
USAGE - CONSERVATION BASE RATE	12 @ .640	$7.68
USAGE - INEFFICIENT	10 @ 1.280	$12.80
USAGE - EXCESSIVE	10 @ 2.560	$25.60
USAGE - WASTEFUL	19 @ 5.120	$97.28
WATER SERVICE CHARGE		$2.90
SEWER SERVICE CHARGE		$5.90
LATE PAYMENT FEE		$2.00

YOUR ALLOCATION FOR THIS BILL IS 20 CCF
BILL CALCULATION BASED ON .05 ACRES

Source: *IRWD*

quately respond to changes in weather (ET). This alerted the District to the need to develop programs to target the landscape customer, and special efforts were made to develop efficiency tools for landscape professionals, and education and outreach programs.

The rate structure has raised customer awareness of water use, and IRWD has responded to customer needs by designing programs to help customers use water efficiently and prevent penalty payments. The rate structure is thus the foundation of the District's conservation program and is regarded as a long-term water management tool.

Evaluation of Success

Customer Acceptance and Equity

Certainly customers who pay penalty rates for high water bills are not happy, and they do get angry. However, IRWD has found that its rate structure is very defensible. All customer groups have the same rate structure. The base allocations are determined through sound measurements of expected use, and every effort is made to allow a customer to remain within the base allocation. IRWD has the capacity to develop an individualized base allocation for every customer, and the variances allow for customers to adjust their allocations based on their situations.

The conservation program is geared to respond to a customer's desire to remain within his or her base allocation and efficient use, keeping customer water bills as low as possible. The rate structure and its signals have, in fact, increased interactions between the agency and its customers, fostering positive working relationships. IRWD's conservation program for residential customers includes targeted home water audits and landscape site analysis, free low-flow devices for indoor plumbing (faucet aerators, etc.), and low-flow toilet rebates. To assist landscape customers, IRWD has held numerous workshops and seminars for landscape professionals, offered landscape equipment rebates and zero interest loans, given free software for irrigation scheduling and meter reading, staffed an ET hotline, and provided soil probes to measure soil moisture. (See *Reducing Water Use in Residential, Industrial, and Municipal Landscapes,* Chapter 4, for more information). For commercial and industrial customers, IRWD provides workshops and audits, and participates in MWD-sponsored rebate programs to assist with purchase of water-efficient equipment.

Revenue Requirements

By separating its fixed and variable costs, IRWD was able to maintain a stable revenue base through its fixed monthly service charge,[1] leaving the ascending block rate structure to promote water conservation without resulting in insufficient revenue. Commodity charges for water rates have remained unchanged since 1993.[2] Excess or penalty revenues brought in over the cost to deliver water are not needed for daily operations. Instead, they are allocated to the Conservation Fund. This money is used to:

- Subsidize the low volume tier, rewarding efficient water use;
- Fund conversion of potable water systems for landscape irrigation or industrial processes to recycled water;
- Fund district-wide outreach and conservation programs, including rebates, loan programs, and home and business audits; and
- Cover software and staff time for development and implementation of ascending block rate structure.

Conservation Results

It is often difficult to separate the impacts of the water rate structure from other conservation program activities or external factors (i.e. weather, economy, etc.). Thus, while not all the savings can be attributed solely to the change in rate structure, it is worthwhile to examine the change in water use since the rate structure has been instituted.

The landscape customer group saw an initial 13.5 percent decrease in water applied (4.4 acre-feet/acre/year to 3.8 acre-feet/acre/year) from the pre-program level, with consistent improvement each year. Because climate is an important factor in determining landscape water use, it is perhaps more valuable to compare water consumption to the average ET for that year. Each year with the programs in place shows substantial improvements in water use compared with ET, with 1997 water use at 56 percent of ET and 1998 projected to be 55 percent of ET. Since the average ET is that for high water-using turf grasses, the lower consumption in part reflects the fact that most landscapes are not 100 percent turf, and therefore sufficient water use should be lower than the ET for turf. IRWD attributes much of the savings in the first five years of the program primarily to improved irrigation practices (better scheduling, less overwatering, etc.) and not changes in types of landscaping (Ash 1998). Ash notes, however, that new developments in the area since 1996 have decreased turf acreage in favor of landscapes using water-efficient plants.

The residential water use customer group showed a 19 percent water use reduction from the pre-program baseline for the first two years following implementation of the rate structure. Both were drought years. Water use increased after the drought, but remained below pre-program levels. This efficiency level has held for approximately four years. Overall, average water savings for the past six years has been 12 percent below 1990–1991 levels.

Conclusions/Lessons Learned

The IRWD rate structure was created to address drought, increasing wholesale costs, and fair customer water costs, and to develop a long-term water conservation ethic in the District. It has succeeded in doing so. By send-

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[1] District costs are also supported by fees and property taxes.

[2] Historically, water rates had increased each year, though maybe only by a fraction of a percent (Ash 1998).

Table 2-3

Change in Non-Residential Landscape Water Use

Year	Acres	Total AF Sold	Average ET (AF/acre)	Actual Average Use (AF/acre)	Percent of Average ET	Programs in Place
1990	3,034	13,338	4.1	4.4	107%	Pre-program baseline
1991	3,265	12,439	4.0	3.8	95%	Rates
1992	3,486	12,211	4.2	3.5	83%	Rates
1993	3,778	12,424	4.1	3.3	80%	Rates, education, rebates
1994	4,567	14,629	3.9	3.2	82%	Rates, probes, software, rebates, education
1995	5,928	14,239	4.2	2.4	57%	Rates, probes, software, rebates, education
1996	6,322	15,402	4.3	2.4	57%	Rates, probes, software, rebates, education
1997	6,685	16,598	4.4	2.5	56%	Rates, probes, software, rebates, education
1998*	7,000+	15,900	4.0	2.2	55%	Rates, probes, software, rebates, education

Total Acre-feet Saved:	59,000
Total Avoided Costs:	$16.2 million
Total Program Costs:	$3.8 million
Net Benefit:	$12.4 million

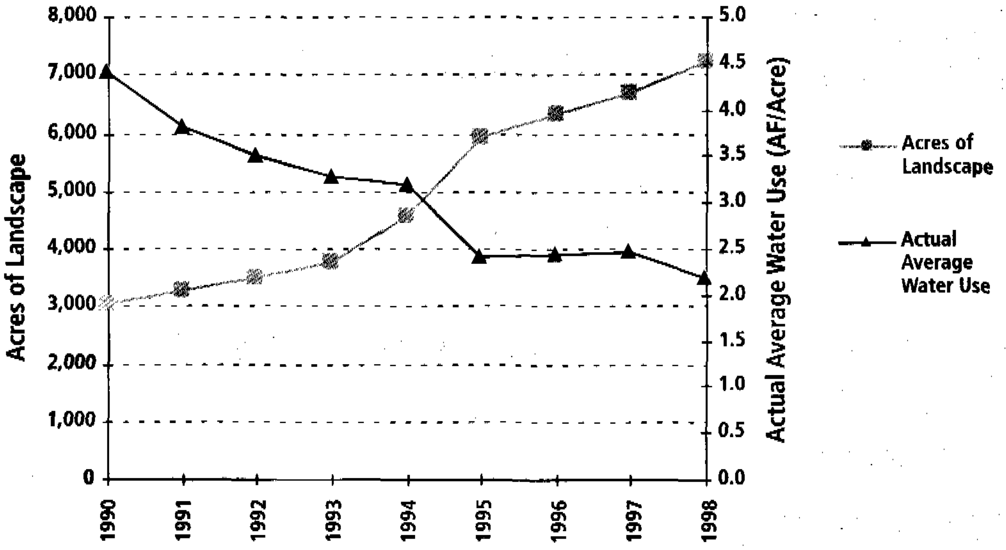
1998 projected water use per acre based on six-month customer group data.

Avoided costs are the cost of imported water not purchased based on expected pre-program use (i.e. the difference from 4.4 acre-feet/acre.)

Source: Ash 1998a

Figure 2-2

Comparison of Acres of Landscape and Water Use, 1990–1998



1998 projected water use per acre based on six-month customer group data.

Source: Ash 1998a

Table 2-4
Change in Residential Water Use

Year	Average Use per Account (household) in Acre-Feet	Savings from Baseline	Programs in Place
1990–91	.32 (drought)	—	Pre-program baseline
1991–92	.26 (drought)	19%	Rates, education
1992–93	.26 (drought)	19%	Rates, education
1993–94	.27	12%	Rates, education
1994–95	.27	12%	Rates, education
1995–96	.27	12%	Rates, education
1996–97	.30	6%	Rates, education
1997–98	.28	12%	Rates, probes, targeted audits, education

Average Savings: 13 percent
Acre-Feet Saved: 14,261
Total Avoided Costs: $5.5 million
Total Program Costs: $0.5 million
Net Benefit: $5 million

Source: Ash 1998a

ing the appropriate signals to penalize excessive use, IRWD was able to build a firm foundation for its other conservation programs.

Five key elements of the rate structure worked to ensure its success: adequate customer information and analysis; structure design; equity and customer acceptance; revenue stability; and coordination with other conservation programs. In developing its rate structure, IRWD embarked on substantial analysis and evaluation of customer uses and customer group demand factors. The District developed a database and billing system that could track, update, and maintain the relevant information.

The design of the rate structure made use of the customer information gathered to develop reasonable baseline allocations. Interaction between the customer and the agency was thus embedded in the design. The rate structure itself builds customer awareness, sets targets, and provides incentives for customers to use water efficiently. It provides customers with a water budget, allowing them to gauge performance in relation to their base allocations. The penalty rates send clear price signals about excessive use.

Flexibility was built into the system through the establishment of variances and the ability to adjust individual allocations. Customer-friendly rebates were provided to customers who took action to correct excessive use or those who received new allocations. The separation of fixed and variable costs was particularly important in allowing IRWD to establish a rate structure that would not have a negative impact on the District's fixed costs while promoting conservation—a key to revenue stability. Penalty charges are simply fed back into the conservation programs.

With respect to equity considerations, each customer has essentially the same rate structure. However, the ability to tailor base allocations to customer situations based on demand factors relieves many of the equity or fairness problems other rate programs have faced. The rate structure relies on science and historical water use to determine base allocations. These objective data provide the agency with a defensible standard for all customers.

Finally, the rate structure was accompanied by sound conservation programs that were, in fact, informed by the rate structure. The information gathered on customer use helps the District identify patterns of excessive use, problem areas, and seasonal targets to guide design and implementation of conservation programs. Ultimately, the rate structure proved itself to be an important tool in building a relationship between the agency and the customer to further support the district's education and outreach programs.

Contacts

Tom Ash, formerly at Irvine Ranch Water District. Now with CTSI Corporation.

Marilyn Smith, Community Relations, Irvine Ranch Water District.

References

Ash, T. 1998. Irvine Ranch Water District. Irvine, CA. Personal communications.

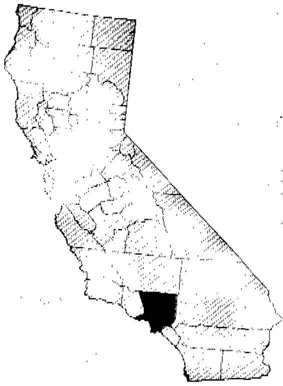
Ash, T. 1998a. Unpublished materials for Water Conservation Analysis for Program Efficiency report. April 1997. Updated June 1998. Irvine Ranch Water District. Irvine, CA.

Hunt, T. 1998. Irvine Ranch Water District. Irvine, CA. Personal communications.

Irvine Ranch Water District. Materials available on website. *www.irwd.com*

Effective Public Participation in the Rate Setting Process: LADWP Blue Ribbon Committee on Rates

Arlene K. Wong



Introduction

Historically in California the public has not been involved in major water policy and planning decisions, decisions intrinsic to the state's growth trends. With the exception of ballot measures such as the State Water Project and the Peripheral Canal, decisions on water policy have largely been made by government agencies, water utilities, and agricultural districts, primarily composed of engineers. The environmental community in recent years has been very active in water planning discussions, particularly with the advent of the California Urban Water Conservation Council and the CALFED consensus process to fix the Bay–Delta estuary.

However, despite progress over the past 10 years in bringing the urban, agricultural, and environmental stakeholders together, water policy debates continue largely outside the public consciousness, and water issues are defined by a small number of stakeholders before being brought to the public's attention. Even when public participation is permitted, it is often limited to a public hearing process (held after major decisions have been made) or a public election where input is reduced to simple approval or rejection of a proposal.

Without broader public participation, water policy and management fails to recognize the many needs of California's increasingly diverse society, particularly low-income communities and communities of color that have historically been poorly represented. As California's water problems continue to be debated, and as the demographics of the state continue to change, social, economic, and environmental conflicts over water may intensify. Second, the narrow framing of California water problems precludes more innovative solutions that would better balance the state's social, economic, and environmental needs. And third, lack of public understanding of and interest in water policy issues limits public responsiveness and willingness to resolve the critical problems we face.

Many people and organizations involved in water policy or planning are beginning to acknowledge this problem. A wide variety of recent activities have tried to broaden public participation in water policy decisions and to include members of the public in discussions of water problems. Los Angeles's Blue Ribbon Committee on Water Rates offers one example of a process that successfully involved citizens in the policy process. The water rate structure is commonly thought of as serving an agency's revenue function, but it also has implications for equity (who pays and how much) and water conservation (sending signals regarding water use and reflecting the true cost of delivering water). Despite the rather technical nature of designing a water rate structure, the Los Angeles Department of Water and Power saw fit to form a citizens' committee to lead the process.

Background

In the spring of 1990, the Los Angeles Department of Water and Power (DWP) imposed mandatory water conservation throughout the city of Los Angeles. DWP required a 15 percent cutback, and like consumers in many California water districts during the drought, city residents exceeded the request and reduced water use by 30 percent (Reifsnider 1993). Water sales, and thus DWP revenues, fell far below projections, and DWP was compelled to request a revenue increase of 11 percent, later reduced to 3 percent. Not surprisingly, customers were angry that they were being charged more for using less water.

The city council approved the rate hike but attached a proviso requiring DWP to develop a new rate structure within a year that encouraged water conservation and would not penalize consumers who conserved.

The Project

In the summer of 1991 Mayor Tom Bradley appointed the Blue Ribbon Committee on Water Rates in response to the city council's proviso. The last time the Los Angeles Department of Water and Power had revised its water rate structure was in 1977 after a severe two-year drought prompted the mayor to appoint a similar blue ribbon committee (*A Consensus Approach to Water Rates* 1992). During the 1977 rate restructuring, DWP switched from a declining block structure to a uniform rate structure. Then, as in this case, DWP requested an independent blue ribbon committee to investigate and propose a new structure. It was strongly believed that such a process offered a more productive way of gaining public acceptance and appreciation for the changes needed.

The new Blue Ribbon Committee (the committee) was charged to:

- Learn about rate design, demand (factors that affect the amount of water used), and supply;
- Decide on principles to guide rate design for the next decade; and
- Assist in the initial implementation of a new rate structure.

One of the first acts of the committee was to establish a mission and strategy statement, set forth in the sidebar. The committee was composed of 24 members—12 citizen members with "voting" privileges, selected by the mayor's office, and 12 non-voting members from DWP staff, the mayor's office, and the city council. In selecting the citizen members, the mayor's office first identified the various stakeholders impacted by the rate structure that would be representative of interests throughout the city. These included homeowners, renters, landlords, the business community, the academic community, organized labor, developers, environmentalists, ethnic groups, and neighborhoods. Representatives for these interests were then identified by staff and asked to join the committee. Members served *pro bono*, volunteering their time, energy, and experience for the year-long process. The final report was prepared by the committee members and offered first to DWP's board of commissioners and then to the mayor and city council for final approval.

To further explore the water quality, cost, supply, and demand conditions facing Los Angeles, the committee organized into several subcommittees: Finance, Economic Growth and Development, Conservation and Water Recycling, Equity, and Public Participation. The Public Participation Subcommittee held hearings throughout the city to obtain input from the public. These subcommittees reported their findings to the larger group for consideration. The full committee voted on all major decisions. Decisions were mostly reached by consensus, with the committee attempting to identify and resolve conflicts before reaching final decisions by vote. The final report was approved by consensus of all members.

Blue Ribbon Committee Mission and Strategy Statement

Committee Mission Statement

The Mayor's Blue Ribbon Committee on Water Rates exists to formulate an equitable strategy for the next decade to link water rate structure with water conservation, water supply, water quality, and environmental quality, so the Department of Water and Power can assure the citizens of Los Angeles that it will be able to continue serving their needs in a fashion that is cost-effective, environmentally sensitive, and fair to all customers.

Strategy Statement

In pursuit of this objective, the committee shall investigate and determine the effects of such factors as Los Angeles's short- and long-term supply; required water quality improvements; the Metropolitan Water District's supply, programs, and anticipated rates; the social and economic implications of water rates; and the cost and effectiveness of the City's water conservation and water recycling program. The above factors will be considered in investigating and recommending a water rate structure, but will not be topics for recommendations by this committee, except insofar as they directly affect water rate design or are in turn affected by water rates.

Source: A Consensus Approach to Water Rates 1992

Committee Approach and Activities

After adopting the mission and strategy statement, the committee selected a consultant to assist them in their examination of rate design and the rate setting process. Significantly, while the committee relied on DWP for information and expertise, they selected their own consultant to facilitate the process. The consultant reported to the committee, not DWP, and largely provided technical assistance at the committee's direction. Another important facilitator was a representative from the mayor's office. She served as a liaison between the committee, mayor, and city council. Importantly, she helped to clarify the committee's mission, set deadlines, and provide the authority and support of the mayor's office. It was vital for the committee to establish its independence, and that DWP participate as an equal, and not dominant, member of the committee.

Another important step was the establishment of rate-setting objectives to guide the process (see sidebar). As was the case throughout the rate-setting process, the objectives reflected the interests of different stakeholders as well as public feedback gathered at early public hearings. As such, they embodied the diverse and sometimes conflicting directions the committee members pursued. Members wrestled with proposed objectives, defined them, and consistently used them to guide decision making (Reifsnider 1993).

An education process on water rates and statewide water supply issues was imperative for the committee. The committee heard presentations by representatives of other cities with different types of rate structures and rate design philosophies. They learned the extent to which varying approaches to rate design helped or hindered Seattle, Phoenix, and Denver in pursuing conservation and equity objectives. In addition, the committee had discussions with officials from DWP, Metropolitan Water District, the California Department of Water Resources, the California State Water Resources Control Board, and the U.S. Bureau of Reclamation to learn about supply and water reliability issues. Reviewing population statistics and long-term supply data, committee members concluded that future population growth and water supply limitations necessitated increasing efficient water use by every consumer.

Coupled with the year-long time commitment, this education process allowed the committee members to become familiar with rate design, to listen to the concerns of the public at lengthy hearings, and to develop strong working relationships with each other and the credibility and expertise to represent the committee's ideas. The committee held over 75 meetings, some lasting all day, others lasting into the evening. Through such exchanges, they came to speak a common language and appreciate each other's viewpoints.

Exploring several alternative rate design philosophies, the committee determined that a marginal cost-based rate design best served the needs of the city by linking the cost of water to the cost of finding additional supplies. A Technical Advisory Panel was established to provide guidance to the consultant on how to explore a marginal cost-based approach to water rates. Also, the rate design would remain revenue neutral, based on the revenue requirements for budget year 1992–1993 contained in DWP's five-year budget. Rates would be built on the assumption that $422 million would be raised by water rates through the sale of approximately 240 million billing units[1] or approximately 550,800 acre-feet.

Rate Setting Objectives

Water should be affordable.

Rates should maximize the efficient allocation of resources.

Rates should be forward looking.

Rates should be simple and understandable.

Rates must generate adequate revenue.

Rates should not include the full cost of growth.

Rates should be equitable across customer classes.

Rates should not penalize customers for reducing consumption.

Rates should not discourage potential employers.

The public should understand the rate setting process.

Source: Mayor's Blue Ribbon Committee on Water Rates 1992

Problems with the Old Structure

The uniform rate structure in place when the committee was convened was one commonly used by many water utilities. Customers were charged a fixed amount depending on customer class[2] and meter size in the form of a minimum monthly charge and meter service charge. These fixed charges helped the utility generate stable revenues and capture fixed costs, and accounted for approximately 15 percent of total revenues from base rates (West 1997). Actual usage was charged at a uniform summer or winter rate per billing unit.[3] The winter and summer differential reflected, in part, the higher cost of providing additional capacity for the higher summer demand.[4] In addition, the bills contained automatic rate adjustments such as the Water and Energy Cost Adjustment and Low-Income Subsidy Adjustment to cover other utility costs.

The committee identified a number of problems with the old rate structure. First, the old rate structure spread the cost of developing new supplies over all customers within both the fixed and per unit charges. As a result, the marginal cost of developing new supplies was hidden, making it difficult for customers to understand the impact of their actions on their own water bill and utility costs. Second, when there is a water shortage and widespread conservation, rates go up because the number of units sold decreases, forcing the cost per unit sold to increase to cover fixed costs unrelated to the volume of water sold. This problem is accentuated by the need to buy more expensive water from Metropolitan Water District to supplement DWP sources; i.e. during drought years, the marginal cost of water is higher.

A third problem with the old rate system was that subsidized classes (low-income and lifeline) were restricted to single-family homes, while more and more residents eligible for such assistance resided in multi-family dwellings. The committee also felt that the existing low-income subsidy was unjustifiably low.

First Rate Structure: Summary of Changes

The committee proposed replacing the system of fixed and per unit charges with a two-tiered marginal rate structure (Figure 3-1). All fixed charges for residential and non-residential users would be eliminated so that bills would more directly relate to water usage. The second tier rate was set equal to the marginal cost of obtaining and delivering the next (marginal) unit of water for the city.[5] Seasonal differences in applying this rate reflected the greater infrastructure capacity required to meet the higher demand during the summer months as well as the seasonal storage costs.[6] The break point between the two tiers was set so as to provide first tier users with a reasonable quantity of water at the lower rate.[7] Usage beyond the break point is charged at the higher second tier rate. The first tier rate was set to meet DWP's revenue requirements and remain revenue neutral compared with the old rate structure. In fact, the first tier rate was determined to be lower than the old water rate, resulting in savings for most customers (see Table 3-1). The rate structure also provided for different second tier rate charges, and different break points for water-short years depending on the severity of the shortage.

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[1] A billing unit is 100 cubic feet or 748 gallons.

[2] Customer classes were divided into Residential and Non-Residential. The Residential class included Single-Dwelling users and Multi-Dwelling users. The Non-Residential classes included Commercial, Industrial, and Government (CIG) users, Schedule "M" customers who were publicly-owned large turf areas, and Other, such as Fire Service.

[3] Summer months referred to April through May; winter months referred to October through March. These seasons were redefined with the 1993 rate restructure.

[4] This is a modest form of marginal cost pricing, referred to as seasonal or peak pricing.

[5] The marginal cost of new water was calculated based on DWP's current supply plan, which calls for Los Angeles to meet its additional water needs for the next 20 years entirely through conservation and water recycling. Marginal cost for the high block rate was calculated as the cost of constructing recycled water facilities.

[6] The higher marginal cost rate for the summer included the capital costs for the transmission, treatment, distribution, and reservoirs required to meet peak demands, as well as the difference between Metropolitan Water District's summer and winter water prices, which approximated the cost for seasonal storage.

Table 3-1

Comparison of the Old and 1992 Proposed Rate Structure

	Old		Proposed	
	Summer[a]	Winter[b]	Summer	Winter
	prices are per billing unit[c]			
RESIDENTIAL				
Single-Family	*71% will see a reduction in their water bill*			
First 21 billing units/mo.	$1.76	$1.55	$1.71	$1.71
Additional Water	$1.76	$1.55	$2.92	$2.27
Meter Charge/mo.[d]	$2.72	$2.72	None	None
Minimum Charge	$6.00	$6.00	None	None
Median User Annual Bill	*$310.68*		*$287.28*	
Multi-Family	*63% will see a reduction in their water bill*			
Average Winter Amt	$1.76	$1.55	$1.71	$1.71
Next 25%	$1.76	$1.55	$1.71	$1.71
Additional Units	$1.76	$1.55	$2.92	$1.71
Meter Charge/mo.[d]	$9.53	$9.53	None	None
Minimum Charge	$6.00	$6.00	None	None
Median User Annual Bill (on a per dwelling unit basis)	*$144.42*		*$143.64*	
NON-RESIDENTIAL				
Commercial, Industrial, and Governmental	*65% will see a reduction in their water bill*			
Average Winter Amt	$1.76	$1.55	$1.78	$1.78
Next 25%	$1.76	$1.55	$1.78	$1.78
Additional Units	$1.76	$1.55	$2.92	$1.78
Meter Charge/mo.[d]	$15.00	$15.00	None	None
Minimum Charge	$6.00	$6.00	None	None
Median User Annual Bill	*$370*		*$300*	
Schedule M (Open space, parks, irrigation)				
1990–91 usage level	$0.58	$0.45	$0.62	$0.62
Additional usage	$0.58	$0.45	$2.92	$2.27
Meter Charge/mo.[d]	$15.00	$15.00	None	None
Median User Annual Bill	*set to create no change on average*			

[a] Summer months are considered June 1 through October 31.

[b] Winter months are considered November 1 through May 31.

[c] A billing unit is 100 cubic feet or 748 gallons. Thus, 21 billing units/mo. is about 525 gallons per day.

[d] This is the average or typical charge for this class. Actual charges vary based on meter size.

Source: Mayor's Blue Ribbon Committee on Water Rates 1992

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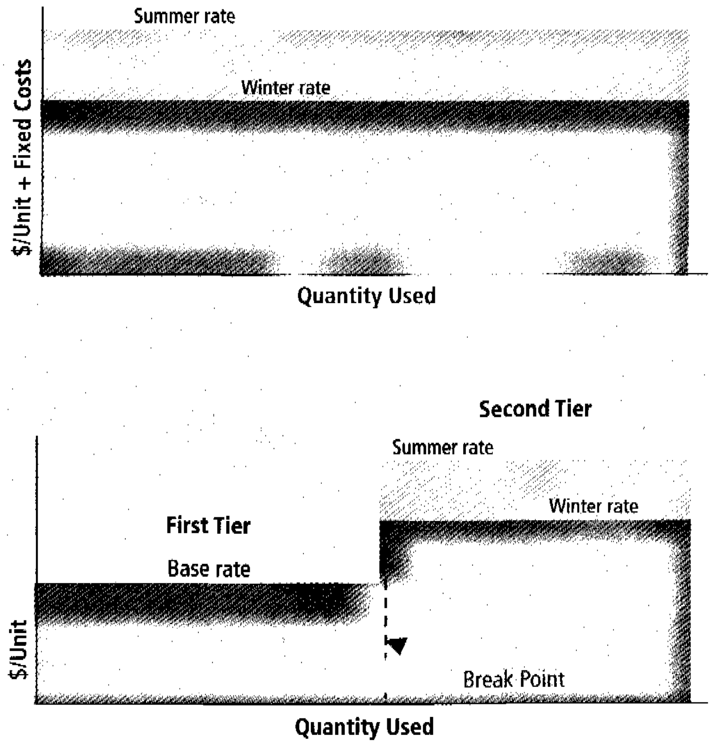
[7] In determining a "reasonable" amount, committee members debated whether break points should be determined by water requirements developed by the state of California, or actual city customer usage data. The committee adopted the latter as the baseline.

Figure 3-1

Representation of Uniform Rate vs. Tiered Rate



For single-family customers, the committee recommended that the break point between the first tier and second tier be set at 175 percent of the median use for single-family customers across the city. Thus, households using under 21 billing units of water (approximately 525 gallons per day) per month would pay the first tier rate. Any usage above that point is charged the second tier rate. The second tier would be seasonal, reflecting a higher rate in the summer months.

Most multi-dwelling structures do not have separate water meters for each unit; therefore tenants do not receive individual water bills. Further, multi-family dwellings vary in number of units and vacancy rates. Thus, assigning a single median break point was deemed inappropriate. The committee based the low block on the amount of water used during the winter season for each building, assuming winter use best approximated indoor uses. During the winter, multi-family customers are charged at the first tier rate, and during the summer, multi-family customers may use up to 125 percent of their previous winter's average at the first tier rate. Summer usage beyond the break point would be charged at the higher rate.

Rates for the commercial, industrial, and governmental customers were designed with similar characteristics. Again, it was deemed inappropriate to set a break point based on an overall median figure since water use varies so widely by the size of buildings, type of activity, and business and production cycles throughout the year. During the winter season, commercial, industrial, and governmental customers are charged at the first tier rate. During the summer season, the break point is set at 125 percent of their prior winter's average monthly usage.

Schedule M customers are publicly-owned large turf areas. The city set rates below cost to encourage the use of water for green belts and parks. The committee supported continuing the subsidy, but added a second tier rate to encourage efficiency as well. The first tier rate continues the past level of subsidy and is based on 1991–1992 actual use (a drought year). The second tier rate reflects marginal costs.

In addition, the committee recommended changes for both the low-income and lifeline customers. Under the old structure, a low-income subsidy program is available to single-family customers who meet income requirements based on federal poverty guidelines. The program allowed qualifying members to purchase water at a discount. To fully receive the benefit, the customer would need to use at least nine billing units, offering a maximum subsidy of $2 per month. The committee recommended increasing the subsidy to a flat monthly $5 credit for single-family customers with up to three household members, with a benefit increase of $1 for each additional household member, up to a maximum credit of $10 per month. The flat credit would fulfill the equity concern without creating an incentive to use more water. The subsidy would also be made available to qualifying customers in multi-family dwellings by offering the credit through the electric bill. Almost all apartments are separately metered for electric power.

Lifeline rates are offered to single-family customers who are 62 years of age or older, and/or disabled, and who have an adjusted gross household income below a specified level. Lifeline rate customers benefit from substantially lower water rate and fixed charges, as well as exemptions from adjustments factors. The committee recommended simplifying the subsidy by offering a flat $10 credit.

Under the old structure, in water-short years when customers actively conserve, less water is sold and DWP collects less revenue. The recommended structure attempted to ensure that DWP can maintain revenues to cover fixed costs despite reduced sales, without having to raise all rates and penalize customers who conserve. In shortage years, second tier rates would increase and break points would be adjusted downward depending on the severity of the shortage (see Table 3-2). First tier rates would remain the same. The committee did recognize the necessity of including a revenue adjustment billing factor that would allow DWP to adjust the first tier rate upwards if water sales resulted in revenue shortfalls.

The structure offered three main features. The first tier rate remained the same as normal years, so those who conserve should not experience higher bills. Second, the break point is lowered with the severity of the shortage, providing a greater signal to conserve. Third, the second tier rate is increased with the severity of the shortage, signaling the need to conserve as well as reflecting the cost of procuring the additional water. Finally, the steeper second tier rate structure allows DWP to maintain revenues to cover fixed costs despite the reduced sales.

Public Participation

Public participation was a vital component of the committee process and took place at two levels. First, each committee member very seriously attempted to represent the interests of his/her various constituencies. Members regularly spoke to their own membership or constituencies to exchange information about the issues raised at committee meetings. Secondly, public meetings were held at two different points in the process, and again when the rate structure went before the board of commissioners and the city council.

The first round of public meetings was held very early in the rate setting process, well before the committee began making decisions on possible rate structures. Six scoping meetings were held throughout the city (the Harbor area, East-side, West-side, South, Central/ Downtown, and the San Fernando Valley).

Table 3-2
Proposed Rate Structure for Water-Short Years

RESIDENTIAL				NON-RESIDENTIAL			
	First Tier Rate	Break Point (billing units)	Second Tier Rate		First Tier Rate	Break Point	Second Tier Rate
Single-Family				**Commercial, Industrial, Government**			
10% Shortage	1.71	19	$3.70	10% Shortage	1.78	115%**	$3.70
15% Shortage		18	$4.44	15% Shortage		115%**	$4.44
20% Shortage		17	$5.18	20% Shortage		110%**	$5.18
25% Shortage		16	$6.05	25% Shortage		110%**	$6.05
Break point=175% of Median Level usage							
Multi-Family				**Schedule "M"**			
10% Shortage	1.71	115%**	$3.70	10% Shortage	1.62	100% of 1990-91 Adjusted Usage	$3.70
15% Shortage		115%**	$4.44	15% Shortage			$4.44
20% Shortage		110%**	$5.18	20% Shortage			$5.18
25% Shortage		110%**	$6.05	25% Shortage			$6.05

*** % of Adjusted Prior Year Winter Average*

Source: Mayor's Blue Ribbon Committee on Water Rates Final Report 1992

Residents speak out at a public meeting. (Photo courtesy of DWP)

While these meetings were only lightly attended (between 10 and 20 people for most), they proved valuable for committee members to hear public sentiments about what they valued in a water rate structure and from DWP. Public participants were very clear about wanting a rate structure that was fair and that eliminated the cycle of rate increases, particularly when customers were asked to conserve. Another clear message was that the public wanted bills that made sense and that simply communicated what the costs were. Across the city, participants indicated that they cared about water conservation. The committee constantly referred back to these public concerns in defining their objectives and later the rate structure.

The second round of public meetings was held in the spring of 1992, after the committee had drafted its rate structure recommendations. These meetings were better attended (20–30 people on average) as water issues and rates had garnered increased public attention with the continuing drought. These meetings were valuable in gauging public concerns regarding water and reactions to the rate structure. Throughout the rate setting process, it was clear to committee members that the greatest challenge with respect to public acceptance would be convincing those who would see a rate increase as a result of the restructuring—the higher volume water users. Water quality had also become a growing issue in Los Angeles at this time, with local media reporting on brown tap water in certain parts of the city. At the public meeting in South Central, residents were very vocal about their concerns about the water quality in their neighborhood.

Implementation and Public Response

The committee submitted their recommendations to DWP's board of commissioners who adopted all recommendations. Again, public hearings associated with the board's review were well attended. In fact, the San Fernando Valley meeting was attended by some 200 people and lasted well into the night, reflecting the opposition from that specific constituency. Largely as a gesture to the higher volume users, an adjustment was made to change the single-family break point from 175 percent of median use to 200 percent of median use. The structure also acknowledged modest increases in seasonal uses by setting a higher break point for summer months (break point for residential users was set at 22 billing units for winter months and increased to 28 billing units for summer months). This rate structure was then approved by the mayor and city council.

The rate structure went into effect in February of 1993. The full impact of the new structure was not felt by customers until the following summer, when water usage increased, and water bills for high users significantly increased. The majority of residential customers saw lower bills under the new rate system—about 70 percent saw a decrease. However, those customers who used a lot of water experienced a cost differential of about $1.20 per billing unit. Those customers using 100,000 gallons per month (about 10 times the city-wide median usage) would have a summer bill of $361 per month as compared to $270 per summer month under the old system. While such large users were small in number, they were quite vocal.

City offices received a significant amount of correspondence complaining about the 1993 rate structure. Media and other comments were construed by many in the San Fernando Valley as implying that the new structure was designed to make valley residents pay more for water than other customers. Vocal customers complained that the rates were inequitable to large lot owners and those living in warmer climates.

The new mayor, Richard Riordan, decided to reconvene the citizen's committee to review the impact of the new rate structure and decide if the structure was appropriate. The mayor asked back all the members of the old committee and appointed three additional representatives from the San Fernando Valley to provide more balanced geographical representation, bringing the total number of valley residents on the committee to five.

Second Rate Structure: Summary of Changes

The committee reviewed the concerns of customers and held additional public hearings. They decided that the two-tiered structure and marginal cost-based rates remained appropriate. However, they did conclude that the 1993 structure for single-family rates made it unreasonably difficult for some people who used water responsibly to stay in the low block and that others could use water in irresponsible ways and still pay the lower rate. Thus, they decided that rather than selecting a single median usage as a break point for all residential customers, it was valid to consider various factors that affected use and compare customers in similar circumstances.

The committee concluded that lot size, climate (temperature), and household size were factors impacting water use that should be reflected in the rate structure. They created four categories of lot size and three temperature categories[8] allowing for 12 groupings of customers who shared more similar characteristics. Separate break points could then be determined for the various lot size and temperature combinations. The committee opted to set the winter and summer break points at 125 percent of each group's median usage based on past usage. An additional adjustment to increase the lower block usage would be made based on household size.

The rate structure that DWP adopted reflected the committee's recommendations with the addition of a fifth lot size category. Table 3-3 summarizes the rate structure adopted by DWP effective June 1995. The new structure takes into account the major differences in customer characteristics, instead of lumping everyone together. It makes it easier for customers with large households, large lots, and/or who are living in hotter climates to stay within the lower rate base if they use water reasonably.[9]

Policy and Planning Recommendations

The Blue Ribbon Committee recommendations went beyond commenting solely on rate structure. The committee members took it upon themselves to respond to some of the broader issues raised in their deliberations with each other and discussions with the public. The committee recommended 24 changes in policies or practices not directly related to the rate structure. These included recommendations to expand long-range planning to avoid future water shortages and better estimate the costs of alternative water supplies; to adopt a Water Supply Offset Policy locally and regionally to require that new developments offset increased water demand by installing conservation measures in public facilities, funding specific conservation programs, or underwriting recycling projects; to accelerate the pace of construction of water reclamation projects; and to examine the impact of marginal rates on per capita use among residential customers. Not all of these recommendations were necessarily originated by the committee, but their support and leadership was notable. Some have been included in DWP's 1995 Urban Water Management Plan. The committee also specifically stated that DWP must continue to improve the infrastructure throughout the city to guarantee a consistent level of quality for all residents. This has been linked to DWP's 10-year capital plan and is listed as an explicit objective. As part of the rate restructuring, a Water Quality Improvement Adjustment was established to recover expenditures to upgrade water quality and equalize improvements throughout the city.

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[8] Each zip code in the service area was designated as a high, medium, or low temperature zone.

[9] As with the previous rate structure, in setting the break points for the various customer classes, past median usage for each class was used as the baseline, and therefore defines "reasonable" use.

Table 3-3
1995 Rate Structure

First Tier Rate

Rate per Hundred Cubic Feet: $1.13 + automatic adjustments

First Tier Usage (in Hundred Cubic Feet)

Break points are determined by lot size and temperature zone (which is established for each zip code)

Winter Season: November 1 through May 31

Lot Size Group	Temperature Zone Low (<75°F)	Temperature Zone Medium (75–85°F)	Temperature Zone High (>85°F)
1 – 7,499 sq. ft.	13 ccf	14 ccf	14 ccf
7,500 – 10,999 sq. ft.	16	17	17
11,000 – 17,499 sq. ft.	24	25	25
17,500 – 43,559 sq. ft.	28	29	29
43,560 sq. ft. and above	36	38	38

Summer Season: June 1 through October 31

Lot Size Group	Temperature Zone Low (<75°F)	Temperature Zone Medium (75–85°F)	Temperature Zone High (>85°F)
1 – 7,499 sq. ft.	16 ccf	18 ccf	19 ccf
7,500 – 10,999 sq. ft.	23	26	27
11,000 – 17,499 sq. ft.	36	40	42
17,500 – 43,559 sq. ft.	45	51	53
43,560 sq. ft. and above	55	62	65

Second Tier Rate

Usage above the first tier usage block will be billed as follows:

	Rate Per Hundred Cubic Feet
Winter season – November 1 through May 31	$2.33
Summer season – June 1 through October 31	$2.98

Household Size Adjustment

Household Size	Additional ccf at First Tier Rate
6 persons or less	no adjustment
7 persons	4 ccf
8 persons	8
9 persons	12
10 persons	14
11 persons	16
12 persons	18
13 persons or more	20

Note: ccf = hundred cubic feet

Source: LADWP 1995

Evaluation of Success

In evaluating the success of the Blue Ribbon Committee, we must examine both the quality of their recommendations and the effectiveness of the process itself.

Conservation Signals

All committee members agreed that the marginal cost-based, two-tiered system was an improvement over the old rate structure. Removing the fixed costs better links water usage with water bills, and marginal cost pricing for the second tier more accurately signals the cost of acquiring additional water. While it is difficult to isolate rate impacts on conservation and use,[10] water demand has not returned to pre-drought levels since the rate structure has been in place.

Some people feel that the second rate structure in 1995 was a retreat from conservation incentives of the earlier rate structure, increasing the lower rate block from 21 billing units a month (15,708 gallons or approximately 525 gal/day) to a range of 13 to 65 billing units (9,724 gal/mo or approximately 324 gal/day to 48,620 gal/mo or approximately 1,621 gal/day). Critics argue that people with larger lot sizes and/or living in hotter climates should pay higher rates for higher water use. The easing of the break point on one end of the scale (bigger lots and warmer climates) also tightened the break point on the other end of the scale. Overall, the efficiency incentives of the tiered structure remain, though they are perhaps not as strong as some would have liked.

Affordability

Despite removing the fixed charges, the new rate structure has met DWP's revenue needs while reducing bills for most customers. In particular, the rate structure made important adjustments to low-income rates, broadening coverage to multi-family dwellings. Eligibility increased from 60,000 single-family households to 160,000 households. According to Richard West, DWP's Water Rates Manager, DWP is the only agency to offer low-income and lifeline rates to multi-family dwelling users.

Creating Leadership and Strengthening Relationships

The Blue Ribbon Committee process created a citizen group of experts who were able to offer their leadership on water issues that had long been the purview of DWP. Committee members became spokespeople who engaged in both educating and representing their own constituencies throughout the city.

Committee members not only strengthened relationships with each other, but also with DWP. The process allowed DWP staff to engage in open and equal discussions with members of the communities they serve. Prior to these exchanges, communities largely viewed DWP as monolithic and impenetrable, and DWP viewed the public as uninformed and unable to really engage in issues. Allowing the committee members time to educate themselves allowed them to better represent their interests and communicate with DWP. Staff interaction with the committee lent credibility to the idea that issues can be worked out *with* community involvement instead of *in spite of* community opposition or misunderstanding. Building this mutual respect among participants created good will and a sound foundation for dealing with future issues.

Public Participation and Acceptance

Both DWP and the committee members learned a lot about communicating with the public. The Blue Ribbon Committee process achieved credible public participation and representation. By all accounts, committee members individually took responsibility for representing major interests throughout the city. And, the vocal response from San Fernando Valley residents perhaps exemplified the efforts

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[10] Other influences include the weather, hard conservation activities such as retrofitting fixtures, general economic conditions, and other costs related to water use such as sewer rates.

of the committee and the process to solicit and respond to public concerns. Though some may feel that the rate structure went too far to accommodate large volume users, the committee's solution reflects its efforts to keep the impacts equitable across all classes of users. Adjusting the break point for residential users to consider lot size and climate was an important consideration to win public acceptance from impacted customers.

Conclusions/Lessons Learned

The success of the Blue Ribbon Committee process shows that a citizen's group can educate itself about a complicated issue and produce a workable rate structure that has been responsive to both DWP and the identified needs of the city's residents and businesses.

Though it is difficult to separate the success of the committee from the individuals involved—who showed tremendous commitment and leadership—there were general aspects of the process itself that lent to its success. For one, both the city and DWP recognized that the independence of the committee was vital to lending credibility to its findings. Committee members were drawn from outside the traditional water policy circles. And importantly, committee members were given resources and authority independent of the water agency. They had their own consultant facilitate the process, gather information, and conduct analysis. The mayor's office offered important leadership, establishing a clear mandate to produce a water rate structure and granting the authority of the mayor's office and the city council to carry out that mandate. Second, the members engaged in a thorough education process, meeting not only with water officials and experts but the public as well. The education process, including access to outside consultants, provided committee members with a sound foundation upon which to make their decisions as well as confidence and credibility when dealing with DWP staff and others. Exchanges with the public helped to keep the process grounded by establishing clear citizen priorities and concerns. Third, the year-long process provided members adequate time to educate themselves and establish working relationships with each other and DWP.

Finally, an additional lesson learned is that publicly-driven decisions—even when those decisions are revisited—are more durable because of the decision's responsiveness to its constituency and the investment of the constituency in that decision.

Contacts

Richard West, Water Rates Manager, Los Angeles Department of Water and Power

Betsy Reifsnider, Blue Ribbon Committee Member, then with Mono Lake Committee (now with Friends of the River)

Cecelia Escalano, then the Mayor's Environmental Policy Advisor

References

Escalano, C. 1997. Formerly with Los Angeles Mayor's Office. Personal communications.

Mayor's Blue Ribbon Committee on Water Rates. 1992. *Proposed Water Rates.* City of Los Angeles.

Mayor's Blue Ribbon Committee. 1992. *A Consensus Approach to Water Rates.* Final Report. City of Los Angeles.

Mayor's Blue Ribbon Committee on Water Rates. 1994. *Recommendations for Revisions to Water Rates.* City of Los Angeles.

Reifsnider, B. 1997. Friends of the River. Sacramento, CA. Formerly director of Mono Lake Committee and member of the LADWP Blue Ribbon Committee. Personal communications.

Reifsnider, B. 1993. "Public Participation in Rate Setting." Paper delivered at Conserv93. Las Vegas, NV. December.

West, R. 1997. Los Angeles Department of Water and Power. Los Angeles, CA. Personal communications.

Chapter 4

Reducing Water Use in Residential, Industrial, and Municipal Landscapes

Dana Haasz

Introduction

Approximately 673,000 acres of California's landscape are dedicated to lawns (Chan 1995). During the peak summer months, landscape watering can account for up to 76 percent of an urban utility's total water demand—generally the time when demand for its supplies is highest and reliability is lowest.

This does not have to be the case. Cost-effective conservation measures can reduce landscape water use by 10 to 55 percent, depending on the aggressiveness of the program. These measures range from careful maintenance and scheduling of irrigation systems, to proper landscape design in accordance with water-efficient principles. The three examples presented in this case study illustrate the potential water savings that can result from three different landscape management approaches.

All three examples attest to the tremendous potential of reducing landscape water use. The North Marin Water District examined the effects of applying xeriscape principles at residential sites and found that average water use fell by up to 54 percent. The District's primary target for landscape water reduction programs is developers, who are recruited with incentives in the form of credits and rebates. In contrast, the Irrigation Technical Assistance Program (ITAP) at the Santa Clara Valley Water District (SCVWD) is a voluntary audit program targeting large landscape customers. The ITAP focuses exclusively on proper irrigation scheduling and careful maintenance and has succeeded in cutting water use in half at some of its sites. This method is virtually cost-free to the customer. In the third example, the Irvine Ranch Water District (IRWD) implemented landscape water budgets based on evapotranspiration rates, combined with incentive rates and customer support. IRWD targets both commercial and residential landscapes through its progressive rate structure and outreach programs. Water use at IRWD has dropped by one half for landscape customers (those with dedicated irrigation meters) and by 13 percent for residential customers, with low program costs for the agency.

Landscape Water Use Facts

- Outdoor water use may account for 40 to 80 percent of a utility's peak summer use.
- Water applied to turf is estimated to account for 75 to 95 percent of all outdoor water use, but only about 40 percent of the total irrigated landscape area.
- A typical portable lawn sprinkler applies approximately 300 gallons of water per hour of operation, in very imprecise ways.
- Drip irrigation applies 30 to 50 percent less water than sprinkler irrigation and still meets most plants' water requirements.
- Efficient watering methods alone can save at least 10 to 15 percent of the water used year-round. Reducing turf area can increase water savings to 30 percent or more.
- Narrow strips of turf require 300 to 500 percent more water than large, more efficiently irrigated turfgrass areas.
- Excessive landscape watering is one of the largest contributors to freshwater pollution, as irrigation runoff carries pesticides and nitrates into nearby waterways.
- Peak landscape use tends to coincide with critical low-flow periods. Reducing this use would allow for more water to maintain fisheries and critical stream habitats.

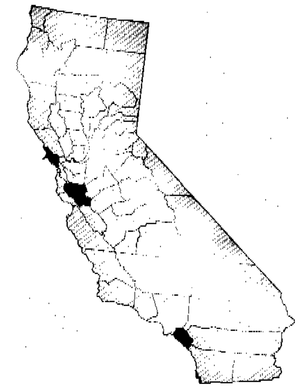
Source: Sciutto and Zamost 1993, Water Program 1991, NMWD 1997

Background

Outdoor water use is 95 percent lawn, landscape, and garden watering. When this watering is unnecessary or inefficient, it is one of the most obvious sources of water waste. Landscape water use is generally highest in the middle of the summer, which coincides with low natural flows in source streams. Since peak use tends to drive the need for additional water treatment and storage capacity, landscape watering is a prime target for load management programs and often the first conservation measure adopted during a drought (Water Program 1991).

Landscape water conservation is a tricky issue. The traditional use of turf (grass), adopted from old English-style lawns and East Coast traditions, usually results in very high water use. The issue, however, is complicated by the attachment people feel to their lawns and the connection that is made between a lush green lawn and quality of life. At the same time, alternative landscape approaches are gaining favor.

The goal of outdoor water conservation programs is not to do away with gardens and green space; rather it is to maintain the aesthetic and other beneficial aspects of these areas, but in such a way that is less water demanding. By following the fundamentals of xeriscaping (*xeros* being the Greek word for drought) (see sidebar), which combine principles of landscape design and efficient management, users are able to reduce their water consumption considerably without compromising aesthetics. In fact, properly designed, water-efficient landscapes are as lush and pleasing as traditional landscapes.



The Seven Principles of Xeriscaping

1. **Planning and Design.** A properly designed site should include consideration of slope, soils, aspect, drainage, privacy areas, play areas, and so on.
2. **Soil Improvement.** Soil improvement allows for better water penetration and improved water holding capacity.
3. **Limited Turf Areas.** When possible, turf should be limited to small plots and high visibility areas.
4. **Efficient Irrigation.** Plants should be grouped according to their water requirements. Drip irrigation, which saves water and reduces weed growth should be used whenever possible, and the system needs to be carefully maintained and monitored in order to maximize its potential benefits.
5. **Mulches.** Mulches cover and cool the soil, reduce weed growth, slow erosion, and minimize evaporation.
6. **Low-Water-Use Plants.** Scores of species of plants that use limited amounts of water are available, including low-water-use turf.

Sound Maintenance. Proper mowing, fertilizing, pruning, weeding, and water-schedule adjustments contribute to water savings.

Well-designed, water-efficient landscapes can be attractive and lush. (Photo by Lisa-Owens Viani)

The Projects

North Marin Water District

The North Marin Water District (NMWD or District), which serves customers in the city of Novato and adjacent surrounding areas, has been conducting research on landscape water conservation since the early 1980s. The District was one of California's earliest contributors to the literature on management of water used for landscape purposes, and one of the few to quantify the differences in the inputs required for traditional and water-conserving landscapes.

Novato is a suburban city with a population of 53,000, situated in an inland coastal valley about 40 miles north of San Francisco. Mean annual precipitation in Novato is 27 inches, while the annual applied water requirement for grass is 36 inches. NMWD provides water service to about 20,000 connections, 85 percent of which are residential customers: 65 percent of these are single-family homes. Outdoor water use accounts for 40 percent of residential water use, rising to 65 percent in the peak month of July. Of total outdoor water use, turf irrigation is estimated to account for 75 to 90 percent (Nelson 1989). Depending on the time of year and amount of turf, between 30 and 56 percent of all water supplied by the District is used for residential landscape irrigation. The District realized several years ago that any effective water conservation plan for the region had to include programs targeted at residential outdoor water use.

Based on growth rates, NMWD projected that the Greater Novato area could reach its growth limit as soon as 2014. In response NMWD established a goal of achieving a permanent reduction of 15 percent in peak period water use (compared with the average level of demand of the eight-year period ending July 1976) by 2015 in order to balance its water supply with growing demand (NMWD Annual Report 1997). The District then began to develop strategies that would allow it to achieve identifiable reductions in water use. Landscape irrigation was a primary target because the research conducted by the District in the mid-1980s revealed the substantial potential savings that could result from increasing the efficiency of landscape uses.

The Studies

In 1985 NMWD conducted an eight-and-a-half-month research project comparing the use of water, labor, fertilizer, fuel, and herbicide in traditional and water-conserving landscapes. The sample consisted of seven developments (townhouses and condominiums) containing 548 dwelling units, all with mature landscapes. Four of these developments were landscaped according to traditional standards, while the other three were designed to meet the specific water conservation design criteria described in Table 4-1. The landscapes were all maintained by professional landscape contractors.

Turf perimeter was concluded to be the single best indicator of outdoor water use in this study, with turf area a close second. The importance of turf perimeter makes sense for two reasons. First, perimeter limitations set corresponding limitations on turf area, which is the primary dictator of water demand. Second, minimizing turf perimeter (by reducing the amount of turf in narrow strips) generally allows for a more efficient irrigation layout and consequently more uniform irrigation, with fewer water losses to non-turf, non-landscape areas.

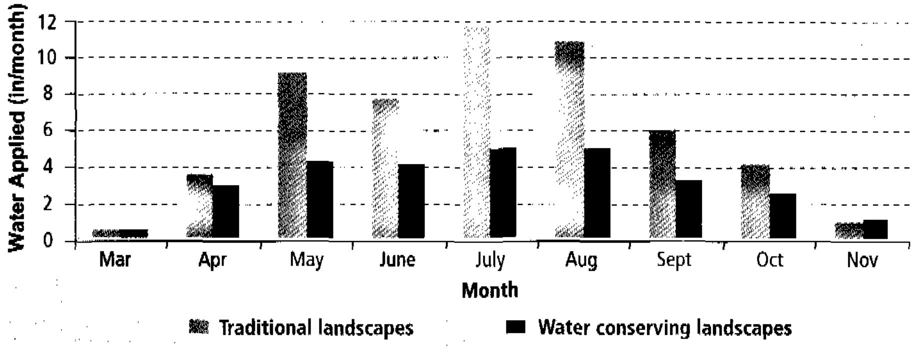
The results of this study indicate that proper xeriscaping can substantially reduce the inputs required for landscape maintenance. The water-conserving projects showed reductions of 54 percent in water use, 25 percent in labor, 61 percent in fertilizer use, 44 percent in fuel (used for mowing and hauling), and 22 percent in herbicide use. These reductions amounted to an annual savings of $75 per dwelling unit. In addition to the significant reduction in the amount of water used, the water demands of the conserving landscapes were more level

Table 4-1
Criteria for Qualification as a Water-Conserving Project

Parameter	*Criterion*
Area of turf	Less than 500 square feet per dwelling unit (d.u.).
Perimeter of turf	Not more than 20 linear feet per d.u.
Overall turf area	Less than 40 percent of total landscaped area.
Turf layout	Turf consolidated into large relatively flat areas, with no turf along narrow paths, median strips, or foundations of buildings.
Non-turf area	Planted predominantly with water-conserving trees, plants, and shrub varieties that are available locally.
Irrigation system	In-ground system equipped with modern controllers; recommended monthly irrigation schedule (run time and frequency) consistent with field capacity of soil and local evapotranspiration data; and appropriate selection of sprinkler heads.
Soil preparation	Tilling and preparation of ground as necessary to achieve a well-drained soil with adequate field capacity characteristics and chemical balance.

Source: Nelson 1986

Figure 4-1
Average Water Applied to Traditional and Water-Conserving Projects



Source: Nelson 1986

throughout the growing season and lacked the dramatic peak demands common to traditional landscapes (Figure 4-1).

In a second major study, NMWD analyzed the water use of 382 single-family detached dwellings during the summer of 1993, with the intention of isolating the effects of lawn irrigation. For this analysis two groups were defined: half consisted of traditionally landscaped homes while the other consisted of xeriscapes.

The xeriscaped sites had to meet the following criteria:

- The softscape area (that portion of the front yard landscape not covered by structures of any kind or areas made up of predominantly rock or gravel) was made up of less than 15 percent irrigated lawn.
- Vegetation other than turf, but not necessarily xerophytic, dominated the landscape.
- Landscape had to appear relatively well maintained.

For each site that met the xeriscape criteria, a matching traditionally landscaped site nearby was also identified. Proximity was important in order to minimize the effects of microclimate, property values, slope, sun orientation, shade, wind, and age of landscape. The matching traditionally landscaped site had to be located within a block of, and be similar in size to, the xeriscape site, and its softscape area had to consist of at least 70 percent irrigated lawn.

Once the site pairs were identified, water meter readings were taken,[1] and information about the backyard landscape, occupancy, water-use fixtures, and irrigation methods was collected from every site. Billing data from the month of January, when no irrigation occurs, was used as a measure of indoor water use. Outdoor use was then approximated to be the difference between January and July use.

The information gathered was then used to predict annual, summer, and outdoor water use. The predictors selected for each analysis were total lawn area, home value, sprinkler system, average home population, winter water use, appearance of front yard, presence of outdoor water features, existence of pool, lot size, existence of front yard xeriscape, slope factor, and percentage of rock in front yard softscape. Of these 12 predictors, home value, yard appearance, turf area, the presence of an in-ground sprinkler system, and winter water use were all found to be statistically significant in explaining summer water use.

According to the analysis, a 100 square-foot increase in turf area corresponded with an increase in summer water use of 8.6 to 14.6 gallons per day (gpd), and the average difference in total turf area between the traditional and xeriscaped landscapes was 1,351 square feet.

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[1] The readings were taken on July 2, and August 9, 1993. The time of the reading was recorded at each location in order to obtain an exact elapsed time and water consumption.

This translates into savings of between 116 and 200 gpd for the xeriscaped homes compared with those that had been traditionally landscaped. The xeriscape sites used 19 percent less water (589 gpd) during the summer than the traditional sites (824 gpd), and 17 percent less annually (356 compared with 482 gpd) due to their reduced turf area.

The Policies

Credit/rebate program

In 1985 the District introduced economic incentives aimed at encouraging developers to reduce the percentage of landscape devoted to turfgrass and install xeriscapes in new residential developments. The incentives consist of credits on connection fees if the initial landscape installation is part of the construction performed by the developer, or a rebate to the property owner if landscape installation occurs later. The credits or rebates, as shown in the amounts indicated in Table 4-2, are contingent on the applicant agreeing to install landscaping conforming to the District's standards. The standards set by the District for a water-conserving landscape are outlined in the accompanying sidebar. A field inspection by the District is conducted in order to confirm that the installed landscapes meet the specified requirements.

Cash-for-Grass

In April of 1989, a pilot program called Cash-for-Grass, aimed at encouraging residential property owners to remove or reduce their turf area and replace it with water-conserving plant materials, was initiated. The program received no official promotion until 1993, relying until then solely on an article in the *Marin Independent Journal* and word-of-mouth endorsement to generate interest. The District offered a rebate of $50 per 100 square feet of turf removed and replaced with water-conserving plants, with a maximum rebate of $340. These rebates were calculated as the avoided capital costs or, in other words, the avoided investment the District projected it would need to make in major upstream facilities necessary to serve new

Table 4-2
Credits and Rebates for Installing a Water-Conserving Landscape

Type of Dwelling Unit	Water Conservation Credit/Rebate per Dwelling Unit
Single-family detached residences and duplexes (SF)	$200
Townhouses, condominiums, triplexes, and fourplexes (THC)	$150
Apartments (APT) (5 units or more)	$100
Senior citizen unit (SC)	$80

Standards for a Water-Conserving Landscape: Regulation 15, R5/92

1. Specific Criteria:

i. The total area of turf shall not exceed the following

Type of dwelling unit	Maximum amount of turf
SF	800 square feet
THC	400 square feet
APT	130 square feet
SC	95 square feet

ii. Not more than 20 percent of total landscaped area shall be turf.

iii. The more restrictive of (i) and (ii) shall apply.

iv. In non-turf landscaped area, a surface of mulch four inches deep shall be installed to inhibit water loss.

2. General Criteria

i. In planned unit developments, turf areas shall be consolidated into large relatively flat areas, creating "oases of green" surrounded by dwelling unit clusters, thus maximizing visual impact while optimizing irrigation efficiency and functional use. Turf shall not be used adjacent to building foundations, along narrow paths or median strips, or within the drip lines of native trees.

ii. Water-conserving plants, shrubs, and ground covers shall predominate non-turf, landscaped areas.

iii. Water-loving plants shall generally be confined to drainage areas, patios or other intensively-used or highlight areas.

iv. Rock plants and/or other colorful water-conserving plant materials should be used to add seasonal color highlights and additional interest and balance.

Source: NMWD 1992

development with equivalent turf acreage (Nelson 1991). In order to determine the rebate value, the District conservatively calculated that each 100 square feet of turf replaced would result in a reduction in water demand of 24 gpd on an average day of a peak month, and 9 gpd on an average day of the year.

These innovative incentive and rebate programs (Cash-for-Grass and credit/rebate) reward both existing homeowners and developers of new residential properties who comply with the District's landscaping guidelines. NMWD's program approaches turf reduction as a voluntary action, with credits and rebates acting as inducement to participate. The turf irrigation system, however, must be designed according to specific criteria and installed by developers as part of their projects.

Since the Cash-for-Grass program's inception, the turf industry has been its principal detractor. The California Sod Growers Association (CSGA) bases its opposition on two arguments. The first argument is that homeowners will lose automatic air cleaning and cooling around their homes. To this NMWD countered that, in combination with the urban heat island effect, turf irrigation increases humidity and tends to compound these problems rather than alleviate them. The CSGA's second argument is that since turf helps fight the greenhouse effect, reducing turf would in fact contribute to the greenhouse effect. NMWD's response to this was that while all green, living things help to combat the greenhouse effect, frequently-cut grass is the least effective contributor. In fact, the cuttings decay and create gases such as methane that worsen the greenhouse effect, thus canceling out any positive contribution of turf in combatting this problem (Sciutto and Zamost 1993).

While some professional landscapers and those in the turf industry were opposed to these programs, most contractors, landscapers, and nurseries in the area have recognized their environmental and business benefits. These groups have been strong advocates of the programs and have helped increase public awareness of their existence.

Results

In a review of the pilot Cash-for-Grass program, Nelson (1991) reports that participants were very receptive and liked the program. Of the 73 applications received (all single-family residences), 46 were eligible for a rebate and, on average, residents removed 1,040 square feet of turf, or 41 percent of their total lawn area. Preliminary research also indicated that only 35 percent of the applicants were motivated by the District's offer while the rest said that they would have reduced their turf regardless of the financial incentive (free riders). Based on the District's water savings assumptions, the 46 completed applications amounted to a total saving of 11,483 gpd in the peak month and 4,306 gpd year-round. Combining the avoided cost benefit of water of $50 per 100 square feet, but taking credit for only 35 percent of the turf area removed (thus excluding the free riders), yielded an avoided cost of $182 per applicant. The average rebate for the 46 applicants, however, was $245, yielding a benefit-cost ratio of 0.74. In order for the District to break even and have a benefit-cost ratio of 1.0, the rebate was reduced to $35 per 100 square feet, with a cap at $200.

The response to the incentive and Cash-for-Grass programs is depicted in Table 4-3 and Figures 4-2 through 4-5.

According to Joyce Arnold (1998) at NMWD, the landscaping programs are directed primarily toward developers rather than individuals. The levels of participation in the incentive programs reflect this inclination. Of the programs targeted at new landscapes, a total of 3.2 percent of SF, 57 percent of THC, and 98 percent of APT units have participated. Since 1990, all townhouses and condominiums have voluntarily complied with the District's landscape standards in order to benefit from the credit program, and only 11 apartment complexes have failed to comply with these standards since the program's inception in 1985.

Arnold attributes the relatively poor participation results of the Cash-for-Grass program to lack of publicity. The credit and rebate programs are promoted to developers, and so developers, aware of their existence, are eager

Table 4-3

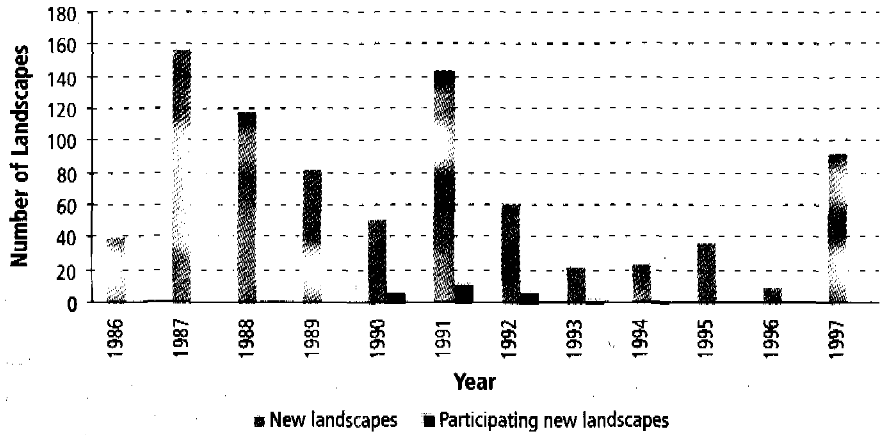
Credit/Rebate for New Landscapes Program 1986-1997

	Type of Landscape			
	Single-Family	**Townhouse and Condominium**	**Apartment**	**Total**
Number of new landscapes	846	836	520	2,204
Number of participating landscapes	27	478	509	1,014
Percentage participating	3	57	98	46

Source: NMWD 1997

Figure 4-2

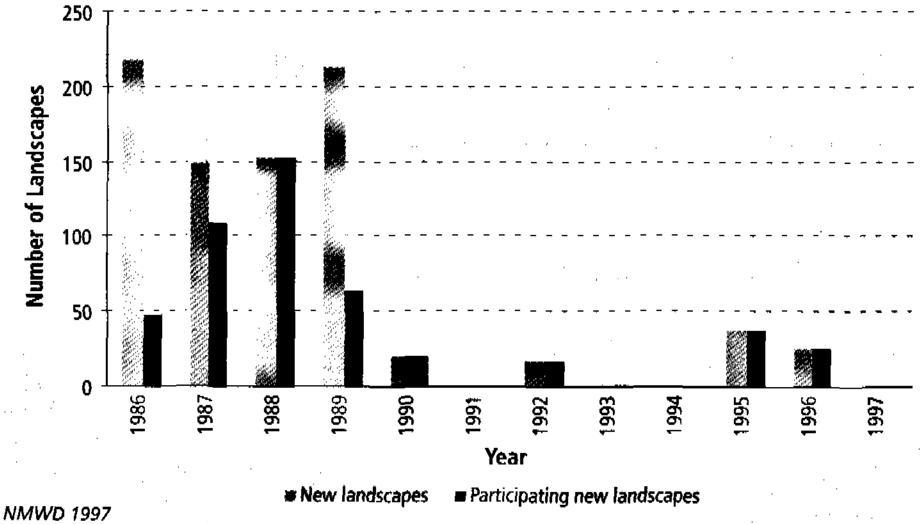
Single-Family Units Participating in Credit/Rebate Program



Source: NMWD 1997

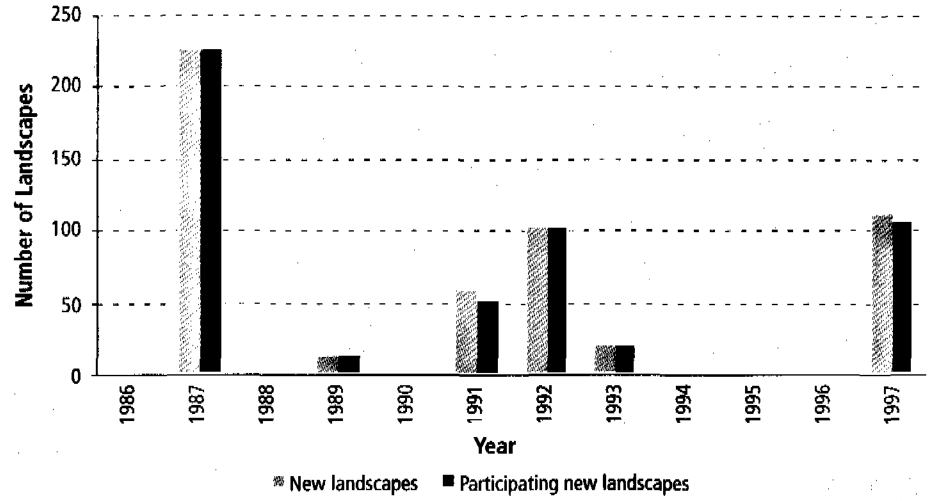
Figure 4-3

Townhouse and Condominium Units Participating in Credit/Rebate Program



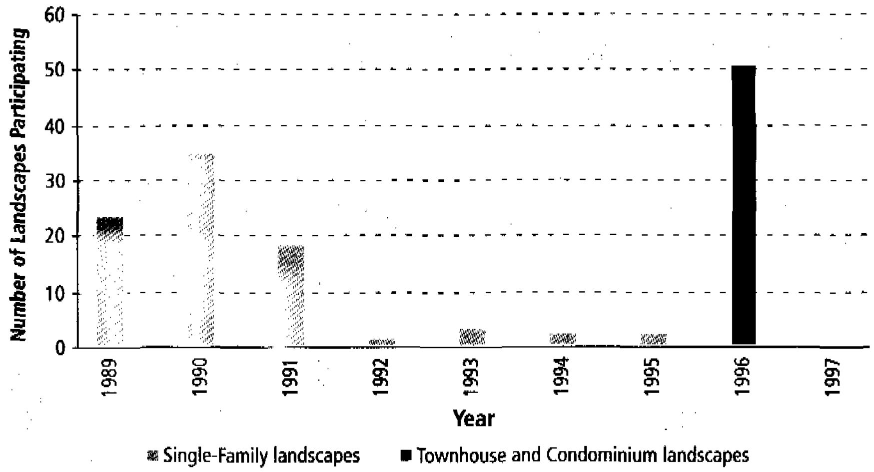
Source: NMWD 1997

Figure 4-4
Apartment Units Participating in Credit/Rebate Program



Source: *NMWD 1997*

Figure 4-5
Units Participating in Cash-for-Grass Rebates for Existing Landscape Modifications



Source: *NMWD 1997*

to take advantage of them. The Cash-for-Grass program, on the other hand, does not benefit from any official promotion, and consequently the public is not aware of the option's existence. These results are also quite revealing about the relationship between individual preference and conservation. Clearly, single-family homeowners are less motivated to change a landscape they are accustomed to in exchange for the financial incentive offered to them. It is understandably more difficult to convert an existing landscape than to install a water-efficient one from the outset, and so it follows that for a program to successfully initiate such changes, it would have to more actively target the homeowner. The NMWD case is a success because of the landscape water savings potential that it has identified and quantified in its studies, and because of the high rate of participation it managed to attract for its credit/rebate program among townhouse, condominium, and apartment dwellings.

Santa Clara Valley Water District

The Santa Clara Valley Water District (SCVWD or the District) supplied 388,000 acre-feet of water during 1997, 90 percent of which went to the municipal and industrial sectors. By the year 2020, the county projects that its population will have increased from 1.65 to 1.9 million and that water demand could increase to about 546,000 acre-feet (af) per year. The SCVWD's various conservation programs are expected to reduce this demand by 46,000 acre-feet (8.4 percent) to 500,000 acre-feet per year (SCVWD 1998a).

Water conservation is a District board priority. It is one of the four primary components of the Integrated Water Resources Plan approved by the District board in 1996. One of the major efforts within the water conservation component is reducing landscape water use, which, according to SCVWD estimates, accounts for over 30 percent of businesses' total water demand.

Irrigation Technical Assistance Program

In 1995, SCVWD initiated the Irrigation Technical Assistance Program (ITAP) with the goal of helping landscape managers improve their irrigation efficiency. Through this program, the District offers free site evaluations to all large landscape customers (one acre or more) followed by a detailed set of recommendations as to how customers can more efficiently manage their water use. The recommendations are all based on management improvements, such as irrigation scheduling and system maintenance, rather than equipment retrofit or landscape changes, and therefore minimal cost is incurred by customers in adopting these recommendations.

There are five components to an ITAP evaluation:

1. System Check
Auditors evaluate the site's entire water delivery system and document the deficiencies that potentially result in significant water losses. Catch-can tests are used to determine average precipitation and distribution uniformity (a measure of how evenly water is applied to a given area), so that the site manager can better understand the system's performance and can thus participate in developing improved irrigation scheduling strategies.

2. Hydrozones and Budgets
Auditors classify plant groups into hydrozones (irrigated landscape areas featuring plants with similar water requirements) in order to estimate a site's actual water needs. The resulting optimum budget is compared to past use to determine potential savings.

3. Scheduling and Tracking Usage
Auditors suggest a yearly watering schedule and establish a system to log meter readings, calculate weekly water use, and graphically compare current use to the suggested budget. These efforts provide a gauge to monitor actual savings. Also, instructions are provided on how to use actual weather and CIMIS data (for more information, see *The Power of Good Information*, Chapter 16) in scheduling the sprinklers.

4. Site Report
Auditors provide the customer with an evaluation of the site's existing irrigation system and landscape water management and a plan detailing how to improve its water-use efficiency.

5. Follow-up Services
Auditors are available for telephone consultations and follow-up visits. The auditors check in with the customer every month for six months following the audit, and once a year for the next five years.

ITAP is a voluntary program publicized by direct mailings to landscape companies, architects, designers, and property managers and owners, among others. It has also been promoted in magazine articles and at workshops, seminars, and fairs. The appeal for customers to participate in the program is, of course, the potential water and financial savings. The District estimates that the average commercial/multi-family residential site can save approximately 450,000 to 600,000 gallons per acre per year, adding up to a potential savings exceeding $1,000 per acre per year (SCVWD 1998b). In addition to the relatively immediate results customers see in their water bills, the program also advocates the long-term benefits of good water management. These benefits include fewer hardscape repairs, because asphalt, sidewalks, and gravel last longer if they are not constantly wet; less overspray onto walls, fences, and windows, therefore reducing hard water spots; and healthier plants, because appropriate watering reduces susceptibility to disease, pests, and physical damage during windy periods. The District also offers landscape managers an opportunity to familiarize themselves with evapotranspiration-based water budgets (see sidebar), a recommendation of the voluntary urban Best Management Practices. The ITAP program provides the manager with the necessary tools and knowledge to adapt to, and prepare for, these changes.

A specific example: the TriNet site

The TriNet site in Milpitas is a typical example of a Silicon Valley industrial site. This two-acre landscape is made up mostly of turf but consists also of parking medians, foundation plantings, and large lawn areas dotted with trees. In October of 1997, an ITAP audit of the TriNet site was conducted.

Evapotranspiration

Evapotranspiration (ET) is the rate at which plants use water. This rate is influenced by environmental conditions, such as wind, temperature, and humidity, as well as plant type and growth stage. The CIMIS stations located throughout the state provide daily estimates of ET demands for irrigated grass, which are referred to as 100 percent ETo. Individuals are able to adjust this information to their specific conditions and determine the actual evapotranspiration requirements of their vegetation and the amount of water they should apply to their landscape.

The auditors first determined the site's hydrozones. They distinguished three discrete zones: cool-season turf areas with some trees; mixed landscape areas with ground covers, shrubs, and trees; and a low-water-use area with ground cover and some trees. The site consisted of 77 percent turf, 16 percent medium-use hydrozone, and 6 percent low-water-use plants.

A comprehensive inspection of the sprinkler system was then conducted, and the auditors found that overspray was causing some non-productive evaporative water losses that could be corrected with minor adjustments. Although some of the problem was caused by irregularly shaped planting beds, some could be easily corrected by turning sprinkler heads, changing nozzles and filters, adjusting the radius of spray, or using new adjustable arc nozzles. In addition, the auditors found that some of the dry spots in the landscape were caused by water being "intercepted" by plant material. This could be corrected by simply adjusting a tilted or low sprinkler head. Few major adjustments needed to be made: some broken heads were found as well as some leaks, which required heads to be replaced. In all, 46 percent of the problems were minor adjustments (adjustments that can be made without digging, such as changing nozzles or rotating heads), 43 percent were "shovel" repairs (repairs that require a shovel, such as straightening a leaning head or fixing a broken sprinkler), and 11 percent required new equipment.

An analysis of the irrigation system and scheduling was then performed along with a description of past and potential water use. The auditors recommended that systems inspections be made on a regular basis to correct turned heads, overspray, and interception. They also submitted a separate report discussing the details of the irrigation scheduling, which included frequency and run time for each separate hydrozone. The ITAP budget was based on an adjusted ET for San Jose (since there is no CIMIS station in Milpitas) averaged over the past eight years.

The overall ITAP water budget developed for the TriNet site is slightly higher than 100 percent ETo during the peak months, due to problems with distribution uniformity. The non-peak budget provided by the auditors was calculated as 80 percent of this amount for turf; 50 percent for mixed tree, shrub, and ground cover areas; and 25 percent for low-water-using zones. This schedule was highly detailed and specific, but its success depended largely on field calibration and adjustments based on observation of plant vigor, soil moisture content in the root zone, and appearance, as well as changes in ET. Having this information available allowed the customer to properly schedule the irrigation for each zone separately according to specific needs. It also enabled the site manager to develop a basic program for any time of the year under most conditions.

Results of the TriNet audit

The ITAP staff have often found that the key to a successful site lies in the attitude of the site manager (Ashktorab 1998). The property manager at TriNet was willing to actively participate in the program and has adopted all of the management recommendations proposed by the auditors. The running totals presented in Table 4-4 show measured and predicted water use in 1998 to be almost 60 percent below that of 1997, and TriNet will have saved over $4,000 in water bills by the end of the year. The gross savings are essentially equivalent to net savings because the cost of implementation of the ITAP recommendations has been minimal (Ashktorab 1998). Even based on the data from the nine months since the audit was completed, water use has declined by 11,386 gallons, or 55 percent from the previous year's use.

Monthly use at TriNet exceeded the budget a number of times. However, as shown in Figure 4-6, the current year's use is well below last year's use in all months. Furthermore, when considering the whole year, new practices have met the water budget projections, and it is expected that once the plants are acclimated to reduced irrigation, further savings will be achievable (Ashktorab 1998). With the TriNet site, ITAP is trying to prove that ET-based water

Table 4-4

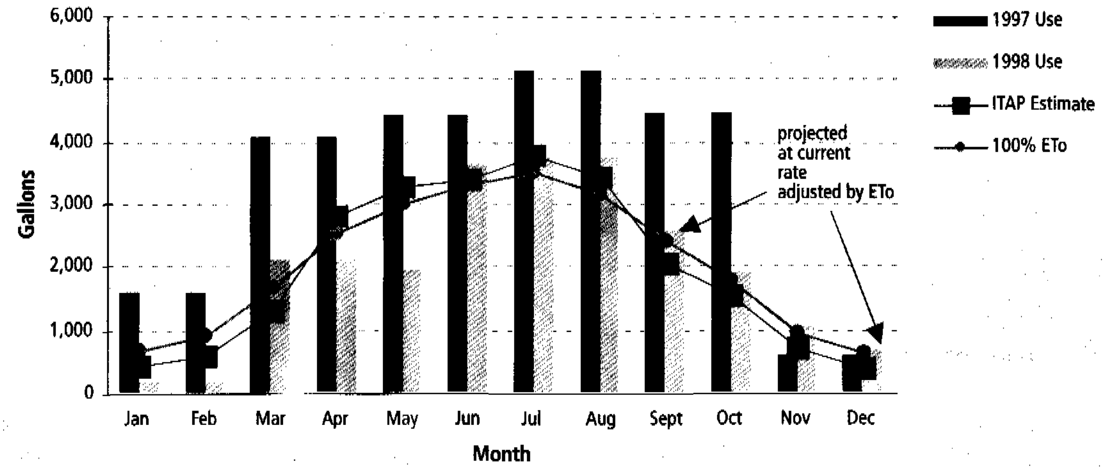
TriNet Site Water Use and Savings

Month	Cumulative ITAP Optimum Budget (Gallons)	Cumulative 1997 Use (Gallons)	Cumulative 1998 Use (Gallons)	Cumulative Savings ($)
January	434	1,564	165	338
February	1,032	3,127	322	675
March	2,334	7,197	2,416	1,150
April	5,154	11,266	4,511	1,625
May	8,416	15,673	6,441	2,220
June	11,805	20,079	10,069	2,408
July	15,583	25,203	13,817	2,740
August	19,024	30,328	17,565*	3,071*
September	21,066	34,779	20,109*	3,528*
October	22,600	39,223	22,024*	4,139*
November	23,326	39,836	23,034*	4,042*
December	23,715	40,442	23,707*	4,026*

** predicted estimates*

Source: Basanese 1998

Figure 4-6
TriNet Site: Actual and Projected Water Use



Source: Ashktorab 1998

management will not result in a stressed landscape, but rather a healthy and attractive one.

The ITAP program is still in its infancy, and therefore there are only a few sites whose water use has been tracked and quantified to date. The audits that have been conducted so far indicate a tremendous potential for reducing water use and saving money. At the Oakridge Mall Shopping Center, a site with approximately 3.35 acres of landscaping, the contractor has saved over $7,000 in water bills between January and July of 1998, and it is projected that water use can be cut by almost half by the end of the year, saving over $11,000. At the five-acre Sonora Ranch residential development, water use was reduced by over 37,000 gallons in 1997–1998, and the Homeowners Association's water bills have decreased by over $1,000 per month. Projections for 1998–1999 indicate additional potential savings of about 15,000 to 22,000 gallons, as the contractor becomes more adept with the management of the system, and the plants acclimate to the new irrigation schedule (SCVWD 1998b).

These savings can be attributed almost exclusively to improvements in water management and tend to be labor, rather than capital, intensive. The ITAP program tries to be as palatable to the landscape manager as possible, and has therefore made it a point to steer clear of recommending any significant structural changes to either the landscape or the irrigation equipment. The ability of a site to meet the potential water budget specified in the audit largely depends on the willingness of the landscape maintenance contractor to carefully monitor the landscape for signs of stress or overwatering, and the equipment for signs of improper adjustment or mechanical problems.

Irvine Ranch Water District

Irvine Ranch Water District (IRWD or the District), located in south central Orange County, serves an annual water demand of about 69,000 acre-feet (af) from a population of 150,000. The District's service area covers 123 square miles and includes the city of Irvine as well as portions of Santa Ana, Newport Beach, Costa Mesa, Tustin, Orange, and Portola Hills.

In June of 1991, in response to the drought, IRWD developed a five-tiered, steep inclining block rate structure, and landscape conservation programs. The structure and fundamental principles of the rate system are described in more detail in *Promoting Conservation with Irvine Ranch Water District's Ascending Block Rate Structure,* Chapter 2.

The new rate structure applies to both residential and landscape customers (those with dedicated irrigation water meters), and, while it elicited an immediate and strong response from residential users, landscape customers had a less pronounced reaction. The lack of response was likely related to the fact that landscape personnel do not usually pay the water bill and therefore are disassociated from the financial implications of their water management practices. However, there was great incentive for the District to get landscape customers on board because, while they make up only 3 percent of the 51,000 accounts served by the District, they account for 17 percent of total water use. This considerable potential for savings prompted the District to establish a customer service, education, and rebate program targeted specifically at landscape customers.

Landscape Outreach Program

The landscape outreach program was established in November 1992 in response to the high rate of irrigation customers (between 30 and 50 percent) whose water use was falling into the highest or "wasteful" tier during the year. Customers in this top tier used over 120 percent of their ET-based allocation. The charge for this excess use was eight times the 100 percent ET base rate.[2] The goal of the program was to establish a constructive relationship with the customers, support them in their conservation efforts, and help them to move out of the high cost top tier. The target was any over-allocation water user, which included parks, schools, hospitals, homeowners associations, business sites, and so on. The program provided these users with education, site walks, and funding (rebates) to update or fix their irrigation systems (IRWD 1998).

While the rate structure provided a clear signal to customers that indicated excessive water use, the landscape outreach program provided a way to instruct those customers as to what their options were when they received a high bill. The customer outreach included both an economic component, in the form of rebate and loan programs, and consistent educational components. The programs used the funds accrued from the high tier penalty charges to help customers finance the correction of their systems or develop programs that would help them change over to more efficient systems. For example, the program offered rebates for irrigation controllers and equipment for up to 50 percent of their cost, and zero-interest loans for up to 50 percent of the cost of upgrading irrigation systems. The other key component of the program, the education programs, included ongoing educational events targeting landscape professionals. Educational materials, site walks, monthly meter monitoring, free soil probes, and free landscape irrigation seminars were offered in Spanish and English. By 1995, scheduling software and a weekly updated ET hotline were also available to landscapers.

The new Water Conservation Department was established during the fall of 1997. Landscape water use has achieved an average use per acre of 60 percent of ET, without additional targeted or rebate efforts. The goals of the new department have been to shift the focus from short-term change to long-term landscape customer maintenance and to devote more time to residential and commercial, industrial, institutional customer participation. The department is currently involved in projects that will allow it to continue to develop long-range conservation programs (IRWD 1998). In 1997, it initiated a pilot program in which homeowners were given free soil probes. Currently the department is testing an automated ET controller that would receive weekly updated ET information from local weather stations and set the homeowner's irrigation schedule accordingly.

Results

The combination of incentive pricing, water budgets, rebate and loan programs, and educational outreach has proven to be very effective in reducing the demand of both irrigation and residential customers. As indicated in Table 4-5,

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[2] The water budgets developed by IRWD were based on ETo data from the CIMIS weather stations.

actual ET of irrigation customers has dropped 2.2 af per acre in eight years, a reduction of 50 percent, and has been hovering around 60 percent of the reference ET for grass since 1995. Prior to 1996, most of the reductions in water use were attributable to improvements in irrigation technology and management, rather than changes in landscape composition. While this is still primarily the case, there is some evidence that, as of 1996, new developments were being designed with more efficient landscape styles (Ash 1998).

While commercial irrigation customers have water meters dedicated specifically to landscape uses, residential customers do not; therefore it is more difficult to gauge changes in their landscape water use following implementation of conservation programs. At the same time, IRWD's programs have, in general, specifically targeted landscape uses, and conservation analysts in the District therefore assume that the larger portion of the water being saved falls into this category (Lessick 1998). Table 4-6 provides an account of these savings.

The soil probes proved to be surprisingly effective at reducing water use. In the first pilot project, the District gave probes to customers attending a spring 1997 garden workshop.

Table 4-5
IRWD Water Consumption Analysis for Irrigation Customers

Year	Acres	AF Sold	Actual ET (AF/Acre)	Reference ET (AF/Acre)	Program
1990	3,034	13,338	4.4	4.1	Pre-program baseline
1991	3,265	12,439	3.8	4.0	Tiered rates/water budget
1992	3,486	12,211	3.5	4.2	Rates/water budget
1993	3,778	12,424	3.3	4.1	Rates, education, rebates
1994	4,567	14,629	3.2	3.9	Rates, education, rebates
1995	5,928	14,239	2.4	4.2	Rates, probes, software rebates
1996	6,322	15,402	2.4	4.3	Rates, probes, software
1997	6,685	16,598	2.5	4.4	Rates, probes, software
1998	7,000+	15,900	2.2	4.0	Rates, probes, software

Total Acre-Feet Saved: 59,000
Total Avoided Costs: $16.2 million
Total Program Costs: $3.8 million
Net Benefit: $12.4 million

Source: Lessick 1998

Table 4-6
IRWD Water Consumption Analysis for Residential Customers

Year	Average Use Per Account (AF)	Reductions from Baseline	Program
1990-91	.32 (drought)	——	Pre-program baseline
1991-92	.26 (drought)	19%	Rates, water budget, education
1992-93	.26 (drought)	19%	Rates, water budget, education
1993-94	.27	12%	Rates, water budget, education
1994-95	.27	12%	Rates, water budget, education
1995-96	.27	12%	Rates, water budget, education
1996-97	.30	6%	Rates, water budget, education
1997-98	.28	12%	Rates, probes, targeted audits, education

Average Savings: 13%
Acre-Feet Saved: 14,261
Residential Program Costs: $500,000
Avoided Costs: $5.5 million
Net Benefit: $5 million

Source: Lessick 1998

IRWD then compared their water use from July to September 1997 to their average 1991–1996 July to September usage. The analysis showed that those using the soil probes saw their use decline by 15 percent while those not using probes had their use rise by 9 percent, a difference of 24 percent in water-use efficiency (Lessick 1998).

In the second pilot project, the District gave probes to customers attending the spring 1998 garden workshop. IRWD then made two comparisons: (1) participants' 1998 usage was compared to their usage in 1997, and (2) participants' 1998 usage was compared with that of a matching neighbor who had not received a probe. In the first comparison, soil probe recipients used (on average) 69 percent less in March to June 1998 than during the same period in 1997. Although ET was lower in 1998, it was only lower by 12 percent. In the second comparison, soil probe recipients used almost 9,000 gallons less in March to June than their neighbors did (on average, excluding outliers) (Lessick 1998). This simple tool could be used to help reduce peak demands caused by overirrigation during summer months.

In addition to the conservation programs developed, IRWD was also involved in a landscape efficiency study. This study was used to gauge and quantify the effectiveness of the programs already in place, as well as to assess other potential efficiency measures to help develop future landscape efficiency programs.

Efficient Turfgrass Management Study

In 1994–1995, IRWD conducted a study evaluating the effects of landscape management practices on water consumption, turf appearance, and plant health. The goal of this work was to determine the combination of management practices that would optimize efficient water use without compromising either plant health or appearance. Funding for the project was provided by the Metropolitan Water District of Southern California, the Municipal Water District of Orange County, and the Irvine Company.

The study included 48 landscaped areas, all located in similar micro-climate zones and planted with cool-season turf. Three management practices, or treatments, were examined in this study, singly and combined. The first practice was optimized irrigation scheduling, which required ET data (available through CIMIS) and monthly crop coefficients, as well as accurate estimates of both system precipitation rates and distribution uniformity (DU).[3] Irrigation frequency was reduced, but run times increased in order to promote deep penetration of the water and encourage roots to grow deeper in the soil. The second practice was preventive system maintenance, the primary objective of which was to ensure even irrigation. This treatment addressed issues such as system leaks, which lead to direct water loss; excess water pressure, which increases atmospheric water loss; and misaligned or improperly elevated sprinkler heads and low water pressure, which can lead to uneven irrigation and the formation of brown spots. The third management tool was advanced horticultural (turfgrass) practices, which included the most numerous and complicated set of tasks, the objectives of which were to improve plant health and appearance, and increase root depth and soil water-holding capacity. Deep roots and amended soil provide turf with a larger available reservoir of water, insulating it from daily ET fluctuations and reducing irrigation frequency.

Prior to the study, the contractor in charge of the sites was performing these activities poorly, if at all. Irrigation scheduling at the sites did not take into account the necessary ET, DU, and precipitation rates, resulting in erratic scheduling and low irrigation penetration. Soil aerification was rarely conducted and never coordinated with irrigation and fertilizer application. The turf was being mowed weekly, and the clippings removed, thus causing soil nitrogen to be depleted. Due to these maintenance practices, pre-study root depth was shallow, and water use was inefficient.

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[3] An added aspect of this study was an evaluation of alternative methods for estimating ET and DU.

Results

Billing histories for the study sites date back to January 1989. The changes in consumption patterns of irrigation customers can therefore be examined in relation to the introduction of inclining rates, outreach programs, and the study's management practices. The results of the study indicate that landscape water conservation programs offer generous returns (d.d. Pagano, Inc. and Barry 1997). A look at the irrigation water use history of each site, beginning in 1989 prior to the establishment of the inverted block rate structure, reveals several conclusions. Figure 4-7 describes the difference between the amount of water allocated and the amount applied for irrigation purposes. In 1989 and 1990, consumption exceeded allocations even during the first quarter of each year—usually the time of the year when little to no irrigation is necessary—illustrating the poor state of irrigation management prior to the conservation measures being initiated. Figure 4-8 describes the ratio of applied to allocated water; any value exceeding 1.0 is interpreted as over-irrigation. So, for example, during the third quarter of 1990, consumption exceeded the allocation by a factor of three, implying 200 percent overwatering.

Only with the introduction, during the first quarter of 1995, of the study's efficient management practices, which combined optimized irrigation scheduling with advanced horticultural practices, did consumption and allocation begin to meet. Analysis of water use trends following application of the study's treatments indicates that the potential for saving water through efficient turfgrass management is immense. The treatments accounted for a reduction of 21.9 inches of water per year beyond the reductions achieved by the rate and outreach programs.[4] As for differences in water consumption between the four combinations of treatments (ET-based irrigation scheduling, irrigation scheduling and maintenance, irrigation scheduling and horticultural practices, and all three combined), no statistical evidence supported any such variation.

In terms of root depth, the combination of all three treatments produced notable results; however, these results were not found to translate into reductions in water use. Part of the reason no variations were observed might be that in February 1995 a new contractor was hired and all the sites, including the control sites, were better managed from then on. Another consideration is that a longer period of time is likely required to observe the irrigation benefits of improved horticultural practices. In the conclusions of the study, the authors warn that, for the aforementioned reasons, these results should not be interpreted to mean that advanced horticultural practices offer no water-saving benefits beyond those accrued from improving irrigation scheduling.

The reductions in water use did not have any negative effect on turf appearance. At all sites the quality of turf was found to have either improved or remained unchanged throughout the duration of the study, though this indicator was considered subjective and difficult to evaluate.

The results achieved at Irvine Ranch demonstrate the potential of landscape programs for reducing water use. Particularly, they highlight the importance of outreach programs. While the rate structure was instrumental in promoting awareness of water use, additional education and outreach programs were necessary to translate this heightened awareness into water savings.

Conclusions/Lessons Learned

The three preceding examples have shown the tremendous potential for reducing water used in landscapes. A combination of proper landscape management and design can effectively cut water use in half. The examples in this case study present only a few of the options available to program managers interested in reducing landscape water use. A number of water utilities throughout the state are developing their own unique and creative programs.

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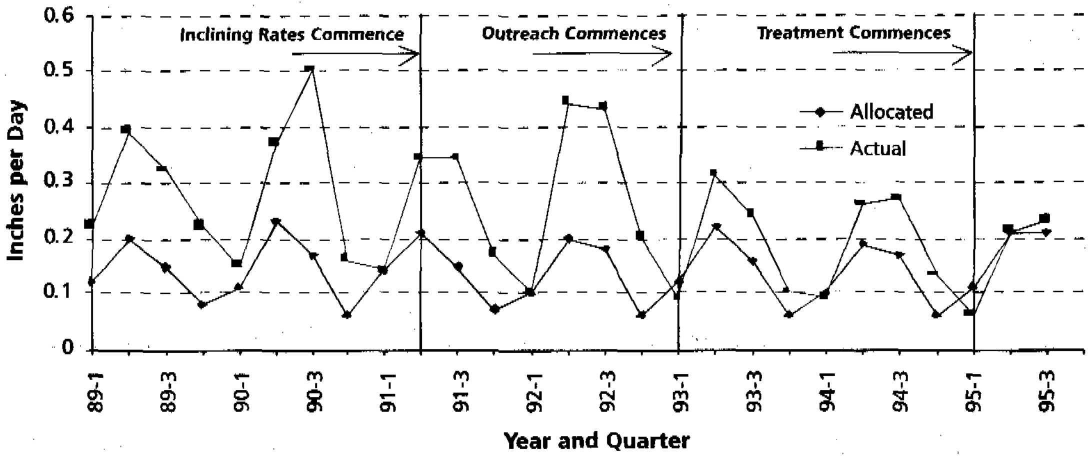
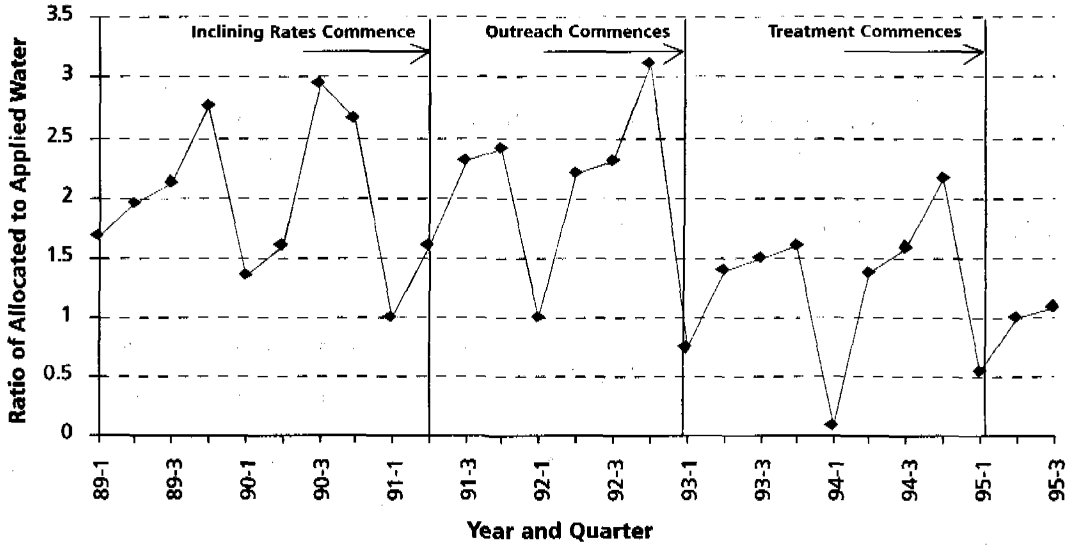
[4] In Figure 4-8, the results seem to indicate that the outreach programs were more effective in saving water than the treatments, due to the temporal sequence of events. This should be interpreted cautiously, as the outreach programs no doubt benefited from the easier conservation opportunities.

Figure 4-7
IRWD Applied and Allocated Water for Management Study



Source: d.d. Pagano and Barry 1997

Figure 4-8
IRWD Ratio of Applied and Allocated Water for Management Study



Source: d.d. Pagano and Barry 1997

A key factor in the success of any landscape program is education and outreach programs. A perverse new trend has emerged in recent years, dubbed "reverse xeriscape" by some in the landscape industry. This term describes the increasingly common practice of conservation-minded people planting low-water-use plants and (due to lack of proper water-management information or skills) over-irrigating them, causing them to die (Willig 1998). Studies have also shown that people who water with hand-held hoses can use up to 40 percent less water than people with automatic irrigation systems. This is likely because people using a system that requires them to be present and observing their landscape are more attuned to its water needs than those people whose systems go on and off automatically but are not accurately programmed. Aggressive education and outreach programs can be effective in reducing wasteful practices.

The potential water savings from irrigation and landscape efficiency improvements are very large; nonetheless there are a number of examples of sites where these improvements have been installed without any measurable water savings. Again, behavior and information are the critical elements in ensuring that water savings expectations are met. The success of the NMWD program clearly lies in those programs targeted at developers, offering incentives based on up-front efficiency measures with very specific design criteria. At SCVWD, water conservation programs employ relatively low-tech solutions—ET-based irrigation and careful site monitoring—that rely on the participation and conscientiousness of the landscape manager, and are therefore very focused on education and behavior. At IRWD, the Water Conservation Department is focused on reducing the dependence of the landscape program's success on individual behavior by setting specific targets and penalties (incentive pricing) to influence behavior of all customers all the time, while continuing to urge more efficient technologies through the use of the future automatic ET controller system.

Water waste often results from simple carelessness. (Photo by Lisa Owens-Viani)

In many ways, it is less difficult to target non-residential landscape water users than residential users because the larger users have more resources to invest, more support from the utilities, and more potential financial rewards from the water savings they accrue. Residential use is trickier because the variables that are factored into individual decisions about landscapes are difficult to predict. While it may be feasible to set specific design criteria for large landscapes, residential users are probably best targeted by allocating quantities of water for landscape maintenance and allowing individuals to select a landscape plan and maintenance program to meet that allocation. Education programs, coupled with water allocation programs and conservation rate structures could encourage a significant shift in urban landscaping to one of attractive, more water-efficient landscapes.

Contacts

Joyce Arnold, North Marin Water District
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References

Arnold, J. 1998. North Marin Water District. Novato, CA. Personal communications.

Ashktorab, Hossein. 1998. Santa Clara Valley Water District. Santa Clara, CA. Personal communications.

Basanese, J.A. 1998. ITAP TriNet 1210 California Circle—Water Management Report. Applied Water Management Services.

Chan, G. 1995. "A Growing Business. " *Sacramento Bee,* June 5, E-3.

Christopher, T. 1994. *Water-Wise Gardening: America's Backyard Revolution.* Simon & Schuster Inc. New York, NY.

d.d. Pagano, Inc. Irrigation Consultants, and J.S. Barry Environmental Consulting. 1997. *Efficient Turfgrass Management: Findings from the Irvine Spectrum Water Conservation Study.*

Ash, T. 1998. Irvine Ranch Water District. Irvine, CA. Personal communications with A. Wong.

Lessick, D. 1998. Irvine Ranch Water District. Irvine CA. Personal communications.

Nelson, J.O. 1986. "Water Conserving Landscapes Show Impressive Savings." Presented at the AWWA Annual Conference in Denver, CO. June 24.

Nelson, J.O. 1989. "Promoting Less Turf with Connection Fee Discounts and Rebates." Presented at the AWWA National Convention in Los Angeles, CA. June 21.

Nelson, J.O. 1991. "Initial Findings of Home Water Savings Pilot Project." Presented to Conservation Management Committee's Mid-Year "Mini-Conference," January 29, 1990, Phoenix, AZ.

Nelson, J.O. 1994. "Water Saved by Single Family Xeriscapes." Presented at the AWWA National Conference in New York City, NY. June 22.

NMWD (North Marin Water District). 1992. Regulation 15, Water Conservation—Novato Service Area.

NMWD (North Marin Water District). 1997. Annual Report 1996-97.

Sciutto, J.E. and B. Zamost. 1993. "Implement a Water-Efficient Landscape Rebate Program." In *Building Sustainable Communities Water Efficiency Series,* No. 1185. The Global Cities Project. San Francisco, CA.

SCVWD (Santa Clara Valley Water District) 1998a. History and Statistics 1929–1998. Gloria Baker Business Resource Group eds.

SCVWD (Santa Clara Valley Water District) 1998b. ITAP: Irrigation Technical Assistance Program brochure.

Water Program. 1991. *Water Efficiency: A Resource for Utility Managers, Community Planners, and Other Decision-makers.* Rocky Mountain Institute. Snowmass, CO.

Willig, C. 1998. Personal communications.

Chapter 5

Community-Agency Partnerships Save Water and Revitalize Communities through ULFT Programs

Santos Gomez and Lisa Owens-Viani

Introduction

Over the past decade, community groups and institutions throughout California have begun working with water agencies, assisted by private facilitators, to educate residents of low-income and other communities about simple actions they can take to conserve water, such as replacing their old water-guzzling toilets with new, ultra-low-flush toilets (ULFTs), that will also benefit their communities. Community participation in these community-based ULFT programs has been higher than in programs run by agencies alone, as the incentives for participating in them—jobs and funding for community programs—are greater and benefit community residents. In another alternative to agency-only ULFT rebate programs, many water agencies are partnering with schools to implement ULFT programs. Revenues from these programs help purchase equipment and support a variety of school programs and activities. The potential water savings from ULFT programs is enormous and has just begun to be tapped. For example, the Los Angeles Department of Water and Power calculates that each resident in Los Angeles who uses an ULFT saves 14 gallons of water per day—and that if every resident were so equipped, the city could save approximately 48 million gallons of water per day (Lerner 1997).

Background

Pressured by the scarcity of water during the 1987 to 1992 drought, California urban water agencies formulated plans to encourage their customers to conserve water and use it more efficiently. One conservation goal and Best Management Practice identified by many agencies was to replace old toilets requiring 3.5 to 7 gallons of water per flush with ULFTs, which only use 1.6 gallons per flush. At a water forum in 1992 in Southern California, Juana Beatriz Gutierrez, president of the Mothers of East Los Angeles/Santa Isabel (MELASI), a non-profit group of women activists who work to improve conditions in their community, challenged the water agencies to work with the community to conserve water while helping solve community problems. Jim Craft of Cooperative Technologies and Services International (CTSI), a private facilitating company, approached Mrs. Gutierrez and suggested that MELASI consider forming a public-private partnership with the Metropolitan Water District of Southern California, Los Angeles Department of Water and Power, Central Basin Municipal Water District, and California Water Service Company. Mrs. Gutierrez agreed to the suggestion, and a pilot ULFT program was born, in which the agencies would pay MELASI $25 for every old toilet replaced (Lerner 1997). This pilot program has since become the most successful and most replicated toilet retrofit program in the state.

The goal of the pilot program was to replace 1,000 inefficient toilets with 1,000 ULFTs over a two-month period in a low-income community, while creating jobs for residents and supporting neighborhood beautification projects. MELASI hired eight previously unemployed community residents to market and distribute the ULFTs locally. Employees canvassed the community (an area of 10 square miles with 100,000 residents), distributing bilingual literature that described the ULFT program and how residents could participate. Residents were extremely receptive to the door-to-door marketing effort, mainly because of the good reputation MELASI had developed in the community and because residents knew many of its employees. The word-of-mouth marketing strategy was a major success: one out of every three households contacted participated in the program (Hamilton 1992 and Hamilton and Craft undated). In its first year of operation, MELASI distributed 8,000 ULFTs; by mid-1997 MELASI had installed some 50,000 ULFTs, employing 25 full-time and three part-time community residents to run the program (Lerner 1997). MELASI has used revenues from the program to fund college scholarships and to pay for clothes and books for students who might have otherwise have dropped out of school (Lerner 1997). MELASI also uses revenues to pay high school students to go door to door urging parents to have their children immunized and tested for lead poisoning; the students also sweep the streets and remove graffiti (Lerner 1997).

California's urban water agencies quickly learned that they could increase the scope, impact, and effectiveness of their water conservation programs by partnering with community-based organizations (CBOs). Since MELASI's pilot program, over 16 additional CBO–agency partnerships have formed throughout the state. The goals of most CBO ULFT projects remain largely the same as MELASI's initial project. Participating water agencies are interested in reducing customer demand, increasing supply reliability, improving long-term planning, nurturing agency-community public relations, and supporting community revitalization efforts. Participating CBOs are interested in revitalizing their communities by creating jobs and generating financial resources to support scholarships, childcare programs, immunization services, and other activities, such as graffiti abatement. While saving water, these programs raise community awareness about water issues and encourage neighborhood unity and collaboration. In this process, CBO ULFT programs help bridge the gap between environmentalists and low-income communities.

How CBO–Agency ULFT Programs Work

The urban water agency will often work with a project facilitator, paying the facilitator a flat fee per ULFT distributed/old toilet recycled. In return for this agreed-upon fee, the facilitator searches for the best CBO, sets up the program, hires and trains community residents, obtains and warehouses the ULFTs, and sets up a system for recycling the old toilets. Facilitators like CTSI will also develop and produce marketing materials, set up both a master and a local database for tracking ULFT installation, report regularly to the water agency, monitor CBO operations (and if necessary retrain its employees), and randomly inspect CBO operations. The CBO in turn is responsible for community outreach, for managing the ULFT inventory, and coordinating the actual recycling of the old toilets. The facilitator pays the CBO a flat fee per ULFT distributed/old toilet recycled. Revenues in excess of expenses are invested in the community. In their community outreach, CBOs promote both the ULFT program itself and the sponsoring water agency, resulting in good public relations for the agency.

To qualify for a ULFT, interested residents are required to provide their water bills and photo identification. The CBOs encourage participants to install the toilets themselves (or with the assistance of family or neighbors),[1] which keeps costs down; they also provide bilingual installation materials and tool kits that make installation easy and relatively inexpensive. Over 95 percent of program participants install the toilets themselves or with the help of friends or neighbors. MELASI also provides participants with the names of local entrepreneurs who will install the toilets for $25. Participants are instructed to return the old toilets within seven days; upon returning the toilets, some CBOs (like MELASI) then provide participants with low-flow showerheads as well. Not surprisingly, over 90 percent of the old toilets are returned for recycling within one week.

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[1] When customers install the UFLTs themselves, they learn how to operate and maintain their toilets, producing greater water savings over the life of the toilets.

Recycling the old toilet provides a way to verify that a ULFT has been installed. Anyone not returning his or her old toilet after one week is contacted by the CBO, and, if necessary, an inspection scheduled to verify the ULFT installation. The old toilets are then broken up and recycled into road material, which reduces impact on local landfills by converting a waste product into useable material while reminding participants and the community of the benefits of recycling.

The Projects: Water Savings and Community Benefits

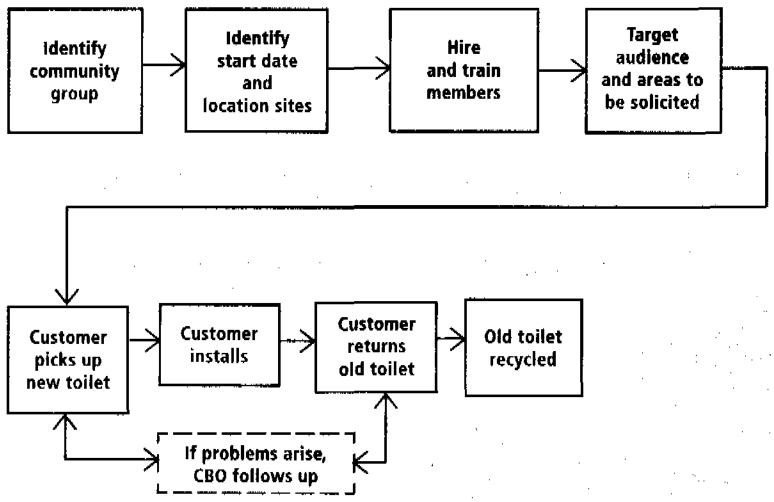
CBOs (including high schools) have installed over 300,000 ULFTs in California to date, for an estimated savings of 12,911 acre-feet of water per year—enough water to meet the annual needs of approximately 25,000 households.[2] Most of these ULFTs were distributed in Southern California, saving Southern California water agencies an estimated 10,482 acre-feet per year, and helping them bridge the gap between supply and demand (CTSI undated fact sheet).

CBO ULFT programs are highly adaptable and can be readily replicated in diverse communities. While the longest running programs are in Southern California, similar programs are catching on in Northern California. ULFT programs have been so successful that schools, especially schools facing financial difficulties, are now using them to raise funds to support activities and purchase equipment.

In addition to the water savings, these programs have helped raise water and environmental awareness in low-income communities and communities of color, and have generated much needed revenues for supporting community programs. In 1993, the First African Methodist Episcopal Church (FAME) in South Central Los Angeles instituted a ULFT program. In the first five months of operations, FAME retrofitted over 8,000 toilets, employed 15 local residents (some who had had trouble finding employment because of difficult pasts), and used profits to support a Micro Loan Program for minority-owned small businesses, the Los Angeles Renaissance Program, and a youth employment and training program (Hamilton and Craft undated).

In 1996, Southern California's West Basin Municipal Water District partnered with the non-profit Los Angeles Opportunities Industrialization Center, which hires and trains young adults in a variety of occupations, to implement its toilet rebate program. The money the center received for the ULFTs it distributed was used to train residents in the computer science, retail services, and job placement fields. West Basin also partnered with several school groups to distribute ULFTs. The $80,000 earned by three schools and three CBOs was used to support school programs and events, purchase equipment, and improve school facilities. In March 1996, Students at Hawthorne High School raised $10,600 helping West Basin distribute more than 700 ULFTs. With the earnings from the program, the school purchased new equipment for its baseball and football programs, a new banner for its band, and a new

CBO ULFT Program Process



Source: Adapted from CTSI

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[2] An acre-foot of water per year serves the annual water needs of approximately two typical, four-person households.

Table 5-1
A Sample of CBO ULFT Programs
(water savings estimates are based on an average daily savings of 37.5 gallons of water per ULFT)

CBO Distribution of ULFTs in Southern California

Year	Water Agency	No. of CBO Sites	ULFTs Distributed	Utility Cost per ULFT ($s) (includes cost of toilet, administrative costs, etc.)	Total Cost ($s)	Estimated Annual Savings (gallons)	Estimated Annual Savings (AF)
1992–1995	LADWP	7	213,882	119	25,451,958	2,927,509,875	8,983
1993–1996	SDCWA	3	22,420	119	2,667,980	306,873,750	942
1992–1996	C/WBMUD	3	13,264	119	1,578,416	181,551,000	557
Total			**249,566**		**29,698,354**	**3,415,934,625**	**10,482**

CBO Distribution of ULFTs in Northern California

Year	Water Agency	No. of CBO Sites	No. of Special Event Sites	ULFTs Distributed	Utility Cost per ULFT ($s)	Total Cost ($s)	Estimated Annual Savings (gallons)	Estimated Annual Savings (AF)
1995–1996	MMWD	1	5	2,700	119	321,300	36,956,250	113
1996–1997	MMWD	1	4	2,178	119	259,182	29,811,375	91
1996	CCWD	1		400	119	47,600	5,475,000	17
1997	CCWD	1	7	1,000	119	119,000	13,687,500	42
1996	City of Sonoma		1	1,000	119	119,000	13,687,500	42
1997	City of Sonoma		1	817	119	97,223	11,182,688	34
1997	City of Santa Rosa		5	3,200	119	380,800	43,800,000	134
1997	City of Rohnert Park		1	850	119	101,150	11,634,375	36
Total				**12,145**		**1,445,255**	**166,234,688**	**510**

High School Programs (Southern California)

Year	Water Agency	No. of Schools	ULFTs Distributed	Utility Cost per ULFT ($s)	Total Cost ($s)	Estimated Annual Savings (gallons)	Estimated Annual Savings (AF)
1994	LADWP	13	10,248	119	1,219,512	140,269,500	430
1994	Anaheim	3	2,800	119	333,200	38,325,000	118
1995	Pasadena	2	2,481	119	295,239	33,958,688	104
1996	Arden Cordova	1	550	119	65,450	7,528,125	23
Total			**16,079**		**1,913,401**	**220,081,313**	**675**

Special Events Programs

Year	Water Agency	Organization Name	ULFTs Distributed	Utility Cost per ULFT ($s)	Total Cost ($s)	Estimated Annual Savings (gallons)	Estimated Annual Savings (AF)
1993	EMWD	Hemet Seniors Group	1,200	119	142,800	16,425,000	50
1995	MMWD	*Marin AIDS Project*	750	119	89,250	10,265,625	31
1996	EMWD	Hermandad Mexicana Nacional	905	119	107,695	12,387,188	38
Total			**2,855**		**339,745**	**39,077,813**	**120**

Source: CTSI

computer program for producing the school newspaper (West Basin Annual Report 1996).

In Northern California, high school students have distributed close to 10,000 ULFTs. The money they earn—$15 per toilet—has been used to improve school facilities and support school events. In Santa Rosa, nine high schools have distributed 6,200 ULFTs in 13 events since the spring of 1997; this program supplements the city of Santa Rosa's existing rebate program (Sanchez 1998). The schools have raised $91,500, which is helping fund a multitude of extra-curricular activities and equipment. So far, 25 percent of Santa Rosa's old toilets have been replaced with ULFTs, and the school program is set to run a third year.

Cost-Effectiveness

While agency expenses per CBO ULFT are somewhat greater than for non-CBO ULFTs ($119 for a CBO ULFT compared to $79 for a "co-pay" ULFT for example), the payoffs in water savings make CBO ULFTs cost-effective. A study performed for MWD indicated that at 45.1 gallons per day, the average per-ULFT savings of CBO programs is slightly higher than the 40.3 gallons saved by non-CBO ULFT multi-family households, and nearly double the 21.6 gallons per ULFT saved by non-CBO single-family households (Chesnutt, et al. 1994).

CBO ULFTs offer a higher per-toilet water savings than non-CBO ULFTs for a number of reasons. CBO households tend to have a greater number of people living in them—approximately 4.3 compared to 2.85 for non-CBO single-family households—and fewer toilets—1.3 compared to the 1.5 of non-CBO households. Generally, as the number of toilets in a home increases, water savings per toilet decreases, in part because some toilets receive greater use than others (Chesnutt, et al. 1994). CBO homes also tend to be older, with older, less efficient toilets. Without the strong financial and community-benefits incentives of the CBO programs, many low-income CBO households would probably not replace their toilets at all. Studies of toilet rebate programs in low-income communities have shown that the prospect of purchasing a toilet and waiting six to eight weeks for a rebate (as in a non-CBO program) is much less inviting than the no-cost CBO programs. Plus, since CBO employees are community residents, they are able to anticipate and respond to the concerns of participants in an empathetic manner. Another, less quantifiable benefit to water agencies from CBO programs is improved community perception of the agency. Few agencies would dispute the value of better agency–community relations.

Table 5-2

Estimated Net Water Savings in Gallons per ULFT per Day

Program	Water Savings
Single-Family Households (non-CBO)	21.6
Multi-Family Unit (non-CBO)	40.3
CBO-Participating Households (average)	45.1

Source: Chesnutt, et al. 1994

Even without these benefits, CBO ULFT programs are still cost-effective for agencies. In a study of one million ULFTs installed between 1989 and 1996, MWD estimated its accrued annual water savings to be around 37,000 af[3] (Hollis 1998). Since MWD estimates its avoided costs to be $154 per acre foot (this represents only the cost of pumping an additional acre-foot), it saved at least $5.7 million through the installation of ULFTs. In Northern California, the Marin Municipal Water District (MMWD) estimates the marginal cost of importing an additional acre-foot of water to be $1,241 per acre-foot. In calculating that cost, MMWD took into account the true costs of developing new supply—the new infrastructure that would need to be built, the estimated lifespan of that infrastructure, the increased energy costs to pump the water, and the cost of acquiring water from an outside source and treating it (Fryer 1998). Having installed over 30,000 ULFTs since 1994, MMWD has saved over 7,000 acre-feet of water, and an estimated $372,300 in the avoided cost of new supply.

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[3] Accrued annual savings also takes into account water savings from earlier years.

CTSI Criteria for Selecting the Right CBO Partner

- Knowledge and understanding of the community
- Close ties to the community
- Other community programs
- Knowledge of pertinent community issues
- Sincere commitment to and enthusiasm for supporting community struggles
- Ability and willingness to commit the necessary resources critical to the success of the project
- Community reputation
- Ability to commit a dedicated project manager to the project
- Insurance and liability coverage
- Location and space to store and manage the toilets

Source: Adapted from Sanchez [illegible] Sanchez

Considerations in Planning ULFT Projects

Because the CBO bears the responsibility for implementing the ULFT project, the success of the water agency-CBO partnership and the project rests on selecting the appropriate CBO. A critical player in many of these partnerships and projects has been CTSI, a private company committed to the promotion of conservation and community, which has developed criteria to aid water agencies in identifying and selecting good CBOs for them to partner with. The right CBO will understand and have strong ties to the community, as well as the capacity and resources to implement the project (see sidebar). To date, CTSI has participated in every CBO project in California as well as many of the school distribution programs.

Planning a ULFT project requires many meetings between agencies and CBOs to identify needs and objectives and determine the most effective methods of achieving both agency and community goals. Experienced facilitators like CTSI can be very helpful in this process and in getting the program off the ground, particularly since many CBOs lack the start-up operating capital to cover up-front program costs, which can include opening a program office, acquiring office equipment, and hiring and training staff. The problem is frequently exacerbated by the lag between the time the first set of ULFTs are installed and receipt of payment from the water agency—up to four weeks. CTSI Corporation helps bridge the start-up-financing gap by working with CBOs to develop financial plans and by procuring the necessary start-up capital.

Successful ULFT programs begin with a sound marketing plan developed by the CBO and implemented through community networks and door-to-door canvassing. The plan should not only include promotional materials tailored to meet the targeted community's needs, but also incorporate materials on the economic and environmental benefits of the program. Most residents in East Los Angeles were eager to support MELASI's program when they realized they would receive a new toilet at no cost, save a minimum of $35 per year on their water bills, and support community activities (Lerner 1997).

Conclusions/Lessons Learned

Good things happen when CBOs partner with water agencies, municipal utilities, and facilitators to develop community-based water conservation programs. As seen in the examples in this study, community involvement can greatly enhance the effectiveness of water agency conservation programs. CBO ULFT programs are cost-effective tools that improve water management and reliability by promoting conservation. They also generate substantial community benefits, including new jobs and revenues for supporting community programs. More importantly, CBO ULFT programs can be replicated and tailored to meet water agency conservation goals and the needs of different communities, regardless of their size or demographic makeup. By partnering with CBOs, water agencies save water cost-effectively, help rebuild communities, and enhance their community image. CBO–water agency partnerships create direct economic and social benefits for communities, while helping to protect and wisely manage California's water resources.

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West Basin Municipal Water District

References

Chesnutt, T. W., C.N. McSpadden, and A. Bamezai. 1994. *Ultra Low Flush Toilet Programs: Evaluation of Program Outcomes and Water Savings; November 1994. A Report Submitted to the Metropolitan Water District of Southern California.* A & N Technical Services, Inc., Santa Monica, CA and Washington, DC.

CTSI Corporation. Undated. *Combined Fact Sheet.* San Rafael, CA.

CTSI Corporation. Undated. *Community Based ULFT Retrofit Programs.* San Rafael, CA.

CTSI Corporation. Undated. *Ultra-Low Flush Toilet Distribution Programs Factsheets.* San Rafael, CA.

Fryer, J. 1998. Marin Municipal Water District. Corte Madera, CA. Personal communications.

Frequently-Asked ULFT Questions

What is a ULFT? Ultra-Low-Flush-Toilets are toilets that look and work the same as conventional toilets. The difference, however, is that they use only 1.6 gpf (gallons per flush) compared to the old standard, less efficient toilets that use 3.5 to 7 gpf.

Are ULFTs more dependable than older toilets? In 1983, state law required that toilets sold in California use no more than 3.5 gpf. To comply, toilet manufacturers essentially put a smaller tank on the same bowl—with mixed results. Since then, however, ULFTs have been completely redesigned, are required to comply with the performance standards of the American National Standards Institute, and, with a more advanced flushing mechanism, work reliably and consistently with only 1.6 gpf.

Can ULFTs be installed like a conventional toilet? ULFTs are installed just like conventional toilets and require no additional tools or hookups, making them ideal for installing during remodeling and new construction.

How much water can I save by switching to an ULFT? Officials at the Los Angeles Department of Water and Power calculate that each resident who uses an ULFT saves 14 gallons of water per day.

Will I ever need to double-flush to wash away wastes? Double flushing with today's ULFTs is seldom needed. ULFTs must meet the same stringent drain line carry requirements as conventional toilets. Even if two flushes are occasionally required, less water is still used than in one flush of a conventional toilet.

Do ULFTs require more cleaning than conventional toilets? No. As with conventional toilets, the flushing action of ULFTs washes the bowl quickly and efficiently.

Do ULFTs cost more? As with older toilets, ULFT prices can vary greatly. Many models start at about $100, but decorator models can run as high as $400 or more. Because many urban water agencies now provide rebates, or provide ULFTs free of charge through CBO programs, the cost to a customer can be substantially less than the normal purchase price.

Are these toilets available in many colors and styles? ULFTs can be purchased in the same spectrum of decorator colors or styles as conventional toilets.

Are ULFTs required by law? As of 1992, California requires ULFTs in all new construction. As part of the 1992 National Energy Policy Act, all toilets sold for residential use must be ULFTs. These requirements were passed to promote water conservation and efficiency. The city of Los Angeles recently passed an ordinance requiring customers to replace their old toilets with ULFTs when selling their homes.

Source: CTSI

Hamilton, F. 1992. "Saving Water & Making Jobs." *Water Conservation News.* Sacramento, CA: Department of Water Resources. October.

Hamilton, F. and J. P.Craft. Undated. CTSI Corporation. *Dynamic Community Programming for Water Efficiency.* San Rafael, CA.

Hollis, M. 1998. Metropolitan Water District. Los Angeles, CA. Personal communications.

Lerner, S. 1997. *Eco-Pioneers, Practical Visionaries Solving Today's Environmental Problems.* Cambridge, MA: The MIT Press.

Sanchez, F. and J. Sanchez. Undated. CTSI Corporation. *Step-By-Step: How to Deliver Conservation Services Using Community Organizations.* San Rafael, CA.

Sanchez J. 1998. CTSI Corporation. Personal communications.

West Basin Municipal Water District. 1996. *Annual Report.* Carson, CA.

Chapter 6

An Overview of Water-Efficiency Potential in the CII Sector

Robert Wilkinson, Arlene K. Wong, and Lisa Owens-Viani

Introduction

Water managers typically identify urban water use in a broad category called *municipal and industrial* (M&I), which generally includes residential uses, as well as commercial, institutional, industrial, and municipal uses. An important sub-set of M&I water use is the non-residential category of *commercial, industrial, and institutional* (CII) users.

According to a California Department of Water Resources (DWR) estimate, in 1990, the CII sector accounted for about 32 percent of all urban water use, with 18 and 9 percent attributed to commercial and industrial uses respectively (DWR 1994). While the potential to increase water-use efficiency in the residential sector has received the most attention, the potential in other urban sectors is less well understood, possibly due in part to the large variety of water uses, technologies, and processes in those sectors. However, recent surveys and actual experiences at specific sites suggest that significant opportunities exist in each of these sectors for efficiency improvements and cost savings. The cluster of case studies that follow this overview include a major CII audit program conducted by the Metropolitan Water District of Southern California (MWD), and specific cases on efficiencies achieved at the San Diego Naval Aviation Depot, UC Santa Barbara, and Oberti Olives in Madera, California.

Definitions

Various definitions of specific water uses and different methodologies have been used by analysts to classify water uses in the CII sector.[1] For the purposes of the present analysis, the following CII uses are defined (adapted from Pike 1994 and 1997) as follows:

> *Commercial* water use includes water for motels, hotels, restaurants, office buildings, and other commercial facilities.
>
> *Industrial* water use includes water for industrial processes such as fabrication, processing, washing, and cooling.
>
> *Institutional* water use includes indoor and outdoor uses at schools, colleges, universities, churches, hospitals, and government facilities.
>
> *Municipal* use includes water system management, fire suppression, and outdoor landscape irrigation in public parks.

Significant Water-Efficiency Potential

Conservation programs often identify water savings for these sectors on a site-specific basis, and care must be taken in generalizing results to an entire sector, or even within a subsector. Two recent studies have attempted to estimate the potential CII sector savings—an audit program sponsored by MWD for its service area (described in more detail in one of the following case studies), and a study, sponsored by the U.S. Environmental Protection Agency (EPA)

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[1] There are various definitions of commercial and other categories of M&I water use. One of the most comprehensive lists and perhaps the best basis available for categorization of commercial uses is found in Pike, C.W. 1997, "Study of Potential Water Efficiency Improvements in Commercial Businesses," Final Report, U.S. Environmental Protection Agency/DWR, April, Table 1, pp.2-5. The U.S. Geological Survey lists water uses according to a categorization scheme. A study by MWD and ERI Services disaggregates the CII categories slightly differently for an extensive analysis of the sectors in Southern California. See Sweeten, Jon, and Ben Chaput, "Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector," paper delivered to AWWA, June 1997.

and written by DWR, of the commercial sector applying data from three audit programs (a total of 744 audits),[2] to 12 utility service areas nationwide (seven in California).

In MWD's service area, CII accounts for about 25 percent of water use, and efficiency potential is estimated at 23 to 29 percent, based on MWD's analysis of over 900 audits (Sweeten and Chaput 1997) (see *The MWD Audit Program,* Chapter 7). MWD's findings are consistent with the DWR study, in which investigators concluded that "commercial water-use volume may be cost-effectively reduced by approximately 22 percent." Table 6-1, adapted from that analysis, shows the average potential water savings (as percent reduction in annual use) for different types of businesses, which include most commercial and institutional uses. On average, potential savings for the sector ranged from 20 to 25 percent across the 12 utility areas (Pike 1997).[3]

According to DWR's analysis of commercial institutions, the potential for water savings (in terms of percent volume reduction) is greatest in the following categories: offices, health care, sales, eating and drinking, hotels and accommodations, education, landscape irrigation, laundries, and meeting and recreation facilities. Not surprisingly, DWR found these categories to be the largest water users. These findings support the commonly held belief that a few CII users use most of the water and that some sectors offer greater savings opportunities than others. The MWD pilot was also based on the understanding that 80 percent of the water is used by 20 percent of the customers (Sweeten and Chaput 1997). From the standpoint of water managers seeking to facilitate and support efficiency improvements, focusing on large volume users or particular sectors makes sense.

Building on Past Water-Efficiency Improvements

In assessing the potential for future efficiency improvements in the CII sector, it is important to recognize that by the late 1980s many firms and institutions had already demonstrated dramatic savings. Some have used these past improvements to suggest that the opportunities for additional reductions are limited. Recent analyses, however, indicate that many opportunities still exist for highly cost-effective efficiency improvements. Several lessons are evident. One is that new ideas and technologies continue to improve the cost-effectiveness of efficiency measures. Second, many CII users have never implemented even the most basic efficiency improvements. Third, many improvements are the result of careful analysis as well as overcoming "human" (versus technological or economic) factors—i.e. changing behavior—in many public and private institutions.

It is also worth noting that the water-efficiency potentials estimated in the EPA/DWR and MWD studies are conservative. The economic criteria used for efficiency measures reflect short payback periods by traditional economic standards (the simple payback period for all recommendations in the 900 MWD audits was 1.7 years). The conservation recommendations primarily involve simple technological improvements or modest changes to management or behavior. Examples of water-efficiency achievements for specific sites show that modest estimates are routinely surpassed. Firms that decide to take aggressive measures can have tremendous results while still meeting their own criteria for cost-effectiveness. A few examples of past CII savings are worth noting as background:

A Dow Chemical plant in Pittsburgh, California reduced water use by 95 percent between 1972 and the mid-1980s (Maddaus 1987).

A 1979 "Review of Water Conservation in the City of Los Angeles" conducted by Brown and Caldwell (prepared for LADWP) found that "45 businesses reduced water

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[2] Audits were conducted by MWD (which provided a majority of the data), the city of Tucson, Arizona, and the Massachusetts Water Resources Authority.

[3] In the EPA/DWR study, data from the audits were used to estimate savings for different commercial sectors. Average savings for the different sectors were then applied to commercial profiles of the 12 utility service areas.

Table 6-1

Average Potential Savings for Commercial and Institutional Categories

Type of Business	Number of Site Audits	Average Savings (%)	Standard Deviation
Car wash	12	27	24
Church–nonprofit	19	31	17
Communications & research	10	18	22
Corrections	2	20	6
Eating and drinking places	102	27	14
Education	168	20	16
Healthcare	90	22	14
Hospitality*	222	22	13
Hotel & accommodations	120	17	11
Landscape irrigation	6	26	19
Laundries	22	15	17
Meeting/recreation	20	27	21
Military	1	9	–
Offices	19	28	17
Sales	56	27	15
Transportation & fuels	24	31	20
Vehicle dealers & services	12	17	10
Total Sites	**741**		

**Hospitality includes "eating & drinking" and "hotels & accommodations"*
Source: Pike (EPA/DWR study) 1997

use an average of 45 percent during California's 1976-1977 drought." Savings of over 50 percent were reported as follows: Standard Nickel-Chromium Plating Company (79 percent); Anheuser-Busch (63 percent); National Standard Company (63 percent); Tyre Brothers Glass Company (56 percent); and Airesearch Manufacturing Company (50 percent) (cited in Maddaus 1987).[4]

EBMUD conducted a survey of its industrial customers after they had achieved higher-than-expected water savings. In 1988, EBMUD requested its industrial customers to reduce water use nine percent from 1986 levels. Industry cut back by more than three times that much (28 percent). A year later the district again requested that industrial users cut back five percent from the same 1986 base (e.g., to even lower levels). The result was a savings of more than five times the requested amount (26 percent) (EBMUD 1990).

A study of 15 companies in San Jose, California conducted by Brown and Caldwell and DWR found that "Conservation measures[5] effectively reduced water use at the (15) case study companies, with 'typical reductions' of 30 percent to 40 percent of pre-conservation use." The 1990 study found that the payback period for capital investment was usually less than one year, with average savings of $50,000 per year and over $100,000 per year for some companies. Finally, the report concluded that

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[4] Citing DWR, *A Pilot Conservation Bill*, Bulletin #191, and Brown and Caldwell, June 1979, *Review of Water Conservation in the City of Los Angeles*.

[5] Measures included monitoring, employee education, recycling with advanced treatment, reuse, cooling tower recirculation and ozonation, air cooling, modifying and choosing more efficient equipment, optimizing processes, using closed-loop systems, improving irrigation techniques, modifying landscapes, and installing low-flow plumbing (Pike 1994).

> "The cost-effective water conservation measures successfully used at the case study facilities can readily be adopted by other facilities and other industries" (Brown and Caldwell 1990).

In response to drought conditions, the city of San Luis Obispo achieved savings of 40 percent in its government facilities through a combination of leak repair, irrigation improvements, and other measures. Specific savings for governmental uses in San Luis Obispo are as follows:

buildings	42%
trees	31%
library	54%
parks	57%
golf course	55%
swimming pool	52%
police building	73%
fire buildings	87%
bus yard	88%
Total savings	**57%**

The average savings for governmental uses in San Luis Obispo was 57 percent for the six-month period from May through October 1990 (Munds 1997).

Tapping the Potential

As demand management continues to grow in importance as a water management tool, it becomes increasingly important to target the CII sector. The Best Management Practices (BMPs) established by urban water agencies requires that agencies reduce CII demand by 10 percent of their 1989 baseline within 10 years. BMP #9 first stipulates that agencies, at a minimum, support CII water conservation by offering audits and incentives to the top 10 percent of industrial, commercial, and institutional customers, providing follow-up audits at least once every five years if necessary.

Some agencies have developed water conservation programs for the CII sector utilizing a combination of audits, financial incentives, water rate structures, and educational programs. The following examples, while not exhaustive, illustrate the range of programs in place and the positive water savings achieved.

MWD followed its audit program with a menu of rebates available to CII customers who undertake water-efficiency improvements. MWD offers customers fixed rebates for retrofitting or replacing toilets or urinals, and for installing flush valves, pre-rinse spray heads, conductivity meters on cooling towers, or horizontal-axis washers.

The East Bay Municipal Utility District (EBMUD) offers both audit and rebate programs to CII customers. Audits for commercial and institutional customers have been offered since 1986 and for industrial customers since 1991. Audits consist of a review of the customer's consumption history, an interview with a facility manager or engineer, and a walk-through of the facility to assess conservation potential. The auditor provides general recommendations and assistance in developing a benefit-cost analysis of identified conservation measures. The rebate program, implemented in Fiscal Years 1996 and 1997, offers rebates to offset part of the initial cost of hardware upgrades or retrofits identified in the audits and expected to result in significant savings. Rebates are calculated based on an estimated water savings rate of $0.73 per billing unit (748 gallons)—or $318 per acre-foot—of water saved and may cover up to half of the installation cost of an eligible conservation measure. Rebates are offered to all customers who apply, subject to the availability of funds. Applications are evaluated on a first come/first serve-basis. As of August 1998, 514 audits had been conducted and 39 rebates, totaling $283,759, awarded. The amount of water saved as of August 1998 is estimated to total over 966,000 gallons—or 1,083 acre-feet—per day. EBMUD's Industrial Water Conservation Representative Mike Hazinski cautions that the rate of water savings from efficiency measures can begin to decrease over time, due to the limited life span of equipment, but he also points out that the overall rate of savings from these measures remains high because new equipment continues to be installed (Hazinski 1998). He notes that for continued optimum performance of water-conserving equipment, employees must be trained to regularly monitor and maintain it. EBMUD considers the rebate program one of the two most cost-effective components of its Water Conservation Management Plan.

In October 1990, motivated by a state mandate to reduce discharges into San Francisco Bay from its wastewater treatment plant, the city of San Jose's Environmental Services Department implemented a Financial Incentive Program for commercial and industrial users. While the primary motivation behind the program is to reduce wastewater, rather than to conserve water per se, the net result is the same—less water is used. To qualify, proposed projects must reduce wastewater by 1,496 gallons per year, and equipment must be purchased or leased within six months of the project being approved by the city. Equipment must have a life expectancy of no less than five years, and leases must cover a minimum period of three years.

At first, the amount of the awards was based on the city's avoided cost of treating the amount of water the new equipment would conserve, as well as its avoided cost of expanding its wastewater treatment plant. The city determined its (avoided cost) savings to be $1,000 per acre-foot, and initially offered customers $435 per acre-foot saved. However, in October 1991, they doubled the incentive, to $870 per acre-foot, to encourage more companies to apply. In 1998, the incentive is again being doubled, to $1,740 per acre foot; the percent of a project's capital costs paid increased from 30 to 50 percent; and the $20,000 maximum award increased to $50,000 per project (Wilson 1998). Although these incentive amounts are greater than the city's avoided costs, according to Melody Tovar, who manages the CII incentive program, they are still cost-effective when compared to the city's reclaimed and other water conservation programs, such as ULFTs. To date, 39 projects have been completed, with an estimated water savings of close to two acre-feet per day, and $297,000 in rebates have been disbursed. Fourteen projects are currently in progress, which will save another estimated 1.5 acre-feet per day.

In 1988, the city of Palo Alto was ordered by the San Francisco Water Department (its chief water supplier) to reduce its annual water use by 25 percent. In response, the city initiated a pilot Water Efficiency Program in September 1991 that included a water audit program for industrial facilities, which represented approximately 19 percent of the city's total water consumption. Limited to a $5,000 budget for the pilot study, the city decided to focus the study on internal plant operations, examining toilets and faucets, heating, venting, and air conditioning (HVAC) systems, and processing applications (materials transportation, rinse baths, lubrication systems, and chemicals) (Zamost 1993). The city chose three companies from the responses to its mailing describing the audit program. The companies—an ice cream plant, a pharmaceutical company, and an electronic components manufacturer—each implemented some of the changes recommended during the audits, and the pilot program was successful enough that the Utilities Director approved an annual budget of $20,000 for an ongoing water audit program. The Water Efficiency Program also included a $10,000 rebate for CII customers who significantly reduced their water usage by installing water-efficient equipment. Palo Alto's conservation programs (CII and residential) were so successful that the city reduced its overall water consumption by 35 percent (Zamost 1993). Unfortunately, the rebate program was discontinued because as demand decreased, revenues were lost (Waik 1998). Although indoor efficiency audits are still performed, the focus in the CII sector has shifted to large landscape water-users, with high-tech audits conducted from planes. One successful result of the pilot study, however, was the city's passage of an ordinance prohibiting the installation of once-through cooling systems (Waik 1998).

Since 1992, the Contra Costa Water District (CCWD), both a water wholesaler and retailer to over 400,000 users, has offered free audits to all of its CII customers, and performs an average of 200 audits per year. CCWD also offers financial incentives to commercial customers for upgrading selected plumbing fixtures, machines, and HVAC equipment. The incentives include $75 for each low-flush toilet, horizontal-axis washing machine, or commercial dishwasher using no more than 1.6 gallons per rack installed; $200 for each conductivity meter installed (conductivity meters automate cooling tower bleed water); and half of the cost, up to $500, of each pressure washer or recirculating pump installed. Funds are available on a first-come/first-serve basis. After the customer receives an audit and a project is approved, the customer has one year in which to upgrade the equipment. According to CCWD Water Conservation Specialist Ray Cardwell, when Safeway installed conductivity meters at its seven stores in the CCWD service area that use cooling towers, average water use by those stores dropped from 3,000 gallons per day (gpd) to 300 gpd, resulting in a payback period of less than one month. The Safeway program was a joint effort between Pacific Gas & Electric and CCWD that took two years to implement. Cardwell comments that one of the biggest challenges in implementing these programs is convincing corporate decisionmakers of their value, since the cost of water is not usually a huge motivating factor. When a project involves cooling towers, Cardwell is sometimes able to convince decisionmakers to implement the project based on the savings they will see from reductions in chemical use: re-using cooling tower water reduces the need for chemicals to treat new water.

CCWD also offers landscape audits for its CII customers, and a cost-sharing program for parks, business complexes, and commercial sites to upgrade their irrigation equipment. CCWD is also part of the Green Business Program, a coalition of 12 government agencies that works with Bay Area businesses to upgrade equipment like irrigation timers, washing machines, conductivity meters, etc. The program pays up to 50 percent of the material cost of water-conserving equipment (Cardwell 1998). Cardwell says the main barrier to participation in this program is fear of governmental regulation or penalties for some type of environmental violation that might be discovered while the audits are being performed. To allay these fears, the agencies offer an "amnesty" program—if violations are found when the customer has come forward to participate, the customer is not fined but given a courtesy "ticket" and the opportunity to fix any violation.

Conclusions/Lessons Learned

It is obvious that significant water conservation potential exists in the CII sector, a potential that many California municipalities have begun to tap. It is also obvious, however, that achieving conservation in this sector relies on raising awareness and motivating customers. Because the sense of urgency for water conservation is not high for many customers, conservation programs need to focus on outreach and establishing strong working relationships to promote continuing employee education and equipment maintenance, as well as pricing incentives or disincentives.

Like this overview, MWD's audit program, provided in detail in the following case, highlights some of difficulties of targeting the CII sector, as well as the potential benefits. Three additional cases provide examples of institutions that have undertaken water-efficiency improvements with great success. In each, the organization was motivated by regulatory actions or other legal constraints that brought a sense of urgency to the need to address water use: UC Santa Barbara needed to reduce water use because of a legal agreement with the local water district establishing a maximum yearly allocation; the San Diego Naval Aviation Depot was responding to a water conservation mandate from the Chief of Naval Operations as well as other federal mandates to reduce energy consumption and waste; Oberti Olives was required by the Regional Water Quality Control Board to reduce wastewater discharges.

Absent an environment that makes water conservation particularly salient to customers, water agencies must develop other tools to convince CII customers of the value of improving water efficiency. Several agencies have established pricing signals—in the form of tiered water rates—for CII customers. Others, like those described in this overview, are developing outreach programs and incentive programs to educate and assist CII customers.

In truth, the conditions that motivated UC Santa Barbara, the San Diego Naval Depot, and Oberti Olives to take action are unlikely to abate, and in fact, are likely to increase. Many water conservation program coordinators in the CII sector point out the connection between water quality issues and efficiency measures, a connection they see becoming increasingly important in the future. As wastewater regulations grow more stringent, particularly as TMDLs (Total Maximum Discharge Limits)[6] and other regulatory measures are established, the motivation for many agencies and municipalities to conserve water—before it becomes a discharge problem—will be greater. Similarly, as water supplies continue to grow scarcer, it will be increasingly important for demand-side management activities to tap the potential savings in the CII sector.

Contacts

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References

Brown and Caldwell. 1990. *Case Studies of Industrial Water Conservation in the San Jose Area.*

California Department of Water Resources (DWR). 1994. *"California Water Plan Update." Final Bulletin 160-93.* Sacramento, CA.

Cardwell, Ray. 1998. Contra Costa Water District. Martinez, CA. Personal communications.

ERI Services, Inc. 1997. "Commercial, Industrial and Institutional Water Conservation Program, 1991–1996." Prepared for Metropolitan Water District of Southern California. Irvine, CA.

EBMUD. 1990. "Industrial Water Conservation." October.

Hagler Bailly Services, Inc. 1997. "Evaluation of the MWD CII Survey Database." Prepared for Metropolitan Water District of Southern California. San Francisco, CA.

Hazinski, M. 1998. East Bay Municipal Utility District. Oakland, CA. Personal communications.

Maddaus, W. O. 1987. *Water Conservation.* American Water Works Association.

Munds, R. 1997. City of San Luis Obispo, CA. Personal communications.

Pike, C. W. 1994. "Water Efficiency Guide for Business Managers and Facility Engineers," California Department of Water Resources. Sacramento, CA. October.

Pike, C. W. 1997. "Study of Potential Water Efficiency Improvements in Commercial Businesses," Final Report, U.S. Environmental Protection Agency/California Department of Water Resources. April.

Rahlmann, R.K. 1993. "Offer Financial Incentives for Industrial Water Conservation," *Building Sustainable Communities Water Efficiency Series.* The Global Cities Project. San Francisco, CA.

Sweeten J. and B. Chaput. 1997. "Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector," paper presented to AWWA conference. June 1997.

Tovar, M. 1998. City of San Jose. Personal communications.

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[6] New federal standards for discharge limits under the Clean Water Act.

Waik, V. 1998. City of Palo Alto. Personal communications.

Wilson, E. 1998. City of San Jose. Personal communications.

Zamost, B. 1993. "Offer Water Audits for Business and Industry," *Building Sustainable Communities Water Efficiency Series*, The Global Cities Project. San Francisco, CA.

Chapter 7

Assessing Commercial, Industrial, and Institutional Water Efficiency Potential: The MWD Audit Program

Robert Wilkinson and Arlene K. Wong

Introduction

In 1991, the Metropolitan Water District of Southern California (MWD), in conjunction with its member agencies, initiated a major water-efficiency improvement program in the commercial, industrial, and institutional (CII) sector involving water audit support, analysis, and recommendations. During its five-year life, the program audited over 900 commercial, industrial, and institutional water users in MWD's service area. Results from these surveys are believed to represent the largest and most extensive database on this sector developed to date, providing valuable information on water use, water savings potential, and future implementation of conservation programs.

The survey work identified cost-effective water savings potential of 29 percent for all facilities studied, 23 percent when two wastewater treatment plants were excluded as outliers. Potential savings were higher than expected. The large sample size has also allowed for valuable analysis of water-savings potential by industry or commercial sector and by conservation measure. A follow-up phone survey of 605 customers (representing 69 percent of total surveyed water use) indicated that water savings from self-reported efficiency improvements implemented after the audits are 3,080 million gallons over the lifetime of the measures installed, which is 26 percent of the potential lifetime water savings identified (Hagler Bailly Services 1997).

Background

Comprised of commercial, industrial, and institutional (including governmental) water users, the CII sector represents a significant portion of urban water use in the state. The California Department of Water Resources (DWR) estimated that the CII sector accounted for about 32 percent of urban water use in 1990, with 18 and 9 percent attributed to commercial and industrial uses respectively, totaling over 2.4 million acre-feet (DWR 1994). CII accounts for about one-quarter of the total water use in MWD's service area, which includes 27 member agencies comprising 14 cities, 12 municipal water districts, and 1 county water authority. The service area extends from the city of Oxnard to the Mexican border. The CII sector in MWD's service area includes approximately 35,000 industrial customers and 350,000 commercial customers (Pimental 1996). Despite the obvious value of establishing conservation and efficiency programs in the CII sector, the heterogeneous nature of water uses in this sector has long posed a challenge to water managers and others interested in developing and implementing assessments and efficiency programs. Awareness of water use is often not very high among these customers, and water use is often a very small percentage of total expenses. For industrial customers the rule of thumb is that water costs average less than one percent of a facility's operating costs (Ploeser 1996). One reason to focus on this sector, however, is that a small number of customers use a large percentage of water: an estimated 80 percent of the water is used by 20 percent of the customers (Sweeten and Chaput 1997). From the standpoint of water managers, this concentration greatly increases the prospects for targeted programs to assist large users with efficiency strategies.

In 1989, well into one of the most serious droughts in California's history, MWD established residential conservation programs. By 1991, it looked to develop a program to target commercial, industrial, and institutional customers. The program was developed with technical support from Pequod Associates, Inc. (now ERI Services), and Black and Veatch, and was carried out over the next five years.

The Program

Goals

The primary goal of this program was to provide a water use survey that would identify cost-effective measures for saving water specific to each individual customer, and to provide users with this information so that they could take appropriate steps to be more water-efficient and cost-conscious. Reports included information on individual retail agencies' specific regional rebate programs, but otherwise financial incentives and implementation assistance were not a part of the audit program. An ancillary purpose was for water agencies to develop an understanding of how water is used in the CII sector, so that agencies can better serve CII customers in developing future conservation programs.

Program Description

The audit program went through several changes in its five-year life as adjustments were made to streamline procedures and better respond to agency and customer needs.[1] In the 18-month pilot phase, 15 sites received full water-efficiency studies conducted by a senior engineer. These initial studies targeted high-volume water users, and the average survey cost was $6,500 (ERI Services 1997). Reports to the customer would review the primary water uses, develop a water balance model, and recommend specific measures that would reduce water use. Only those measures that had a simple payback period within the customer's stated tolerance would be recommended (usually five years or less). To provide a complete picture of expected savings, water, sewer, and the water-related energy and chemical costs savings were factored into the payback analysis.

Results from the pilot phase were used to develop certain program assumptions. It was estimated that a commercial or institutional site could feasibly reduce its water use by 15 percent on average, and that an industrial site could reduce its water use by 20 percent. It was also assumed that implementation would likely result in actual savings of only 25 percent of the total potential savings identified, or a total realized savings of about 4 to 5 percent.

MWD fully funded the pilot phase to develop program guidelines. Expansion of the program would require that member agencies and subagencies agree to participate both administratively and financially. Though the initial program design targeted the large, high-volume customers, MWD soon determined that audit surveys should be designed to include smaller customers. The audits for large, high-volume customers required engineering expertise and thus were costly, ranging from $2,000 to $10,000, which reduced an agency's willingness to participate. Also, these customers were often harder to gain access to than anticipated. By offering a range of surveys, requiring varying expertise, the program was able to offer a more cost-effective service to a broader array of customers. The program set 200 ccf per month ("ccf" equals one hundred cubic feet, or about 748 gallons) as the minimum water use for a customer to qualify for participation, for cost-effectiveness reasons.

Three Levels of Survey and Analysis

By designing different survey levels, the program intended to provide each customer with a survey report that was at an appropriate technical level for their site, while still maintaining the cost-effectiveness of the program. Three levels of surveys requiring different levels of expertise were designed: analyst, consultant, and water- management studies. MWD developed a training program for water auditors specifically to carry out the lower-level analyst surveys, recruiting college students and later offering similar training to water agency staff. In addition to the trained auditors, specialists in

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[1] Elements of the program description are largely taken from the ERI Services report detailing the program and ERI's evaluation of the program (ERI Services 1997).

various technical areas were retained to evaluate the higher-use facilities and those with more complicated water-using technologies. The following descriptions of the three levels of surveys are taken from Sweeten and Chaput (1997):

> **Analyst surveys** were conducted by individuals trained specifically for that purpose. They were able to review all sanitary uses, kitchen use, laundry, cleaning, and cooling tower operations. They also made rudimentary observations about landscape water use. The analysts were equipped with hand-held conductivity meters, flow measurement bags, and temperature gauges. Out of the 902 total surveys performed, 699 were analyst surveys. The cost of analyst surveys performed by the service providers ranged between $450 and $725.
>
> **Consultant surveys** were similar to analyst surveys in format and content but required the services of an engineer to evaluate onsite water-use processes that analysts were not trained to critique. Because of the higher cost of such studies and the desire to maintain cost-effectiveness, the minimum water use to merit a consultant was 1,000 ccf/month. A total of 128 consultant surveys were conducted, at a price between $1,000 and $1,725 per study.
>
> A special consultant survey was developed in response to the need to better address the outside landscape water demands. Some sites, such as larger schools or corporate headquarters, didn't necessarily use water in ways more complicated than an analyst survey would warrant, but used a high percentage of the water for irrigation, and thus a certified landscape auditor was brought in to consult. This report covered all of the indoor uses and included a sampling of catch-can tests and other more detailed outdoor water-use evaluations. However, because it was developed later in the program, only a few of these audits were conducted.
>
> **Water-management studies** were the most detailed engineering studies provided. They were employed for sites using more than 4,500 ccf/month, where water was used in technically complex or varied processes, and at large sites that presented a logistical challenge. The entire site, with a special emphasis on the process portions, was evaluated by an engineer. The scope of analysis often included extensive energy and material balances as well. They ranged widely in complexity and also in cost: from $2,800 to $13,500. There were 69 water-management studies conducted in the course of the survey program.

Table 7-1

Summary of the Three Levels of Audits

Level of Water Use	Number of Audits	Range of Cost per Audit
200 + ccf/month	699	$450-725
1,000 ccf/month	128	$1,000-1,725
4,500 ccf/month	69	$2,800-13,500

Agency Participation

Since MWD is a water wholesaler, the CII program required the participation of its member agencies, who retail water to CII customers. Once a retail agency expressed interest in participating, the next step would be to obtain customer billing information to help target the agency's CII program. Categorizing each agency's unique data proved a challenging and time-consuming task. Billing data were analyzed to rank customers by water use and separate them into the three CII sectors so that the appropriate level of survey could be assigned to each site. From this, MWD and the agency could identify the scope of the CII program since the agency needed to establish a budget and contract with MWD. In implementing the program, MWD would work with each agency to establish preferred customer target choices, communication protocols, marketing strategies, and specific agency efficiency and water conservation programs that could be promoted.

During its five-year life, the program went through several distinct phases to solicit agency participation. The pilot phase (September 1991–October 1992) was funded entirely by MWD. Agencies needed only to provide water-use records to allow MWD to screen for potential customer participants. After the pilot phase, program expansion required that member agencies and sub-agencies agree to participate administratively and financially. Three different financial arrangements were offered: 50/50 split cost, "Water for Water" Credits program, and a U.S. Bureau of Reclamation (USBR) grant.

Initially, MWD offered a straightforward 50/50 split, requesting that participating agencies pay for 50 percent of the survey costs. Three agencies participated in this arrangement—San Diego County Water Authority, Irvine Ranch Water District, and Chino Basin Municipal Water District—accounting for approximately 40 percent of the surveys conducted, though initial participation was rather low. In 1993 the drought had just ended, and agencies were concerned with reduced revenue streams and reluctant to embark on new conservation programs (Sweeten and Chaput 1997). There was also the budget cycle lag, where agencies have to submit a line item for CII conservation and get it approved for the following fiscal year (Sweeten and Chaput 1997).

The "Water for Water" Credits Program was created to encourage broader agency participation. MWD offered to provide five analyst training surveys to agencies for free. These would be conducted by the newly trained college students. Agencies were encouraged to financially support additional analyst surveys for which they could earn credits, based on average monthly water use per site. These credits could be redeemed for higher cost consultant surveys or water-efficiency studies paid for by MWD. Six more agencies participated under this arrangement—Eastern Municipal Water District, Municipal Water District of Orange County, Three Valleys Municipal Water District, and the cities of Anaheim, Burbank, and Torrance—accounting for about 20 percent of the program surveys.

In 1996 the USBR provided MWD with a grant to encourage conservation. MWD used the USBR grant to cover part of the local agency's share of survey costs. Thus, MWD covered 50 percent of the cost, the USBR grant contributed 40 percent, and the agency was only responsible for 10 percent. Eight retail agencies signed up under this arrangement, and 255 surveys, over 28 percent of the total, were completed in a nine-month period.

Customer Participation

Based on the initial customer billing analysis, agencies (or the consultant conducting the surveys for the agency) were able to identify those customers who were above the 200 ccf/month threshold and to determine which level of survey was warranted. Most retail agencies chose to have an introductory letter, produced on agency letterhead, sent to the targeted customers prior to the phone call required to schedule a site visit. Despite offering a free service to customers, it was not always easy to get customers to participate. Traditionally, water bills represent less than one percent of overall operating costs at an industrial facility. For this and other reasons, water issues do not often command a sense of urgency for a customer (Sweeten and Chaput 1997).

One of the most significant findings of the audit program was that the success of such programs can be highly influenced by the people conducting the audits—how credibly the auditors present the benefits of the conservation measures and whether or not they present them with a sense of urgency, among other factors. Success stories that demonstrate the high potential for efficiency improvements in the sector usually are ones in which various human elements were overcome. For example, by using professional telemarketers to schedule audits, the program increased its customer acceptance rate from 25 percent to 90 percent! Again, from Sweeten and Chaput (1997), the following tale is worth quoting (emphasis added):

> [L]etters offering the free water-use survey were sent out and followed up with a phone call. This procedure seemed a standard way to invite customers to accept the retail water agency's offer of a survey. The person making the phone call was a critical element in the success rate of the survey program. Initially, either water agency personnel or the engineer attempting to perform the survey would contact the customer. Because the program was voluntary on the part of the busy customer and it may have been hard for them to distinguish between this offer and the variety of other offers made by sales representatives and the like, an acceptance rate of 25 percent was consistently encountered.
>
> To improve the acceptance rate for the surveys, a professional telephone solicitor was employed. The difference in the approach was significant, and so were the results. Acceptance of the offer of a free survey went from 25 percent to 90 percent. How was this done? *The telephone solicitor, when finally in contact with the appropriate person—and this was an endeavor in itself—simply asked when he could schedule a water-use survey visit at this customer's site.* This is in contrast to the more common lead-in where the water agency employee explains why they are conducting such a program and the possible benefits to the customer, followed by a polite inquiry as to their willingness to participate. One water agency staff member used a similar approach to that of the telemarketer and achieved equally impressive results. Clearly, marketing technique is critical in the effectiveness of such a program, and the necessary skills can either be developed in-house or purchased on an as-needed basis.
>
> Another important aspect of the telephone contact is the chance to do some pre-screening of the customer's water uses on-site. Confirmation of the facility's major water uses, amount of landscape, and number of buildings were of primary concern. This can help avoid the occasional mis-typing of a site, such as assuming the site is a grocery store when, in fact, it is the grocery chain's regional production facility for ice cream and bakery products.

Other important factors encountered and worth noting are the following:

- Lack of time to focus on opportunities within firms and institutions due to low priority
- Lack of information regarding both water-saving technologies and economic benefits
- Insufficient support from senior managers/decision-makers
- Capital constraints (though this is often a false calculation based on unreasonable payback/return-on-investment demands)
- Perverse incentives that lead to undervaluation of efficiency improvements

Any conservation program must work to address these factors. While some are dependent on the mindset and priorities of the business, agency programs can seek to address the information gaps and create the relationships and communication structures necessary to ensure the information reaches the right people. As demonstrated in the telemarketing example, the framing of information and delivery of that information can be very important in soliciting a positive response.

Survey Follow Through

Surveys and reports went through several redesigns to streamline the process and reduce the report generation time. Original reports were created from scratch, but later reports relied more on a computer-driven process by using a spreadsheet to supply customer information gathered from the customer billing and survey information and a library of computer-selected text and computational elements. Analyst survey reports initially exceeding 20 hours per site were eventually reduced to 6 to 10 hours when a new template was designed. Consultant surveys required about 10 to 15 hours for report generation. While both analyst and consultant surveys required between 1 and 3 hours to conduct the site visit, full-fledged engineering studies usually required multiple visits and a significantly longer timeframe for report generation.

Reports included a water balance, billing history, recommended water efficiency measures, and their payback periods. Reports were reviewed by a senior engineer or mentor at the consultant firms, MWD staff, and the individual retail agencies. Turnaround time for the reports was a critical factor in keeping the customer engaged in the process (Sweeten and Chaput 1997). Early in the program, turnaround time was often in excess of two months. This was reduced to an average of four weeks as the program developed.

One weakness identified during program evaluation was the method of report delivery and follow-up. Reports were mailed to the customer with no further contact until several months later when a follow-up phone survey to assess implementation was conducted. Sweeten and Chaput (1997) believe that personal delivery of the report and an immediate review of the findings and recommendations with the customer would have been a much more effective means of imparting the contents of the report. They recognize that while such follow-up can add significant costs to the product price when time for scheduling, visits, and travel is considered, it could also greatly improve implementation rates and thus increase water savings achieved.

Finally, the program arranged for a subsequent follow-up phone survey to determine the extent of implementation of the recommendations. Customers were contacted by phone 3 to 24 months after receiving the report. The recommended measures were reviewed and customers were asked whether or not each of the measures had been implemented. If implementation had occurred, an approximate date was requested, and if not, a reason (from a standardized list of reasons for non-implementation) was assigned. Out of 902 surveys conducted, 605 customers were successfully reached for a follow up phone survey, 20 surveys contained no recommended measures for follow-up, 92 customers were considered unreachable, and 185 surveys received no follow-up.

Evaluation of Success

The size and the scope of MWD's audit program produced valuable information about conservation in the CII sector: it conservatively identified potential savings and provided information on water use and potential water savings by both specific sector and type of conservation measure. It also identified various non-technical factors important for making CII audits and efficiency improvements a success.

Potential Savings Exceeded Expectations

Initial estimates of savings potential within the CII sector were 15 percent for the commercial and institutional and 20 percent for the industrial sector. The findings of the program exceeded these estimates by a considerable margin, with an overall potential for 29 percent water savings. This was adjusted to 23 percent when two remarkably heavy water-using wastewater facilities were excluded. Examining the audit results by sector shows the industrial sector with 26 percent identified savings, the commercial sector with 20 percent identified savings, and the institutional sector with 19 percent identified savings (see Table 7-2). Table 7-2 also lists the potential savings for the customer groups in each sector for which the most surveys were conducted.

The study was careful to employ conservative assumptions regarding both the potential of conservation measures and economic feasibility. Only measures within a specified payback period (usually no more than five years) were included. The simple payback period for implementation of all audit recommendations was 1.7 years. Recommendations did not include all available conservation measures, and instead favored the most basic of available options. For example, landscape water efficiency improvements represented nine percent of identified savings and were based solely on adjusting the

Table 7-2
Potential Water Savings by Sector and Selected Large Customer Groups

Customer Group	Number of Surveys	Potential Water Savings[a] (Percent)
Industrial[b]	**183**	**26**
Distribution Centers	20	33
Misc. Food Producers (not incl. Beverages)	19	16
Electronics Manufacturers	16	26
Commercial	**453**	**20**
Hotels/Motels	104	14
Restaurants	93	27
Office Bldgs., Complexes, Strip malls	54	27
Grocery Stores	45	28
Institutional	**264**	**19**
Schools	151	16
Nursing Homes	59	25
Hospitals	22	23

[a] *Assumes all recommendations are implemented. Savings are based on annual water use and annual savings estimates.*

[b] *Industrial total does not include the two wastewater treatment plants.*

frequency and duration of irrigation—probably the most simple of the numerous landscape efficiency options (Sweeten and Chaput 1997). Landscape savings, even with this modest approach, was "a large portion of the potential savings at many sites" in the MWD study. A more comprehensive approach, such as converting CII landscapes and irrigation systems to more water-efficient (and maintenance-efficient) designs, was not included. Using a *technical efficiency potential at current cost-effectiveness* test, a significantly higher water-efficiency potential would be feasible. Similar methods in other areas of the study make 23 percent a very reasonable estimate of water-efficiency potential that is well within the boundaries of cost-effective investment criteria.

The industrial sector represented about 52 percent of the water use in the survey, but it represented about 58 percent of the identified water savings.[2] A number of customer groups in the industrial sector showed water savings potentials well above the sector average of 26 percent, though each had a rather small sample size (see Table 7-3). The tremendous savings from the two wastewater treatment facilities were dropped as outliers in the data. *Each* was capable of saving on the order of one million ccf per year (nearly 2,300 acre feet per year [afy]) for a total of approximately 4,600 afy, reducing water use by 80 percent (Sweeten and Chaput 1997). Though this level of savings is unusual, it is not unique, and it appears that many water districts may have a small number of large water wasters. The primary recommendation in the audits was replacement of once-through cooling systems. Other water utilities have uncovered similar opportunities in other parts of the state. As can be seen in Table 7-3, the high water savings in some of the other industries indicates that basic conservation measures can produce significant savings.

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[2] This calculation was done for 866 of the 902 sites. It does not include 34 nonstandard surveys and the 2 wastewater treatment plants.

Recommended Conservation Measures

ERI Services grouped conservation recommendations into seven major categories: sanitary, irrigation, kitchen, industrial processes, cooling, laundry, and wastewater cooling. Sanitary measures included installing ultra-low flow toilets and showerheads, faucet aerators, and flow straighteners. Irrigation measures consisted primarily of reducing or modifying the frequency and duration of irrigation schedules, or installing controls. Kitchen measures included installing water-saving equipment, reducing the number of dishwasher loads and ensuring loads were full before being run, and replacing equipment. Industrial process measures included adjusting equipment, changing operational practices, installing new equipment and parts, recycling process water, and repairing leaks. Cooling measures primarily involved adjusting blowdown cycles.[3] Laundry measures included loading machines to full capacity and installing horizontal-axis machines. Table 7-4 illustrates the distribution of potential water savings by the conservation measure. Each measure represents a single efficiency category that could be implemented for multiple units; i.e. retrofitting toilets is a single measure that can apply to numerous units. The data indicate that the largest portion of savings can be achieved through changes in industrial processes, followed by changes in wastewater treatment plants, sanitary measures, and irrigation.

Other factors to consider when evaluating conservation measures are the likelihood and ease of implementation, the cost of implementation, and the potential savings at a site. For example, Table 7-5 shows the average potential savings per site for each of the types of measures. Savings potential continues to emphasize the value of industrial process measures, which average 23 percent of the savings identified per site, but also indicates that installing cooling controls (17 percent of savings per site) and horizontal-axis washers (10 percent of savings per site) offer significant savings as well for a site.

Table 7-3
Water Savings Potential for Selected Industries

Customer Group	Number of Surveys	Potential Water Savings[a] (Percent)
Wastewater Treatment	2	81
Petroleum Refineries	2	65
Primary Metal Industry	5	52
Paper Mills/Paper	9	39

[a] *Assumes all recommendations are implemented.*
Source: ERI Services 1997

Table 7-4
Distribution of Water Savings by Conservation Measure for the 902 Sites Surveyed

Measure Type	Number of Times Recommended	Percent of Total Identified Water Savings for All Sites
Industrial processes	316	37
Wastewater cooling	3	32
Sanitary	2,057	17
Irrigation	419	9
Cooling	230	4
Kitchen	402	1
Laundry	103	1

Source: ERI Services 1997

Implementation Results

The overall effectiveness of any conservation program depends on implementation of conservation practices. The follow-up phone survey provided one of the few estimates of implementation rates from audit programs. These implementation results must be approached with caution. Responses by customers have not been verified and therefore are subject to self-reporting biases. It is generally accepted that self-reported implementation rates may be inflated. Without verification, it is also unclear whether implementation was

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[3] A typical cooling tower recirculates water to spray and cool air blown upwards through the tower. Blowdown refers to the release of recirculated water that has grown concentrated with mineral salts. Water released must then be replaced. Blowdown cycles can be adjusted by increasing the concentration of salts before water is released.

Table 7-5
Potential Savings Per Site for Selected Measures

Measure	Number of Times Measure Was Recommended	Average Potential Savings (Percent) per Site for Sites that had Measure Recommended
All industrial process measures	316	23
Cooling: Install new controls	31	17
Laundry: Install horizontal axis washers	10	10
Irrigation: Reduce irrigation schedule time	395	8
Sanitary: Install ultra-low-flush toilets	616	7

Source: ERI Services 1997

effective or durable. On the other hand, the long-term rates of implementation may actually be much higher since the customers may not have had sufficient time to take action on the recommendations between the audit and the follow-up survey. Even with these cautions in mind, the data offer important insights into factors affecting implementation, insights that could be verified with additional study and follow-up.

Hagler Bailly Services conducted a detailed analysis of implementation results for MWD. Hagler Bailly adopted MWD's estimates of each conservation measure's expected life to calculate lifetime savings rather than simply comparing annual use estimates. MWD's lifetime estimates for a given measure ranged from less than a year of savings from changes in behavior to 20 years of savings for changes in hardware such as ultra-low-flush toilets and urinals. The lifetime estimates for other measures ranged from one to five years. Hagler Bailly noted that they felt MWD's lifetime estimates were conservative and underestimated the potential lifetime savings. Reported implementation of specific measures is estimated to have achieved 26 percent of the water savings identified, or about 7 percent of total water use surveyed (Hagler Bailly Services 1997).[4] This exceeded the initial expectation of 4 to 5 percent total savings.

By CII Subsector

It is interesting to examine the breakdown of implementation rates for 16 identified subsectors (Table 7-6). Three of the 16 subsectors achieved over 50 percent of the identified water savings. These results are highly influenced by the types of measures recommended for each subsector and the customer's ability to implement that measure. Despite the industrial subsector's lower implementation rate (20 percent) compared to other subsectors, water savings from this subsector represented over 30 percent of the total lifetime implemented savings.

Customers were asked why they did not implement a recommended conservation measure, and responses were categorized as one of seven reasons. Across all sectors, financial reasons were cited most frequently (by 53 percent), followed by scheduling (16 percent), impracticality (13 percent), no interest (6 percent), report not read (6 percent), availability/labor (4 percent), and low savings (1 percent). Breaking down the responses by subsector shows that "financial reasons" was the most common response for 7 of the 16 subsectors: Education (61 percent); Hospitals (42 percent); Hotels/Motels/Tourist Courts (64 percent); Industrial (63 percent); Offices (47 percent); Recreation (75 percent); Retail/Wholesale (54 percent); and Trucking Terminal Facilities (51 percent). Car Wash (59 percent) and Other (49

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[4] Implementation data relies on analysis by Hagler Bailly Services. Hagler Bailly Services evaluated data from the 605 sites involved in the follow-up telephone surveys.

Table 7-6
Percent of Water Savings Implemented by CII Subsector

CII Subsector	Number of Sites	Identified Savings (ccf/lifetime)	Implemented Savings (ccf/lifetime) Reported	Implementation Rate (Percent of Water Savings Implemented)	Percent of Total Lifetime Implemented Savings
Utilities	7	123,335	113,623	92%	2.8%
Recreation	18	855,874	701,261	82%	17.0%
Car Wash	9	100,855	72,426	72%	1.8%
Hotels/Motels/Tourist Courts	58	894,391	409,862	46%	10.0%
Other	10	159,188	64,562	41%	1.6%
Trucking Terminal Facilities	18	135,762	45,417	33%	1.1%
Education	112	2,311,143	757,879	33%	18.4%
Retail/Wholesale	62	499,203	149,965	30%	3.6%
Offices	37	587,521	159,159	27%	3.9%
Industrial	124	6,368,202	1,242,390	20%	30.2%
Eating and Drinking Places	65	795,523	148,462	19%	3.6%
Hospitals	10	863,349	140,838	16%	3.4%
Government	11	269,272	20,672	8%	0.5%
Laundry, Cleaning, and Garment Services	5	232,346	16,810	7%	0.4%
Nursing and Personal Care Facilities	51	1,317,611	72,170	5%	1.8%
Religious Organizations	8	92,411	2,394	3%	0.1%
Total	**605**	**15,605,986**	**4,117,890**	**26%**	**100.0%**

Source: Hagler Bailly Services 1997

percent) sites not implementing measures listed "report not read" most often. Nursing and Personal Care Facilities (60 percent), Religious Organizations (69 percent), and Utilities (67 percent) cited "scheduling" as the most common reason for not implementing measures. Government sites cited "financial reasons" (41 percent) and "no interest" (52 percent) most often.

By Conservation Measure

An examination of implementation rates by conservation measure identifies those measures where implementation was high, such as "cooling measures" (61 percent implementation), which largely involved adjusting blowdown cycles, and "irrigation measures" (63 percent implementation), which primarily involved reducing irrigation frequency and duration. However, the largest portion of savings came from "sanitary" (63 percent of potential savings) and "other" (30 percent of potential savings), which includes industrial processes. Because ultra-low flow devices were assumed to have the longest lifetime (20 years for new installation; 10 years when using a retrofit kit) and were commonly recommended, sanitary measures accounted for a large portion of potential lifetime water savings with 63 percent of total implemented savings (Table 7-7). (Sanitary measures represented 17 percent of total identified water savings when only annual—instead of lifetime—savings were compared.) This lifetime assumption heavily weighted the value of sanitary measures and emphasized the payoff for taking such measures. For example, it represented over 90 percent of lifetime identified water savings for 11 of 16 subsectors identified by Hagler Bailly (1997), including schools, restaurants, hotels/motels, nursing facilities, office buildings, and retail/wholesale facilities.

Table 7-7

Implementation Rates by Conservation Measure*

Conservation Measure	Identified Savings (ccf/lifetime)	Implemented Savings (ccf/lifetime)	Implementation Rate (Percent of Savings Implemented)	Percent of Total Lifetime Implemented Savings
Cooling	149,337	90,502	61%	2.2%
Irrigation	204,414	128,005	63%	3.1%
Kitchen	92,237	29,759	32%	0.7%
Laundry	356,575	16,750	5%	0.4%
Other	5,411,677	1,249,458	23%	30.3%
Sanitary	9,391,743	2,603,415	28%	63.2%
Total	**15,605,983**	**4,117,889**	**26%**	**100.0%**

**Calculated for the 605 sites with telephone survey results.*

Source: Hagler Bailly Services 1997

Efficiency Improvements Are Highly Cost-Effective

Cost-effective estimates will depend on assumptions about cost of implementation, implementation achieved, and savings from implementation. Estimates of implementation costs were calculated by the survey firms but were not verified with customers. Costs include the direct expenses for retrofits or installation minus any retrofit rebates from water agencies. Water savings estimates were also developed by the survey firms—actual field measurements were not obtained. The total conservation costs to customers for all sites were estimated at $12,500,000, with the potential dollar value of water, sewer, and energy savings at $7,500,000 per year, which represents a simple payback of 1.7 years (ERI Services 1997). Some measures requiring operational changes were assumed to have no investment (such as adjusting the blowdown for cooling towers or rescheduling irrigation times) and therefore were extremely cost-effective. An examination of the sites involved in the follow-up survey shows that the simple payback for all measures was 1.6 years, and the average payback for those measures reported implemented was 0.8 years. It is not surprising that customers would chose to implement those measures with shorter payback periods.

Another measure of cost-effectiveness is the cost to the water agency to achieve savings as compared to other methods of saving water or acquiring supply. Hagler Bailly calculated the cost per acre-foot saved for each subsector by dividing survey costs by reported water savings (over the measures' lifetimes) for the sites in the follow-up survey. Table 7-8 shows that 9 out of the 16 subsectors have a cost per acre-foot of water savings under $100, with the program averaging $74 per acre-foot saved. Direct costs only include survey costs paid to ERI Services and Black & Veatch. They do not include MWD's administrative costs or other indirect costs. Indirect costs for the 605 surveys sampled averaged $62 per acre-foot. Many of the indirect costs were related to program development.

At $74 per acre-foot, and even including indirect costs, the audit program compares extremely well to other supply and demand-management programs.

Conclusions/Lessons Learned

Audits can provide a valuable assessment tool that can allow an agency to better segment the complicated CII market, learn about water use in its service area, and better target efficiency measures. Requiring an initial (and one-time) investment of nearly $2 million, MWD's audit program resulted in a large database that revealed the significant potential water and cost savings available within the CII sector studied by MWD and the study team. With reasonable technical and economic criteria, the study identified water savings potential on the order of one quarter of the sector's use, provid-

Table 7-8
Average Cost Per Acre-Foot Saved

CII Subsector	Number of Sites	Survey Direct Cost Total	Lifetime Reported Implemented Savings (ccf/lifetime)	Average Direct Cost to Agency per Acre-Foot Saved
Recreation	18	$28,215	701,261	$18
Other	10	$4,925	64,562	$33
Utilities	7	$9,500	113,623	$36
Education	112	$80,645	757,879	$46
Hotels, Motels, and Tourist Courts	58	$47,320	409,862	$50
Car Wash	9	$12,200	72,462	$73
Offices	37	$28,775	159,159	$79
Eating and Drinking Places	65	$32,675	148,462	$96
Trucking Terminal Facilities	18	$10,200	45,417	$98
Hospitals	10	$32,625	140,838	$101
Industrial	124	$294,265	1,242,390	$103
Retail/Wholesale	62	$37,050	149,965	$108
Government	11	$9,250	20,672	$195
Laundry, Cleaning, and Garment	5	$10,675	16,810	$277
Nursing and Personal Care	51	$55,950	72,170	$338
Religious Organizations	8	$3,900	2,394	$710
For 605 surveyed sites	**605**	**$698,170**	**4,117,890**	**$74**

Source: Hagler Bailly 1997

ing a benchmark for conservation potential. These savings may not include other measures that could also be cost-effective for customers.

As a water conservation tool, audits can be part of an effective package to motivate and assist customers in making water-efficiency improvements. Implementation of recommended measures reportedly achieved 26 percent of the lifetime water savings identified by MWD's audit program. Lifetime savings for recommended measures were estimated conservatively, and the seven percent total savings rate from measures implemented is expected to yield over 9,000 acre-feet of water over the measures' lifetimes, exceeding program expectations. While these numbers may seem slight, the audit program was conducted absent any aggressive follow-up with customers or financial incentives. Even with only 26 percent implementation, this effort yielded major savings. The return on investment from the audits to MWD and its member agencies is highly competitive with other investments in supply expansion and efficiency improvements.

MWD's five-year experience implementing the audit program also provides a number of lessons for program implementation:

- Pilot projects provided a benchmark to evaluate the effectiveness of the program.
- The program was able to institute changes as information on what succeeded and what failed was accumulated.
- Three levels of audits provide a cost-effective way to increase program flexibility, allowing the program to audit more customers and still tailor reports to meet individual customer needs.
- Incentives to generate agency participation are important.
- Customer participation in audits can be improved by using a more aggressive mar-

keting approach rather than simply offering free audits.

- Customer participation in audits, and ultimately implementation of recommended measures, requires building relationships between auditors and customers, educating customers, and establishing credibility and trust.

Contacts

Jon Sweeten, Metropolitan Water District of Southern California
Ben Chaput, ERI Services
Paul Pimentel, ERI Services

References

California Department of Water Resources (DWR). 1994. *"California Water Plan Update." Final Bulletin 160-93.* Sacramento, CA.

Chaput B. 1997–1998. ERI Services. Irvine, CA. Personal communications.

ERI Services, Inc. 1997. "Commercial, Industrial and Institutional Water Conservation Program, 1991–1996." Prepared for Metropolitan Water District of Southern California. Irvine, CA.

Hagler Bailly Services, Inc. 1997. "Evaluation of the MWD CII Survey Database." Prepared for Metropolitan Water District of Southern California. San Francisco, CA.

Pimentel, P. 1996. "How Well Does ICI Conservation Work?," paper presented to AWWA conference. June 1996.

Ploeser, J. 1996. "Conservation and the Industrial Customer." *Journal AWWA.* January.

Sweeten J. and B. Chaput. 1997. "Identifying the Conservation Opportunities in the Commercial, Industrial, and Institutional Sector," paper presented to AWWA conference. June 1997.

Sweeten, J. 1997–1998. Metropolitan Water District of Southern California. Los Angeles, CA. Personal communications.

Chapter

Increasing Institutional Water-Use Efficiencies: University of California, Santa Barbara Program

Robert Wilkinson

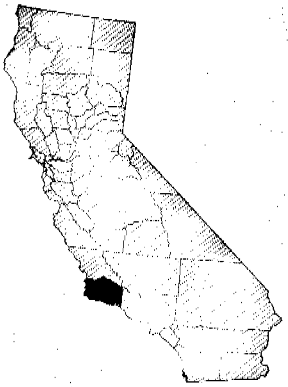
Introduction

The University of California, Santa Barbara (UCSB) campus provides an important institutional example of a comprehensive water efficiency program that led to significant water and cost savings. Total campus water use was reduced by nearly 50 percent between 1987 and 1994, even as the campus population increased (see Figures 8-1 and 8-2). Total cost savings to the campus for the years 1989 through 1996 from efficiency improvements are on the order of $3.7 million, excluding energy and maintenance savings. Capital costs for the efficiency measures are estimated at less than $1 million, and significant elements of the program involved replacing equipment that would have been replaced anyway for maintenance reasons. Construction of new campus facilities, limited by a set water allocation, has been facilitated through these significant water efficiency improvements.[1]

UCSB achieved these significant water, wastewater, and energy savings through a combination of interior and exterior efficiency measures in all areas of campus operations, including residential facilities, food service, irrigation, laundry, instructional and administrative facilities, and other uses. This program, which began prior to the establishment of legal requirements for efficient plumbing fixtures, provides a useful example of a major institutional program achieving consistent resource and cost savings over time. It also provides important insights into the difficult process of establishing a comprehensive program in an institutional setting.

This case is particularly interesting because most of the efficiency measures were implemented in the late 1980s, providing a 10-year "test" of the durability of the savings. Over a 20-year time frame, total per capita water use has decreased by over 50 percent (Figure 8-1).[2] The pattern of reductions reflects two different programs—a voluntary, "low-tech" approach established in the 1970s that had shorter-term effects, and a more comprehensive program established in the late-1980s with greater reductions and greater long-term success.

Background



Colleges and universities use significant amounts of water to meet the various needs of their populations. The University of California at Santa Barbara (UCSB) is located north of the city of Santa Barbara, on the coast in a semi-arid climate. The 815-acre campus has a student enrollment of approximately 18,500 and 5,100 faculty and staff. Functioning in many ways as a small town, the campus maintains a fire department, police station, post office, medical clinic, food-service facilities, offices, laboratories, housing for approximately 4,200 students (2,600 in residence halls and 1,600 in apartments), housing for faculty and their families (150 units), recreational facilities, including playing fields and several large pools, laundry facilities, and extensive landscaping.

UCSB, like many universities in California, has experienced significant growth in enrollment throughout the past several decades. Due

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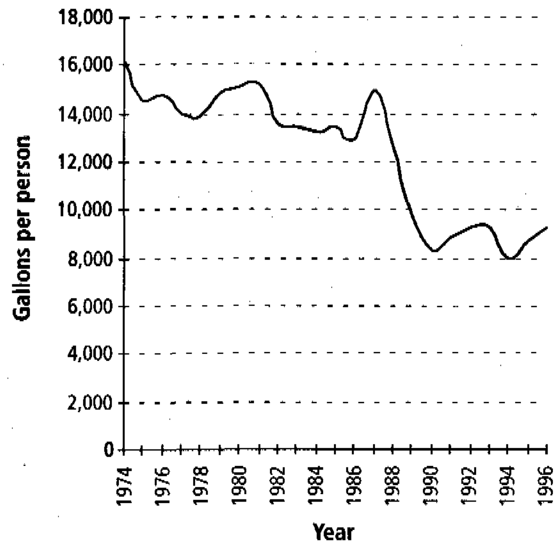
[1] UCSB has historically been limited to 963 acre-feet of potable water per year by agreement with the Goleta Water District. This limit has since been renegotiated and reflects a new formula that raises the cap, but also includes a provision for water recycling.

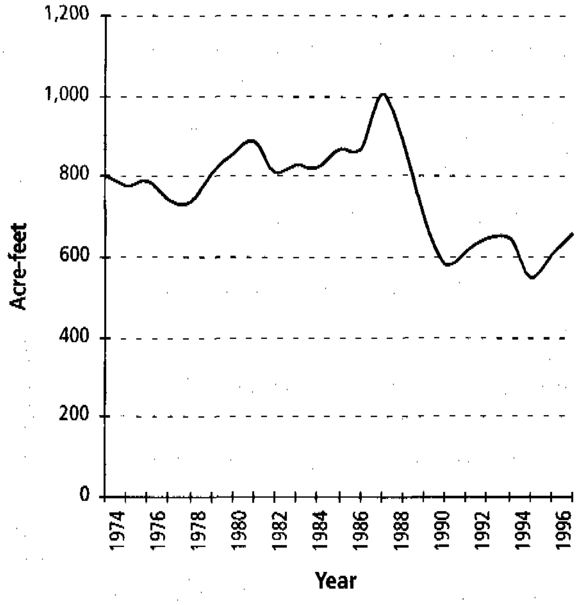
[2] Per capita potable water use decreased by over 50 percent in the 20 years between 1974 and 1994, from more than 16,000 gallons per person in 1974 to less than 8,000 in 1994. It has increased slightly since 1994.

Figure 8-1
UCSB Annual Per Capita Water Use, 1974–1996



Source: UCSB

Figure 8-2
UCSB Total Annual Water Use, 1974–1996



Source: UCSB

to limited water supplies (the Santa Barbara region is very dependent on local water resources), UCSB has been legally limited by agreement with the local water district to a maximum allocation of 963 acre-feet of water per year (afy) for all uses on the campus. The university's Long Range Development Plan (LRDP) reflects this critical constraint on water supply. Projections for campus consumption without efficiency measures indicate that UCSB would have reached its allowable limit of water supply by 1994. In fact, with climbing enrollment and increased water use, the campus exceeded its legal limit in 1987.

Earlier efforts to reduce water use during drought periods were effective, but failed to produce significant long-term results. These programs were based on voluntary measures and "low-tech" conservation efforts such as toilet dams, flow restrictors, and admonitions to "take shorter showers." For example, as Figure 8-2 indicates, the drought in 1976-77 produced a decrease in water use; however, water use quickly rebounded when the drought ended. By 1981, water use was higher than it had been before the drought began. This is due in part to the shift in attention away from the issue of water conservation, and partly to poor performance of the toilet dams, restrictors, and other devices.

By 1987, faced with a need to reduce its water use to meet local requirements, the campus embarked on a comprehensive program to increase water-use efficiency. The scope of the institutional model provided by UCSB includes a wide variety of water-efficiency measures as well as the use of both "graywater" and recycled water for irrigation.

Goals of the Program

The main goal of the new UCSB program was to more effectively reduce total campus water use through increased efficiency in order to comply with limits set by the local water district. To allow for future growth of the campus, the university also needed to develop a "surplus" of water availability beyond its immediate requirements yet within its allocation.

Additional goals were to achieve cost savings from reductions in water, wastewater, and energy bills. In implementing the program, the university played an important role in the testing and demonstration of various water-saving devices and new water-use technologies. As the program evolved, the university expanded its goals to include becoming an institutional role model that would showcase cost-effective technologies and programs.

The Program

The water-efficiency effort at UCSB was modeled on a highly successful energy-efficiency program the campus had developed and implemented over the previous decade. Building on lessons learned in that process, the campus first conducted extensive water audits to determine use and technology factors and to identify waste and areas for potential efficiency improvements. All water-using devices were identified, priorities were determined, budgets and plans were developed and approved, and the campus began the process of implementing a wide variety of conservation measures.

As the program advanced, both costs and benefits were recorded, not only for water and wastewater savings, but also for energy efficiency. Other benefits, such as improved system operation (fewer clogged sewers and costly emergency calls) and reduced maintenance requirements (especially in the landscape area) were also realized.

Following achievement of the initial goals (reducing the campus water use to a level within the allotment and with a margin for campus growth) the program was continued and expanded. The principal reasons for this were that: 1) the program was saving money (with a very attractive return on investment for the university); and 2) university staff and administrators were inspired by the idea of simultaneously making sound business decisions and improving the campus environment. It is worth noting that many of the key players were also motivated by the fact that the university was providing an example for the community through its water conservation technology and good environmental management. Some university employees really do care about conserving resources, and their leadership and personal enthusiasm were important to the program's success.

Actors

The parties responsible for developing and managing the UCSB water-efficiency program were officials in the university's housing and facilities management programs and key administrators, with strong support from the vice-chancellor and chancellor. This program was implemented by a team of committed people from every level of the institution, from the housekeeping, food service, and building and grounds maintenance staffs to department directors, budget analysts, and top administrators. Without this commitment at all levels, it is doubtful that the program could have been implemented.

One of the critical elements of the program was communicating with and involving skeptical staff, particularly those in the maintenance, food service, grounds, facilities management, and housekeeping areas. At the same time, key administrators at the highest level of the institution had to be convinced both that the efficiency strategies would work and that they were worth the allocation of scarce resources. Once the technologies were tested and proven, the staff became convinced. With cost savings on target and attractive returns seen on capital invested, the administrators became convinced as well.

Implementation

The program implementation followed a now familiar pattern. Water audits were undertaken, leaks were repaired, basic plumbing devices were replaced, irrigation systems were improved, ground-maintenance practices were changed, modest landscape changes were made, and equipment due to be replaced (such as washing machines and large-scale dish-washing machines) was upgraded to water-efficient models.

Table 8-1

Sample List of Technology Measures Employed

Technology Change	Number
Shower head replacement	1,399
Toilet/urinal replacement	2,744
Sink aerators	2,281

Table 8-2
Other Conservation Measures

- Commercial dishwashing machines replaced with water-efficient models
- Laundry machines replaced with horizontal-axis machines
- Drip irrigation installed for landscapes
- Irrigation controls and sprinkler heads replaced
- Chipper purchased and landscape mulched
- Pool backwash system replumbed to capture and re-use water

Initially, some of the program's measures met with serious opposition. While 1.6 gallon per flush toilets are now mandated by both state and federal law, they were considered highly suspect when the university undertook the program in the late 1980s. The maintenance staff, including long-established "experts" on the subject of sewer problems, proclaimed that the sewers would back up because of the new low-flow toilets. High-level administrators were assured that the campus would face a crisis if the new technologies were installed. Others warned that existing landscaping would die and that any changes would surely mean a barren landscape of cacti and rocks.

As an initial step, the university purchased virtually every model of low-flow showerhead, toilet, aerator, etc. available and ran them through tests involving quantitative measurements of performance (e.g., gallons per minute of flow for showerheads) and actual *in situ* testing by both the end-users and those responsible for maintaining them. The university found that some showerheads failed to meet performance claims (gallons per minute) by as much as an order of magnitude. The simple but effective tests were conducted by some of the most skeptical maintenance staff members. Preference tests were then conducted with the users (e.g., students for showerheads) to determine which ones they liked best. Trial installations were then made to test performance in actual use.

Once these steps were completed, the university developed a large-scale replacement project that employed students, in addition to the university staff, to install the low-flow hardware and toilets (see Table 8-1). Installation was complemented by a strong educational program communicating what was being undertaken and why. The direct involvement of staff and students, and the pre-testing of technology, were major factors in the high level of acceptance and performance of the program. Water use (and sewage volumes) decreased, with commensurate cost savings to the university. Sewer problems actually *decreased* significantly, in part due to an improved preventative maintenance program developed as part of the overall conservation strategy. Irrigation system improvements reduced leaks, over-watering, and overspray, resulting in a more attractive landscape. No cacti were planted.

In the following stages, flushometer-type toilets and urinals were replaced (again ahead of the current legal mandates and again against "expert" advice that the campus would face a plumbing crisis); swimming pool management practices were changed; horizontal-axis washing machines were installed in the university's laundromats; ozone water-treatment technology was employed; additional drought-tolerant plants were selected for areas requiring landscaping; and other technologies and measures were applied (see Table 8-2).

Following the implementation of a wide variety of efficiency measures throughout the campus, the university began research on various forms of reuse. Not surprisingly, the idea of water reuse met with skepticism. The university made a special effort to involve the appropriate authorities, including health officials, as the various programs were developed. The result was a safe program that performed well over time. Some innovative practices were developed, such as utilizing the pool filter backwash water to fill the tank trucks that clean the sewer lines with high pressure washers (pool filters are backwashed with chlorinated pool water, which had previously been dumped down the drain). The otherwise wasted pool water was also captured in tanks and used for irrigation. Another innovative project involved research into using nano-filtration or "low-pressure reverse osmosis" filters to clean and recycle laundry water. Though the project was tested at the university laundomat, it was determined to be too maintenance-intensive to warrant continuous use.

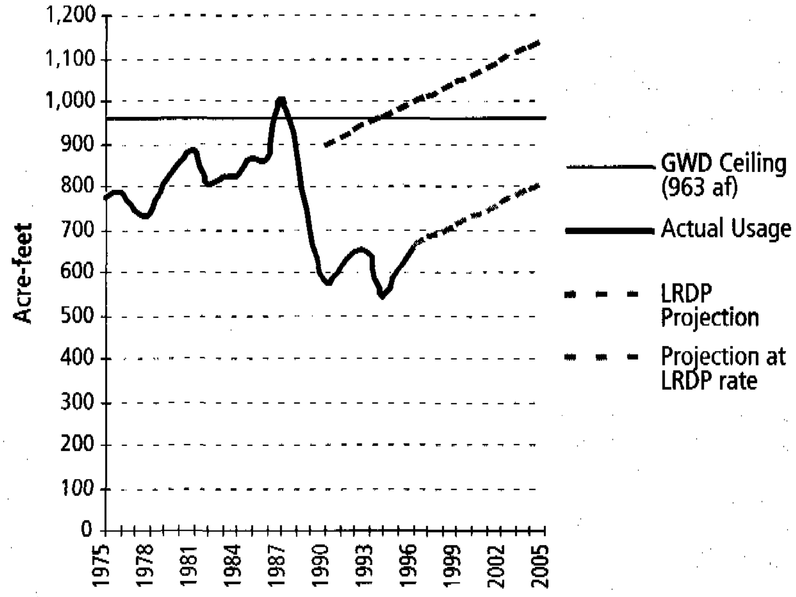
In 1994, the campus moved beyond its own reuse options to sign an agreement with the local wastewater agency to use recycled water for various irrigation needs. A considerable portion of the landscape is now irrigated with recycled water, further reducing the university's impact on local potable water supplies.

Evaluation of Success

UCSB provides an example of what a large, complex organization with diverse water uses can do to improve efficiency and reduce water use in a cost-effective manner. The results surprised senior administrators, who confessed they were highly doubtful that retrofitted toilets, showerheads, washing machines, and other devices could really amount to much savings. They were concerned that skeptics might be right, and were relieved when the new technologies worked so well. The landscape looks better than it did before the program, and there have been no problems with the use of recycled water. The administrators were delighted with the strong return on their investment, especially in light of tight university budgets. There is continued interest in supporting and researching additional innovations that might further improve performance while saving money.

Campus potable water use is presently only two-thirds of its original allotment, and projections, even at the Long Range Development Plan (LRDP) growth rate (shown as a projected curve from 1997 in Figure 8-3), indicate that water use will remain within the allocation well beyond the 2005 scenario in the plan. From 1987, when the campus exceeded its allotment and used over 1,000 acre-feet, to 1994, the campus reduced its annual use nearly 50 percent, from 1,003 acre-feet to 546 acre-feet. Over this same period the number of students, staff, and faculty increased, and the campus added major new buildings, two more swimming pools, a recreation center, and other facilities (Figure 8-4). Per capita use dropped from 14,921 gallons per year in 1987 to between 8,284 and 9,268 gallons per year from 1990 onward (Figure 8-1). The figures for total water use in 1996 show a slight increase to 659 acre-feet (Figure 8-2), with even more facilities and an additional 1,000 students, staff, and faculty. This upward creep in water use probably reflects a diminished awareness or sense of urgency that affected behavior.

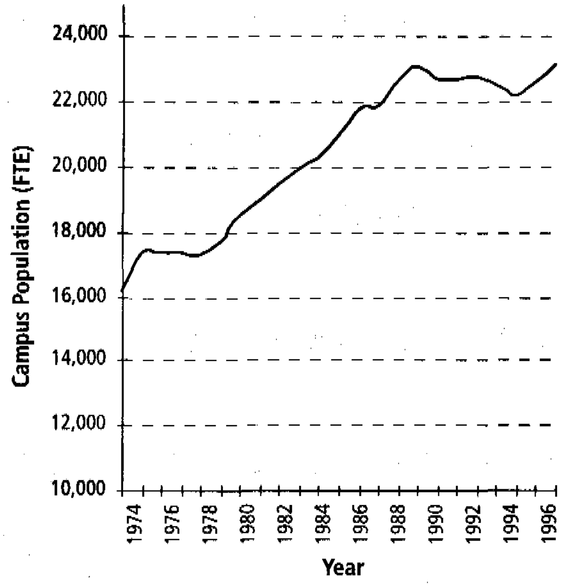
Figure 8-3
Comparison of UCSB's Actual Annual Water Use to LRDP Projections



Source: UCSB

Figure 8-4

Campus Population Served, 1974–1996



Source: UCSB

As noted above, the cost savings in water and sewer bills alone, estimated as the difference between the LRDP scenario and actual use, is on the order of $3.7 million through 1996. Additional future savings estimated to 2005 are in excess of $5 million.

Is this example replicable and generalizable? The answer appears to be yes, both in whole and in part. Other college and university campuses throughout the state and around the country have very similar water-use profiles. Many have undertaken similar measures with good results, and others have identified significant opportunities available in cost and resource savings. Since apartment complexes exhibit water uses similar to university apartment facilities, by upgrading laundry equipment, toilets, showerheads, and aerators, they would similarly benefit from reduced water consumption. While some California facilities have taken these steps, many have not, and they are missing important opportunities to save money and improve services.

The comprehensive program developed by UCSB focused on permanent changes to plumbing devices and equipment and an increase in the quality of water services delivered. While more costly at the outset, the investment is justified through reliable, long-term efficiency improvements and cost savings over time. With good technology in place, even when people are not paying much attention to their consumption, water use is significantly lower.

Are the measures adopted acceptable to the people using them, and are they affordable to those who pay for them? In both cases the answer is clearly yes. After nearly 10 years of use, the technologies are working well and the cost savings have proven them to be remarkably good investments, with reduced wastewater charges, energy use, and water bills. Reduced power demands in campus and building distribution systems and reduced maintenance costs increase the total benefits but have not been precisely quantified.

The cost savings accrue directly to students and the campus community by lowering charges for campus housing and food service and operating costs for tax-supported university facilities. Avoided capital costs for water supply and wastewater treatment due to reduced demand have not been quantified but could constitute considerable additional savings.

Conclusions/Lessons Learned

Many institutions face challenges and opportunities similar to those of a college campus. The technologies and the approach to their implementation are applicable, at least in part, to facilities ranging from higher education to military bases to apartment complexes and vacation resorts. Comparable water, wastewater, and associated energy savings are possible, depending on whether any efficiency measures have already been taken. Even greater savings may be possible in those institutions that have not undertaken the "low tech" and behavioral change efforts that preceded the UCSB program.

Rather than a net cost, the UCSB program proved to have a "net negative cost" based on water and wastewater savings. That is, it was cheaper for the university to capitalize the program than to do nothing, due to the significant return on investment the program produced.

Credit for success must also be given to university staff who supported the program and provided the leadership and energy necessary to convince skeptics that these technologies do work effectively, and that such efficiency changes can indeed save money. The importance of an enthusiastic staff cannot be understated. These key players worked to educate and involve staff at all levels and ensure that water efficiency actions were considered and implemented campus-wide.

Finally, the initial impetus for the program, UCSB's excess water use over a legal allotment, was a source of significant community concern. The allotment system was based on a recognition of the limits of water resources and the need to live within a "water budget" as a community member. By taking the lead on technology applications and developing a serious and permanent water efficiency program, the university reversed its role in the community from an over-user to a water-conserver.

Contacts

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Increasing Industrial Water-Use Efficiencies: Naval Aviation Depot, North Island

Arlene K. Wong

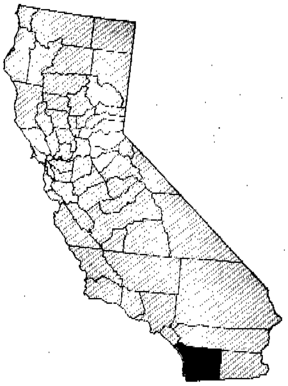
Introduction

Water in California is used for a wide variety of industrial activities. Because much of this water is used non-consumptively and has been a cheap input, there has been little incentive until recently to examine the efficiency of those uses. Over the past decade, however, concerns about the reliability of supply and the cost of disposing of wastewater, and new educational and regulatory incentives have led many industries to begin re-examining their water use. In some cases, substantial savings, or the potential for such savings, have been found. In this case, the Naval Aviation Depot North Island in San Diego instituted a series of programs designed to reduce overall water use. The Depot provides a wide range of engineering, calibration, manufacturing, overhaul, and repair services for navy aircraft and ships. The Depot has traditionally used large amounts of water for cleaning, rinsing, and bathing parts, as well as for operating cooling systems. Between 1987 and 1997, due to new local regulations, higher wastewater treatment costs, and explicit military directives, the Depot reduced its water use by over 90 percent, from 305 million gallons to under 27 million gallons each year. This large savings was a result of reductions in water use and hazardous and industrial wastes.

Background

The Naval Aviation Depot North Island (Depot) has operated for over 75 years, providing engineering, calibration, manufacturing, overhaul, and repair services for military aircraft (currently, F/A-18, E-2, C-2, and S-3) and ships. The Depot is one of the largest single employers in San Diego County, with 3,500 workers, as well as one of the largest aerospace employers in California. San Diego's sunny and arid climate (an average of 330 rain-free days each year) provides pleasant weather, but also means that 90 percent of the area's water is imported, primarily Colorado River water from the Metropolitan Water District.

Until 1990, little thought or concern was given to the use of water at the Depot. In the early 1990s, however, several different federal, state, and local directives, regulations, and incentives focused attention on industrial water use in the military and elsewhere. In 1990, the Chief of Naval Operations directed a phased Navy-wide program for conservation of water, with initial emphasis on the use of water in Navy industrial processes. The program recognized the value of conserving water as a declining resource and also sought economic payback through conservation strategies. A Presidential Executive Order issued in 1991 further directed federal agencies to develop and implement plans to meet the 1995 energy management goals of the National Energy Policy Act.[1] A Navy Environmental and Natural Resources Program Plan required that the Navy reduce its hazardous and industrial waste by 50 percent of the 1987 baseline by 1992. In 1991, the Commander Naval Base of San Diego tasked all naval facilities in the San Diego area to reduce water consumption in 1991 by 30 percent from the 1989 baseline. The Depot was also facing increasing regulations and restrictions on its waste management, which is handled by the Navy Public Works Center (PWC). The PWC was considering shutting down the industrial waste treatment plant to perform repairs, and the Depot faced the prospect of having to find alternative methods of treatment during that



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[1] The Act required that federally-operated buildings reduce overall energy use by 20 percent from 1985 levels by the year 2000.

period. Beginning in 1992, the San Diego Public Works Industrial Waste Treatment Plant began discontinuing use of the waste pipelines[2] from the Depot to the treatment plant and instead required the Depot to transport all of its waste to the plant. These various mandates and closures created an incentive to re-evaluate water-use processes and to look for methods to reduce consumption and waste production. It also provided an emphasis on conservation and waste minimization at all levels in the chain of command.

The Project: Focusing on Water Use

In response to these incentives and regulations, the Depot focused renewed attention on water use. An energy management office, established in 1975, had gone through cycles of high and low staffing as interest in efficiency waxed and waned. Spurred by the new mandates, the Depot established an Energy and Water Conservation Team and staffed it with 1.5 full-time employees. In direct response to the closure of the waste pipeline, the base created a Zero-Discharge Team to look for ways to minimize waste in all processes. This team was staffed with employees from throughout the base—facilities, equipment, environmental, maintenance, and engineering. The team identified waste streams, examined processes, and made recommendations for eliminating or reducing waste. All recommendations were reviewed by process engineering for feasibility. This team took about six months to conduct the process surveys. Recommendations were implemented in the following years with oversight from the Environmental Office (which houses the Energy and Water Conservation Team). The Energy and Water Conservation Team has continued reviewing processes and making recommendations to reduce waste. The Environmental Office also monitors the buildings for compliance with environmental requirements. The Energy and Water Conservation Team is now seeking to implement greater self-monitoring by the various units.

The majority of the Depot's water is used in its industrial processes, which involve rebuilding engines and repairing aircraft components. Water-savings were achieved largely by changing not what the Depot does, but the methods or equipment it uses. Some reductions occurred through changes in activities while others benefited from changes in the defense industry. Teams basically conducted an audit of processes to identify waste-generating practices and wasteful practices. Reducing water consumption was both a specific goal and a means to meet the waste minimization goal since much of the waste generation was associated with water-intensive activities such as the cooling, washing, rinsing, and plating processes.

Many of the changes implemented were common sense and low-tech. Table 9-1 lists many of the actions taken since 1990. These include recommendations from the Zero-Discharge Team as well as actions identified by the Energy and Water Conservation Team. Many adjustments required simple fixes in equipment, including replacing bath tanks with smaller volume tanks, since modern aircraft are smaller and do not require as large a tank for parts; installing float valves in tanks so that water only filled until tanks were full, instead of running continuously; shutting valves off at the end of the day instead of allowing water to run continuously; replacing equipment, such as steam guns, with more efficient equipment, such as power washers; and closing system loops to recirculate water in cooling systems and scrubbers.

Other changes required changes in processes. In one example, the rinse system for a plating process was changed from a single-rinse to a triple-rinse system. By using three (smaller) baths instead of one, the rinse water is contaminated less quickly and does not have to be replaced as often. Changes in plating procedures reduced contamination of the bath waters. Another water-saving change was the switch from chemical stripping of paint, which required hosing down the aircraft, to a dry sys-

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[2] Use of the pipeline was discontinued so as to avoid expensive upgrades to double-line the underground tanks to meet U.S. Environmental Protection Agency regulations. This was phased in as various pipelines were sealed.

Table 9-1
Actions Taken to Reduce Water Consumption Since 1990

Project Description	Est. Water Savings (kgal/yr)	Est. Water Savings (af/y)	Est. Cost Savings[a] ($/yr) (includes water and waste disposal savings)	Project Capital Costs ($)	Payback Period (yr)	Est. Cost Savings for Water Supply[b]
Recirculate fume scrubbing water from 10 scrubbers	41,788	128	$707,053	$0	0.0	$167,152
Eliminate continuous makeup water and control dumping of metal quench bath	6,375	20	$107,865	$0	0.0	$25,500
Recirculate cooling water for high temp (ABAR) furnace through cooling tower	11,520	35	$194,918	$51,502	0.3	$46,080
Convert water cooled air-conditioning system to air cooled air-conditioning system in the bonding shop	4,003	12	$67,731	$65,400	1.1	$16,012
Recirculate cooling water for all high temperature ovens through cooling water	1,577	5	$13,005	$30,028	2.3	$6,308
Install water level sensor in the non-destructive testing rinse tank	374	1	$6,328	$242	.04	$1,496
Replace vapor degreasing equipment with aqueous degreasing equipment to eliminate water cooling requirement	7,080	22	$119,794	$90,000	0.8	$28,320
Install low-flow devices to reduce water use in urinals, toilets, and faucets	6,084	19	$45,144	$15,630	0.3	$24,336
Condition and recycle continuous cooling tower water bleed off	1,170	4	$22,136	$50,000	2.3	$4,680
Close loop, treat and recycle wastewater from all steam gun and wash rack operations	1,564	5	$29,622	$120,000	4.1	$6,256
Implement water conservation measures to reduce general waste, and chrome and cyanide rinse water	649	2	$12,279	$74,000	6.0	$2,596
Source treat and recycle to reuse vibraclean/vapor blast wastewater	81	0	$1,532	$10,000	6.5	$324
Implement plastic media blast (replace required wash down with hose)	1,066	3	$20,169	$140,000	6.9	$4,264
Scrubbers: stop flooding	3,650	11	$62,000			$14,600
Cad rinse tanks: stop flooding	2,100	6	$36,000			$8,400
Ivadizer vac: close loop	350	1	$6,000			$1,400
Degreasers: close loop	16,000	49	$270,000			$64,000
Steam guns: replace with power washers	440	1	$7,400			$1,760
Plasma spray: close loop	1,350	4	$23,000			$5,400
2 heat treatment furnaces: close loop	8,000	25	$134,000			$32,000
Bond room AC: correct operation	2,200	7	$37,000			$8,800
Test stand uf-4: correct operation	8,000	25	$56,000			$32,000
Bell furnace: correct operation	5,256	16	$37,000			$21,024
Steam guns: correct operation and maintenance	110	0	$2,000			$440
TOTAL	**130,787**	**401**				

[a] *At the time these estimates were made, average cost of water supply and wastewater treatment for the Depot was estimated at $17 per 1,000 gallons. Treatment costs will vary depending on whether wastewater is considered industrial or hazardous, and some of the cost estimates reflect these differences. In fact, since those estimates were made, the cost for wastewater treatment has increased considerably.*

[b] *Average cost of water supply to the Depot is estimated at $4 per 1,000 gallons.*

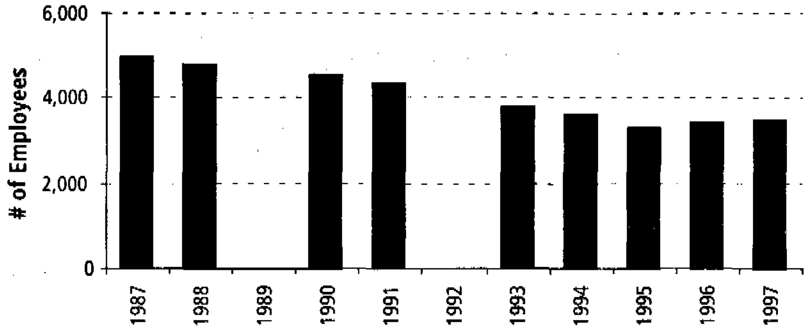
Source: 1997 Naval Aviation Depot North Island correspondence.

tem using plastic media blast (similar to sandblasting). By reducing chemical use, this change helped the base meet federal Clean Air Act requirements, in addition to saving water.

Many of these actions were undertaken with an explicit goal of reducing costs. The cost for wastewater treatment has been increasing rapidly and is much higher than water supply: water supply costs approximately $4 per 1,000 gallons; whereas in 1997, industrial wastewater treatment was $60 to $1,100 per 1,000 gallons. The base saved money by reducing its wastewater streams, and the primary method of reducing wastewater was reducing water use.

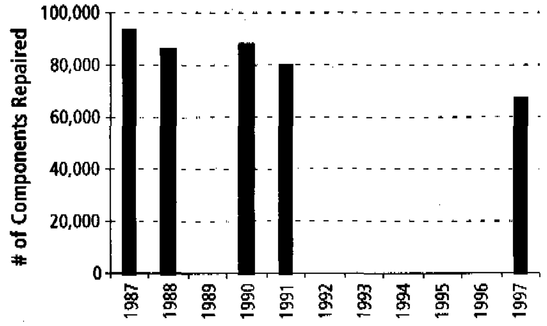
In reducing its water use, the Depot was also affected by changes in the defense industry. Between 1987 and 1997, the defense industry in California shrank. The North Island Depot itself underwent a significant reduction in personnel in 1990 from 4,600 to 3,800 in 1993, and further decreased to 3,500 by 1997 (Figure 9-1). The number of aircraft in the military forces was reduced and therefore affected the workload of repair depots. The industrial processes (and therefore the water-intensive processes) are concentrated in engine rebuilding and aircraft component repair. An examination of the component repair workload (aircraft subassemblies, avionics, and engine accessories) for selected years shows a decrease in units of components repaired (Figure 9-2). This is matched, with the exception of 1997, by a decrease in hours worked on these processes (Figure 9-3).[3] However, these declines are well outpaced by the decline in water consumption, as can be seen in the next section, and cannot account for all of the water savings. Also affecting water use, as mentioned before, were changes in modern aircraft, which meant that many of the aircraft were smaller than in the past.

Figure 9-1
Number of Employees for Selected Years



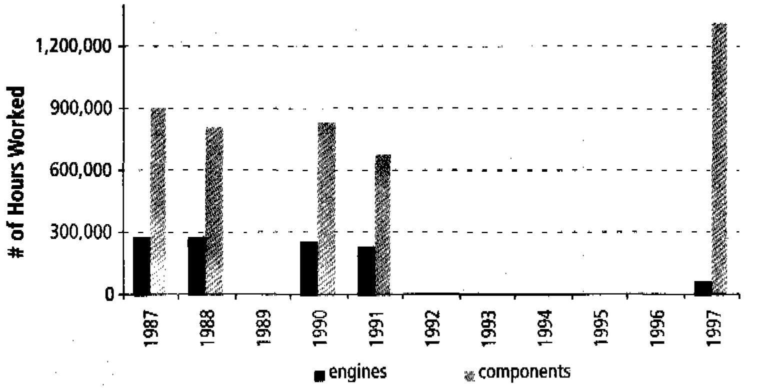
Source: Naval Aviation Depot North Island Fact Sheet Fiscal Years 1987, 1988, 1990, 1991, 1997, and Personal Communications

Figure 9-2
Number of Aircraft Components Repaired for Selected Fiscal Years



Source: Naval Aviation Depot North Island Fact Sheet Fiscal Years 1987, 1988, 1990, 1991, 1997

Figure 9-3
Hours Worked on Engines and Components for Selected Fiscal Years



Source: Naval Aviation Deport North Island Fact Sheet Fiscal Years 1987, 1988, 1990, 1991, 1997

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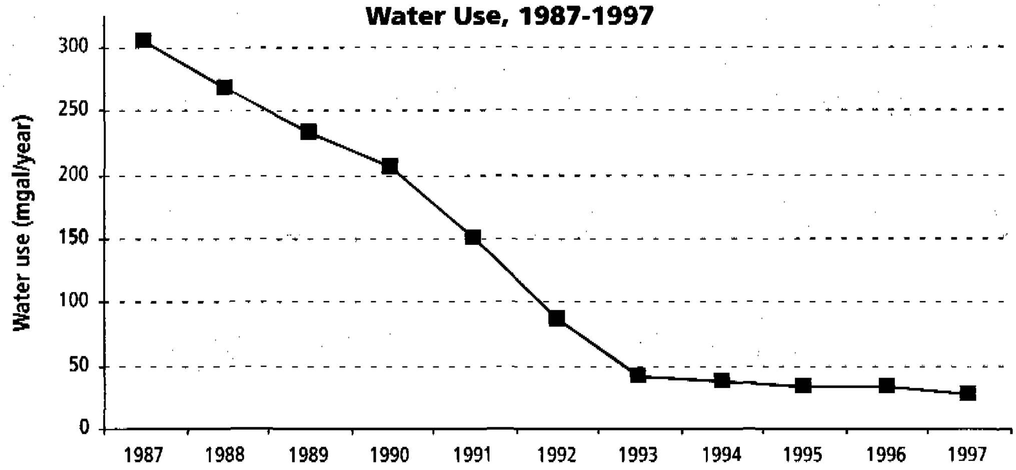
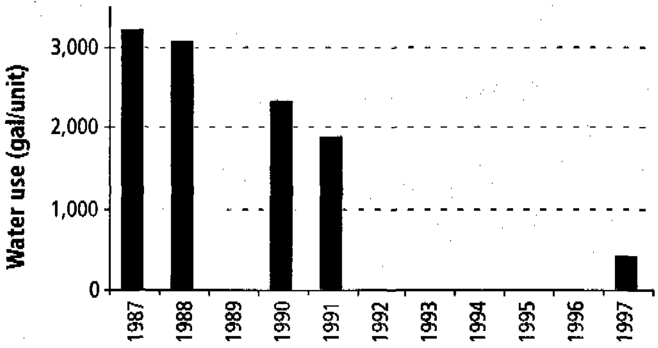
[3] As equipment ages, the complexity of repair is expected to increase and therefore the time worked on each component is expected to increase. The increase in hours worked in 1997 reflects this expected trend of longer repair requirements for older aircraft and ship components.

Figure 9-4
Water Use, 1987-1997



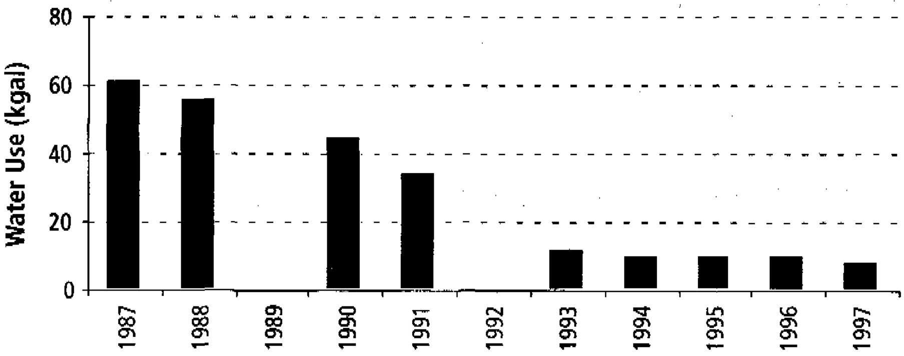
Source: Naval Aviation Depot North Island 1997

Figure 9-5
Fraction of Total Water Use Per Component for Selected Fiscal Years (gal/unit)



Source: Naval Aviation Depot, North Island Fact Sheet Fiscal Years 1987, 1988, 1990, 1991, 1997

Figure 9-6
Per Capita Water Use for Selected Years



Source: Naval Aviation Depot, North Island Fact Sheet Fiscal Years 1987, 1988, 1990, 1991, 1997, and Personal Communications

Evaluation of Success: Dramatic Water Savings Achieved

Figure 9-4 shows the Depot's total water use from 1987 to 1997 and illustrates the dramatic reductions it has achieved. Table 9-1 provides a partial list of activities undertaken since 1990, which account for about one-half of the reductions achieved. While we cannot separate out the impact on water use from changes in the defense industry and how the Depot was affected in terms of workforce and work required, this partial list of activities and discussions with Depot staff indicate that for the most part, the savings were achieved through process-oriented corrections and not changes in the Depot's "products." For years for which we have data, we can compare the total water use with the number of aircraft components repaired (Figure 9-5).[4] *Despite a reduction in volume of* repair work, the numbers also show that water use per component has decreased, as has water use per employee, particularly over the 1992 to 1997 period (Figure 9-6).

The tremendous water savings has not only resulted in economic benefits to the Depot, in terms of savings on water supply and wastewater treatment costs, but has also promoted good public relations with the San Diego community.

Conclusions/Lessons Learned

The North Island Naval Aviation Depot is an excellent example of the potential for water savings in industrial processes. Many of the dramatic improvements were accomplished with low-tech, operational changes that simply reduced water use and prevented waste. Many of the payback periods were less than a year, and the highest cost-recovery period noted was seven years. Efficiency improvements were not difficult to identify and realize once the Depot created the operational priority of bringing attention to the matter and putting in place a procedure (Zero Discharge and the Energy and Water Conservation teams) for conducting the evaluations.

In the case of North Island, the primary motivators for improving water efficiency were various mandates established by the naval command at both the federal and local levels and increased wastewater treatment costs. These mandates were driven by both environmental regulations and cost-saving efforts and made clear the benefits that could be achieved by both reducing consumption and wastewater. With these explicit goals, employees had the freedom (and the directive) to identify and implement changes that otherwise would not have been a priority.

Contacts

Jose Jimenez, Energy and Water Conservation Manager, Naval Aviation Depot, North Island

Michael Hammond, Public Affairs Office, Naval Aviation Depot, North Island

References

Hammond, M. 1997. Naval Aviation Depot, North Island. San Diego, CA. Personal communications.

Jimenez, J. 1997–1998. Naval Aviation Depot, North Island. San Diego, CA. Personal communications.

Naval Aviation Depot, North Island. Fact Sheets for the years 1987, 1988, 1990, 1991, and 1997. San Diego, CA.

Stokes, D. 1997. Naval Aviation Depot, North Island. San Diego, CA. Personal communications.

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[4] This is an imperfect measure as we are not able to break down water use by activity; different components will vary in size and water-use; and each year the components repaired will vary. However, aircraft component repair is the major water-intensive industrial process the Depot undertakes and can offer a per-unit approximation for comparative purposes over time.

Chapter 10

Reducing Water Use and Solving Wastewater Problems with Membrane Filtration: Oberti Olives

Lisa Owens-Viani

Introduction

Most food-processing plants use large quantities of fresh water and dispose of considerable volumes of wastewater each year. In response to environmental regulations and concerns, some companies have begun to implement water-saving or water-filtering/byproduct-recovery systems that reduce water needs and wastewater volumes and offer substantial economic and environmental benefits. One example is the membrane filtration system that has been on-line at the Oberti Olives plant in Madera, California since September 1997.

The food-processing industry is one of California's largest water users, with over 8,000[1] plants each using an average of one million gallons per day (mgd) to wash, cook, and package foods for consumers (Mannapperuma, et al. 1993). Food processors generate and discharge large quantities of wastewater to municipal treatment facilities every day. Disposal of that water is costly, both because of the large volumes and because it contains oils, organics, solids, and salts that are expensive to treat.

Olive Processing and Oberti Olives

Within the food-processing industry, olive-processing plants are among the most intensive water users, requiring up to 10,400 gallons of water per ton of olives processed (T. Moore 1994). The 1993 Food Industry Environmental Conference study revealed the total cost (measured as water supply plus wastewater disposal) of water per ton of olives processed to be between $9 and $60 per ton (Mannapperuma, et al. 1993). At peak production, the Oberti Olives plant in Madera (one of only four olive processors in California—and the United States) processes 128 tons (256,000 pounds) of olives per day—or 600 cans of olives per minute. Water is used in almost every aspect of processing: washing, curing, storing, and packaging. Oberti Olives also processes between 40,000 and 80,000 gallons of olive oil per year (R. Moore 1997). Oberti obtains its fresh water from private wells.

Water Use in the California Food-Processing Industry

- 71 plants used 12 billion gallons of water per year, at a total cost of $18 million:
  - 23 percent of that cost was the charge for fresh water
  - 77 percent of that cost was for wastewater disposal

- Average **yearly cost of fresh water** for half* of the plants: $47,000
- Median **yearly cost of disposal** for 48* plants: $100,000

**Not all plants responded to every category in the survey.*
Source: Mannapperuma, et. al. 1993

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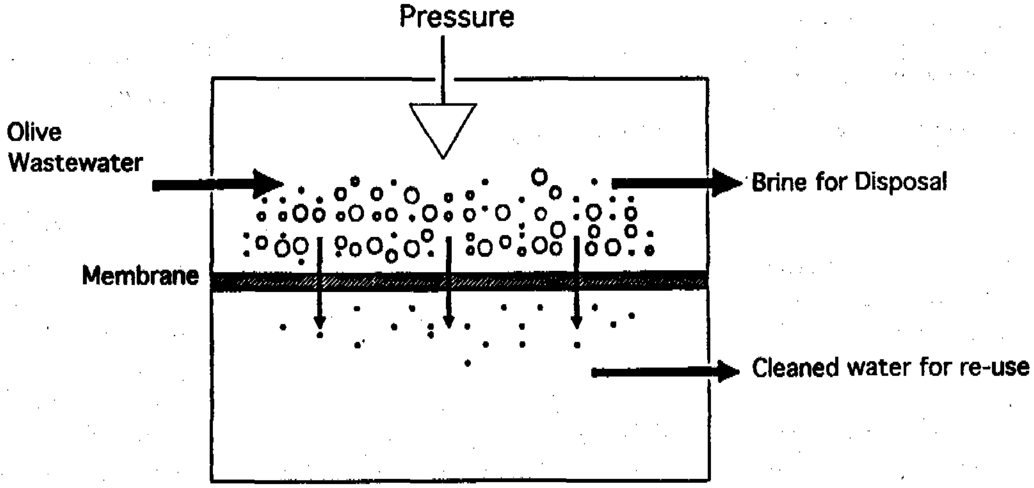
[1] This number was taken from the California Department of Health Services' list of registered food processors, which range in size from large plants to grocery store delicatessens.

Disposal of wastewater has been problematic for Oberti. Because its effluent was high in salts, the plant was unable to cost-effectively discharge it into public water treatment systems. Until recently, Oberti disposed of its wastewater by discharging it into 160 acres of evaporation ponds, where the water was evaporated off and the salts were eventually collected. Although the evaporation ponds were a relatively inexpensive way to dispose of wastewater, they were not environmentally benign. Until the late 1960s, Oberti's evaporation ponds were simply lined with clay. Although Oberti installed a single layer of plastic lining in most of its ponds to comply with changes in Regional Water Quality Control Board (RWQCB) requirements in the late 1960s, a salty underground wastewater plume approximately one mile long had formed, having leached from one of the old clay-lined ponds. After Tri Valley Growers (the cooperative that manages Oberti) was forced to replace about 10 private wells in the area (to protect them from the plume), the ponds no longer seemed like such an inexpensive disposal method. Plus, in 1984, the RWQCB changed its regulations regarding evaporation ponds, requiring pond owners to double-line their ponds and install leachate collection systems. To comply with these regulations would have cost Oberti approximately $40 million. Oberti considered closing its plant, but to do so would have devastated olive growers—Oberti is one of only four olive processors in the state, and many growers are shareholders in the Tri Valley Growers cooperative (Tri Valley Growers 1997). Closing the plant, which had operated in the Madera area since the 1930s, would also have cost the local community about 500 jobs (Graham 1997). Instead, Oberti studied other ways to reduce the amount and improve the quality of its wastewater. After participating in a demonstration study sponsored by utility companies and the food-processing and membrane technology industries, Oberti decided to install a membrane filtration/water-recycling system in its plant.

Membrane Filtration Technology

Membrane filtration has been studied extensively over the past two decades and used commercially for the past 15 years to separate whey in the dairy industry, clarify juices and other beverages, reclaim sugars and other recyclable products from waste streams, and desalinate small amounts of seawater (T. Moore 1994). The basic idea behind membrane filtration is illustrated in Figure 10-1.

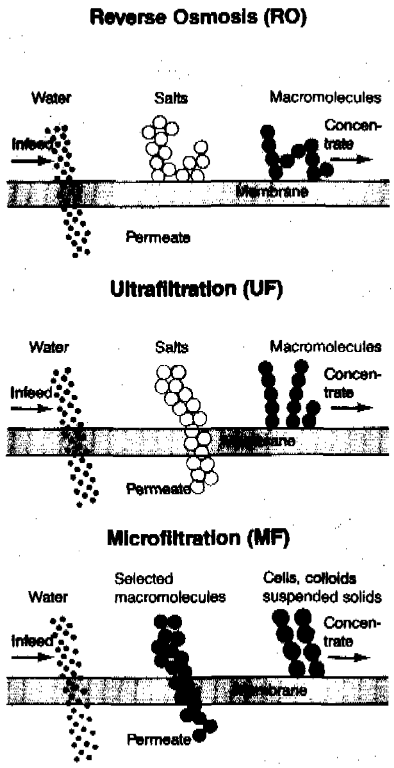
Figure 10-1
Basic Membrane Separation Process



Source: Adapted from EPRI Process Industry Offices Report CR-105377-V1, July 1995

Types of membrane filtration include reverse osmosis, nanofiltration, ultrafiltration, and microfiltration, in order—from small to large—of the particle size each system treats.

Figure 10-2
Different Types of Membrane Filtration



Source: EPRI Process Industry Coordination Office

Membrane systems have several advantages over traditional evaporation and distillation processes, including lower energy use, greater reliability, smaller floor space requirements, lower capital costs, better control of microbes and organic matter in process effluent, and improved product quality (R. Moore 1997; *EPRI Journal* 1994).

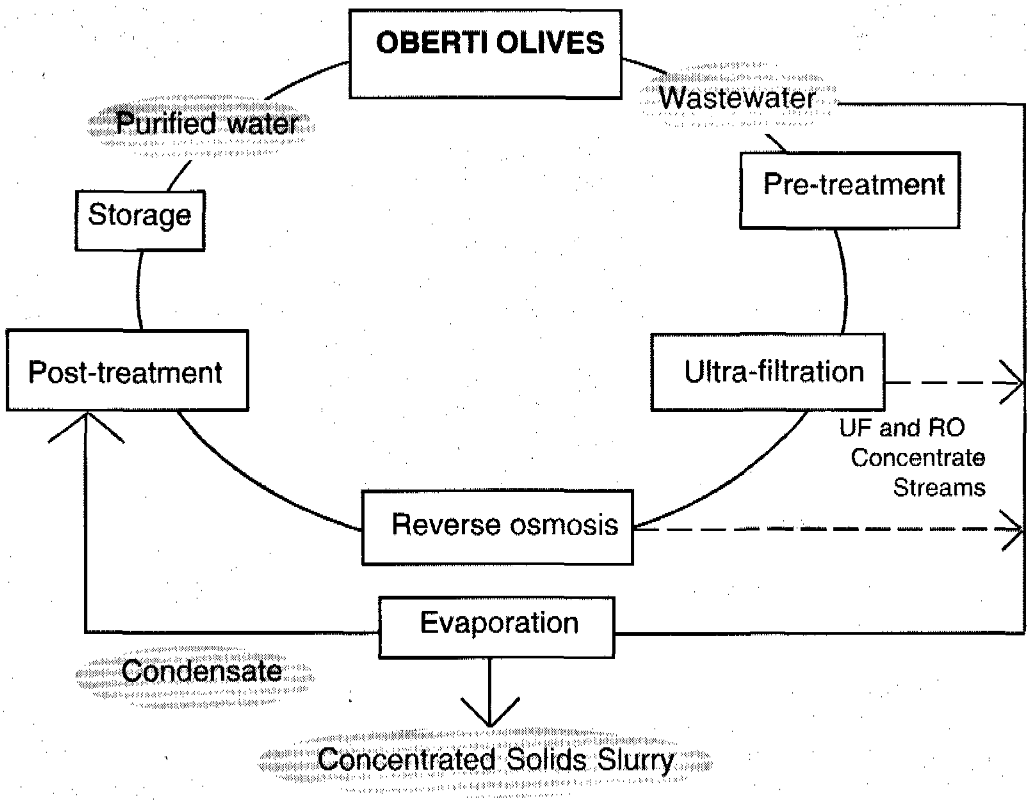
The costs of membrane systems and problems with clogging have prevented the food-processing industry from widely using them. However, in the past couple of years, new types of membranes made of polymeric and ceramic materials have become available. These membranes are more economical and do not cause the clogging problems associated with earlier filters.

The Project

Oberti's goal was to reduce its wastewater discharge to zero, which would eliminate further groundwater problems. Oberti initially tested several biological recycling systems (fermentors and biofilters), but those systems had high labor and energy costs and were incompatible with the high pH and content of Oberti's waste streams. Eventually Tri Valley Growers, the California Institute for Food and Agriculture Research (CIFAR), the RWQCB, and Pacific Gas and Electric (PG&E), with the assistance of many sponsors (see below) worked together to come up with a system tailored to Oberti's needs. In the fall of 1992, Oberti became the first of nine California food-processing plants to test CIFAR's mobile demonstration unit. Sponsored by the Electric Power Research Institute (EPRI), food-processing industry trade groups, the U.S. Department of Energy, Southern California Edison, PG&E, and the California Institute for Energy Efficiency, and operated by agriculture and food scientists from UC Davis, the mobile unit is a 48-by-8-foot trailer that houses a computer and a variety of membrane systems that can be hooked up and tested at various plants. After an eight-week demonstration and extensive subsequent testing, the Oberti membrane filtration system went on-line in September 1997.

Oberti is now the only olive-processing facility with a wastewater discharge of zero (R. Moore 1997). The new technology at Oberti reuses membrane-filtered process water from two different wastewater streams. Flows and pressure are regulated by electrically-powered pumps. Olive wastewater from the storage tank yard and oil mill is sent directly to the evaporator while wastewater from the vat room and cannery are pumped first through an ultrafiltration membrane and then through reverse osmosis filtration. The membranes hold back the salts, sugars, and other solids, allowing only water to pass through (see Figure 10-3). Oberti

Figure 10-3
Flows in Oberti's Olive-Processing System



Source: Adapted from an Oberti Olives diagram

then sells the recovered salts and sugars for use in animal feed. By reusing 80 percent of its olive-processing water, Oberti's daily groundwater pumping requirements have dropped from 1.3 mgd to between 100,000 and 120,000 gpd (R.Moore 1997), a 91 percent reduction. (100,000 to 120,000 gpd are still required for processing and packaging olives.)

Evaluation of Success

Water Use and Wastewater Disposal

Since Oberti obtains fresh water by pumping from its own wells, the primary impetus behind its switch to membrane filtration was not the cost of fresh water but the environmental and regulatory costs of wastewater disposal. Nonetheless, Oberti has reduced its groundwater consumption by about 90 percent—an important reduction since the groundwater table in the Madera area has been declining over the past 50 years and is now approximately 120 feet below the surface (Gilbert 1997). By recycling wastewater that was previously sent to evaporation ponds, causing groundwater contamination, Oberti has eliminated its wastewater disposal problem (although it is still working to clean up the salt plume caused by past activities).

Costs

Compared to the cost of complying with new regulatory measures for wastewater disposal—$40 million—Oberti saved considerably by implementing the membrane system, at a cost of $8 million. The cost was partially offset by grants from PG&E ($100,000), the California Trade and Commerce Agency ($250,000), and the Department of Energy's "NICE"[2] program ($400,000). Oberti also hired and trained four new operators and four assistants who run the system during the plant's production season, at an estimated cost of between $14,000 and $20,000 per person per year (R. Moore 1997).

Energy Savings

Although the new system does use energy for regulating pressures and flows (that the old evaporation ponds did not use), Oberti now pumps only about one-tenth the amount of groundwater it previously pumped. The new membrane filtration system is also more energy-efficient than Oberti's other potential alternative to evaporation ponds—a multi-effect evaporative process system—would have been. A highly efficient multiple-effect evaporator uses 324 million Btu per day (13,500 lbs steam/h x 24 h/day x 1000 Btu/lbs steam) while, in comparison, the membrane filtration system uses only 116 million Btu per day in pumping energy (650 hp x 0.745 kW/hp x 24 h/day x 10,000 Btu/kW), for a daily savings of 208 million Btu (EPRI 1994).

Conclusions/Lessons Learned

Membrane filtration technology is now used by the dairy, chemical, pulp and paper manufacturing, and other industries that use large volumes of water for processing and/or want to benefit from recovering valuable byproducts from their waste streams (Childs 1994). After taking part in the CIFAR mobile unit demonstrations, additional food-processing companies implemented membrane filtration systems. A Sunkist Growers orange juice processing plant in Tipton was able to reduce chemical inputs by 50 percent, saving $120,000 per year, and to reduce the amount of energy used to treat wastewater by 30 percent. That reduction in energy decreased the plant's yearly emissions of NO_x and CO_2 by 1,900 lbs and 1.5 million lbs, respectively.[3] A Del Monte fruit cocktail canning plant in San Jose, where wastewater disposal costs are very high, wanted to contain production costs and efficiently manage water, and found through membrane trials that by filtering several wastewater process streams, it was able to recover sugar concentrate that could be used to supplement or substitute for the syrup needed to fill the cans of fruit cocktail, saving Del Monte the cost of adding new syrup (*EPRI Journal* 1994). EPRI researchers also identified the tomato-processing industry, another intensive water-user, as a potential major beneficiary of this technology.

While membrane filtration technology can be adapted to almost any type of food-processing application, and some funding may be available through programs such as the Department of Energy's "NICE" program, the cost of implementation may be prohibitive for many food processors unless faced with regulatory action or increases in the cost of fresh water or wastewater disposal. According to the 1993 food industry survey, the trend is for further increases in those rates (Mannapperuma, et al. 1993). Dee Graham, with EPRI's Food and Agriculture Office, says that in weighing whether or not to implement membrane filtration, companies will consider the cost of water (which for some is quite high and others low), any environmental issues or regulatory fines (i.e. for exceeding discharge standards), and the value of materials recoverable through membrane filtration (byproducts) compared to the cost of having those materials treated by a municipal agency (some charge for BOD—biological oxygen demand—treatment; others don't). In areas of California where the price of fresh water or the cost of wastewater treatment is high, the cost of installing a membrane filtration system is easily justified (Graham 1997).

Mannapperuma, et al. found in their 1993 food industry survey that more than half of the plants spent over $1,000 per million gallons of water, while 15 plants exceeded $5,000 per million gallons, costs which make membrane treat-

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[2] National Industrial Competitiveness through Environment, Economics, and Energy

[3] Data on water savings was unavailable.

ment of wastewater for reuse an attractive alternative. As additional markets for byproducts in food-processing waste streams are discovered, recovery of those byproducts adds to the value—and offsets the costs—of implementing a membrane filtration system: Oberti's recovery of salts and sugars for use in animal feed is one such offset. And for other food processors or industries where high BOD levels increase the cost of wastewater disposal or where salty water leaching from evaporation ponds is a concern, membrane filtration offers a viable solution.[4] Power plants, for instance, frequently recycle water from cooling towers to the point where it becomes very salty; it is then sent to evaporation ponds, where leaching can occur. Wastewater from oil fields can also be very salty, creating disposal problems; currently, most oil field wastewater is injected into ground wells (Gray 1997). Sewage treatment plants also use evaporation ponds and could benefit from some level of membrane filtration (Gray 1997). In Southern California, a trophy manufacturing plant and a filmmaking plant recently implemented membrane filtration systems to remove excess dyes from their products. These companies were motivated both by wastewater concerns and the potential financial value of the recoverable product—the dye (Nicholson 1998). Prior to installing the membrane systems, these companies rinsed excess dye from their product with de-ionized water that then flowed into the wastewater stream. With membrane filtration technology, the trophy manufacturer was able to decrease its fresh water inputs by 8 million gallons per year and eliminate its wastewater discharge by the same amount (Nicholson 1998).

Membrane systems are generally more effective when they treat multiple source points, rather than one "end-of-pipe" source (Mannapperuma, et al. 1995), so they may not be appropriate in every situation. CIFAR researchers also noted that for membrane technologies to be cost-effective, they should be part of an overall water management strategy. One food-processing plant in CIFAR's trial program could have cut its water consumption by three-fourths—to less than 2,000 gallons per ton of carrots from 8,450 gallons—simply by implementing basic water conservation measures (Mannapperuma, et al. 1995). This reduction in water use would substantially lower the plant's wastewater disposal/treatment costs, which total approximately $250,000 per year (for 80 million gallons of wastewater with 190,000 pounds of BOD).

Dee Graham says that most California food-processing plants use at least one million gallons per day and could cut their water usage by one-half (as a minimum estimate) by installing membrane filtration systems. Ed Yates, with the California League of Food Processors, estimates that at least 1,800 of California's 8,000 food-processing plants could use membrane filtration systems for more economical wastewater treatment. According to Yates, if just 600 plants implemented a membrane filtration system, a conservative estimate of the total amount of water saved would be 920-acre feet per day—or 335,800 acre-feet per year—enough to meet the annual indoor and outdoor water needs of at least 671,600 households.[5]

Contacts

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Dee Graham, Electric Power Research Institute; R & D Enterprises

Robert Moore, Plant Manager, Oberti Olives

E.D. Yates, California League of Food Processors

References

Childs, M. 1994. "Future Food." Comstock's. March.

Gilbert, S. 1997. Regional Water Quality Control Board. Fresno, CA. Personal communications.

Graham, D. 1997. EPRI Food and Agriculture

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[4] At least two other olive-processing plants in California have discharge issues related to salty wastewater (Gray 1997).

[5] Based on the assumption that one acre-foot serves the annual water needs of approximately two four-person households.

Office; c/o R & D Enterprises, Walnut Creek, CA. Personal communications.

Gray, S. 1997. Regional Water Quality Control Board, Fresno, CA. Personal communications.

"Innovators with EPRI technology." 1994. Electric Power Research Institute. Palo Alto, CA. Publication #RP3324.

Mannapperuma, J. D., K.H. Park, R.L. Merson, S. P. Shoemaker. 1995. "Membrane Applications in Food Processing/Volume 1: Fruit and Vegetable Processing Industry/The Final Report on the Membrane Application Demonstrations Conducted by the Mobile Test Demonstration Unit at Eight Fruit and Vegetable Processing Plants in California During October 1992–February 1994." CIFAR, UC Davis. PIO Report CR-105377-V1.

Mannapperuma, J. D., E.D. Yates, and R.P. Singh. 1993. "Survey of Water Use in the California Food Processing Industry." Food Industries Environmental Conference.

Moore, R. 1997. Oberti Olives. Madera, CA. Personal communications.

Moore, T. 1994. "Separable Feast/Membrane Applications in Food Processing." *EPRI JOURNAL*. September.

Nicholson, K. 1998. Southern California Edison. Covina, CA. Personal communications.

Tri Valley Growers. 1997. Press releases.

Yates, E. 1997. California League of Food Processors. Sacramento, CA. Personal communications.

Chapter 11

An Overview to Water Recycling in California

Arlene K. Wong

Introduction

Water recycling, or the beneficial use of reclaimed water, involves the reuse of treated wastewater for non-potable or indirect potable uses. Non-potable uses refer to those in which recycled water is not intended to mingle with the drinking water supply or to be used for human consumption. Indirect potable reuse refers to situations where recycled water is blended with raw potable water supplies, such as in a groundwater basin, storage reservoir, or stream. In a sense, indirect potable reuse has occurred ever since wastewater was discharged into rivers (unplanned or incidental reuse). Recycled water has been used as a planned non-potable water supply in California for over a century (*Water Recycling 2000* 1991), and occurred as early as the 1880s in Pasadena, when raw wastewater was used to irrigate orchard crops—a practice that was soon discontinued (WBMWD 1994). By the early 1900s treated wastewater was being used on farmland and for landscape irrigation. Since then, uses for recycled water have grown to include groundwater recharge, environmental needs, and urban-based uses such as landscape irrigation and industrial processes. As fresh water becomes increasingly scarce or valuable, alternative sources of water, such as recycled wastewater, will become more and more attractive.

Benefits of Recycled Water

Reducing Wastewater Discharge

Early water-recycling projects were primarily motivated by pollution control considerations, and the wastewater treatment regulations that resulted spurred the search for other uses for wastewater to reduce effluent discharges and treatment costs. In 1972 Congress passed the Clean Water Act (CWA) to limit pollution of the nation's waters. Enacted in response to growing public concern over serious water pollution problems, the CWA set two goals: zero discharge of pollutants into surface waters by 1985, and as an interim goal, water quality that was "fishable and swimmable" by mid-1983. Work to achieve these goals continues today.

A primary focus of the CWA was construction of large, centralized water treatment plants. The CWA requires the U.S. Environmental Protection Agency (EPA) to set minimum standards for treatment plant discharges, and the California Regional Water Quality Control Boards, with support from the EPA, are responsible for monitoring effluent quality and enforcing compliance with discharge standards. To help wastewater treatment plants meet state and federal discharge standards, the CWA authorized a major program of federal grant assistance for municipal sewage treatment plant construction and improvement.

Thus, the CWA not only provided for new regulations related to water quality, but also supported the infrastructure for centralized wastewater treatment facilities. In many cases, agricultural water reuse projects grew out of the need to find alternatives for wastewater disposal. Increasing regulations and more stringent standards were making discharge into surface waters more difficult and more costly. Land disposal through irrigation became a more attractive alternative, a forerunner of water recycling as it is practiced today.

The Water Supply Connection

More recently, however, cities and water districts have turned to recycled water as a source of supply. As supplies of fresh water become more constrained, recycled water can free up fresh water by substituting for non-potable water uses or it can provide water for a use that otherwise might not occur, such as environmental enhancement or recreational impoundment. Agencies in Southern California have turned to recycled water for groundwater recharge, which not only helps replenish the basin, but also provides an alternative to purchasing imported surface supplies for recharge. The County Sanitation Districts of Los Angeles County, Los Angeles County Department of Public Works, and Water Replenishment District of Southern California have been recharging the Central Basin with treated effluent since the 1960s. Orange County Water District (OCWD) has used recycled water in its seawater barrier injection operation since 1976. OCWD is also developing a proposal for a groundwater recharge project that will use up to 100,000 acre-feet of recycled water annually. In Monterey County, the Monterey Regional Water Pollution Control Agency and Monterey County Water Resources Agency have partnered on a $75 million regional water-recycling project to ultimately provide 19,500 acre-feet of water annually for 12,000 acres of farmland. This project will replace groundwater pumping from a coastal aquifer that is overdrafted and suffering from seawater intrusion.

Recycled water supplies also have the benefit of increased reliability over surface supplies, particularly during drought periods. While surface supplies become scarcer during drought years, wastewater for recycling projects is not similarly impacted. Thus, many agencies involved in recycled water projects do so to improve drought reliability. These activities have greatly expanded uses for recycled water. Agricultural uses continue to be important, but projects have also been developed to support groundwater recharge and urban uses such as landscape irrigation and industrial uses. Irvine Ranch Water District has promoted broad use of recycled water for urban landscaping for nearly 30 years. The district recently began supplying water to office high-rises that were constructed with dual distribution systems so that recycled water could be used for flushing toilets and urinals. East Bay Municipal Utility District worked with Chevron to develop a recycling project to serve the refinery's cooling tower in Richmond. The project reduces annual potable demand by 4,700 acre-feet. The success stories that follow include the West Basin Water Recycling Project in southwest Los Angeles County and the South Bay Water Recycling Program in Santa Clara County. Both projects provide recycled water to numerous cities.

Environmental Benefits

Fulfilling either the water pollution control or supply goal offers environmental benefits in the form of reduced effluent discharge, decreased pressure on existing potable sources, as well as avoiding or delaying the need for new water supply. Expectations of continued stringent regulation of discharge water quality and effluent impacts on sensitive environmental areas will continue to make recycled water projects viable and desirable. In addition, recycled water is one way to support restoration projects. Since 1988, Union Sanitary District has been providing secondary effluent to assist in a 172-acre marsh restoration project on the Hayward Shoreline along San Francisco Bay. The accompanying case on Santa Rosa's support for recycled water provides an example of using recycled water for constructed wetlands.

Regulation

In California, the State Water Resources Control Board regulates the production, conveyance, and use of recycled water through its nine Regional Water Quality Control Boards. Uses for recycled water are governed by Title 22 Wastewater Reclamation Criteria in the California Code of Regulations. Regulations specify the uses for recycled water, conditions of the use, and the physical and operational requirements to protect the health of workers and the public. The degree of treatment (see sidebar) and expected contact with human activities govern type of reuse. Title 22's allowed recycled water uses identify specified activities and the required treatment level for agricultural irrigation, groundwater recharge, landscape irrigation, wildlife habitat enhancement, industrial use, recreational impoundments, and other miscellaneous uses (included as Table 11-1).

Wastewater Treatment Levels

Wastewater treatment levels are generally defined as primary, secondary, and tertiary. In **primary treatment**, a physical process (screening, settling, or sedimentation) removes some of the suspended solids and organic matter from the wastewater. The remaining effluent from primary treatment will ordinarily contain considerable organic material and will have a relatively high biochemical oxygen demand.

In **secondary treatment**, biological processes involving microorganisms remove residual organic matter and suspended material. The effluent from secondary treatment usually has little biochemical oxygen demand and few suspended solids.

Tertiary treatment further removes suspended and dissolved materials remaining after secondary treatment, and often involves chemical disinfection and filtration of the wastewater.

Source: Tchobanoglous, G. and E. Schroeder 1987

Recycled Water Use in California

In the last 20 years, the number of water-recycling projects and the volumes recycled have significantly increased. A comparison of three recent surveys shows the growth in total volume of reuse from 1987 to 1995 (Table 11-2 and Figure 11-1). Agricultural irrigation and groundwater recharge continue to be the largest volume uses for recycled water. Recycled water use has grown in volume in nearly all of the categories of use. Agricultural irrigation showed a decline between the 1989 and 1993 survey but increased in the 1995 survey, and groundwater recharge appears to have decreased in the 1995 survey.

Evaluation of Success: Barriers to Water Recycling

As the cost of potable supplies increases, recycled water projects will increasingly become more viable economic alternatives for stretching our current freshwater supplies. Interest has grown in supporting and promoting recycled water use. Numerous studies have identified four primary areas that need improvement in order to assist reclaimed water projects: funding, regulatory issues, institutional cooperation, and education.

Funding is important not only because recycled water projects can be costly capital undertakings, but because often the costs and benefits are not evenly distributed across institutional lines. Recycling projects may include significant capital costs for building or upgrading wastewater treatment facilities and developing extensive distribution facilities for the recycled water. The costs of construction may be borne by one entity while the benefits of recycled water use accrue elsewhere.

Another related issue is that of how to value benefits, such as the water quality benefits from wastewater reduction, avoided habitat destruction, drought reliability, or the reduction in demand for new supplies. Placing economic value on such benefits often proves so difficult that they are excluded from the cost-benefit analysis, making recycled water projects that much more difficult to justify. Valuing the benefits and identifying the recipients of these benefits can have important implications for cost-sharing as well.

Regulatory issues include streamlining permit processes, and continuing research and study to determine minimum standards for human health and environmental protection while maximizing use. As recycled water proponents support new and expanded uses for recycled water, it is important to revise regulations to reflect new information, and to provide for consistent application of regulations and mandates to encourage broader reuse.

Table 11-1
Uses of Recycled Water*

Summary of Allowed Uses According to Draft of March 1997 Proposed Revisions for California Department of Health and Safety Title 22 Regulations

	TREATMENT LEVEL			
USE	**Disinfected Tertiary Recycled Water**	**Disinfected Secondary-2.2 Recycled Water**	**Disinfected Secondary-23 Recycled Water**	**Undisinfected Secondary Recycled Water**
Irrigation of:				
Food crops where recycled water contacts the edible portion of the crop, including all root crops	Allowed	Not allowed	Not allowed	Not allowed
Parks and playgrounds	Allowed	Not allowed	Not allowed	Not allowed
School yards	Allowed	Not allowed	Not allowed	Not allowed
Residential landscaping	Allowed	Not allowed	Not allowed	Not allowed
Unrestricted access golf courses	Allowed	Not allowed	Not allowed	Not allowed
Any other irrigation uses not prohibited by other provisions of the California Code of Regulations	Allowed	Not allowed	Not allowed	Not allowed
Food crops where edible portion is produced above ground and not contacted by recycled water	Allowed	Allowed	Not allowed	Not allowed
Cemeteries	Allowed	Allowed	Allowed	Not allowed
Freeway landscaping	Allowed	Allowed	Allowed	Not allowed
Restricted access golf courses	Allowed	Allowed	Allowed	Not allowed
Ornamental nursery stock and sod farms	Allowed	Allowed	Allowed	Not allowed
Pasture for milk animals	Allowed	Allowed	Allowed	Not allowed
Non-edible vegetation with access control to prevent use as a park, playground, or school yard	Allowed	Allowed	Allowed	Not allowed
Orchards with no contact between edible portion and recycled water	Allowed	Allowed	Allowed	Allowed
Vineyards with no contact between edible portion and recycled water	Allowed	Allowed	Allowed	Allowed
Non-food-bearing trees, including Christmas trees not irrigated less than 14 days before harvest	Allowed	Allowed	Allowed	Allowed
Fodder crops (e.g. alfalfa) and fiber crops (e.g. cotton)	Allowed	Allowed	Allowed	Allowed
Seed crops not eaten by humans	Allowed	Allowed	Allowed	Allowed
Food crops that undergo commercial pathogen-destroying processing before consumption by humans (e.g. sugar beets)	Allowed	Allowed	Allowed	Allowed
Ornamental nursery stock, sod farms not irrigated less than 14 days before harvest	Allowed	Allowed	Allowed	Allowed
Supply for impoundment:				
Non-restricted recreational impoundments, with supplemental monitoring for pathogenic organisms	Allowed**	Not allowed	Not allowed	Not allowed
Restricted recreational impoundments and fish hatcheries	Allowed	Allowed	Not allowed	Not allowed
Landscape impoundments without decorative fountains	Allowed	Allowed	Allowed	Not allowed
Supply for cooling or air conditioning:				
Industrial or commercial cooling or air conditioning with cooling tower, evaporative condenser, or spraying that creates a mist	Allowed***	Not allowed	Not allowed	Not allowed
Industrial or commercial cooling or air conditioning without cooling tower, evaporative condenser, or spraying that creates a mist	Allowed	Allowed	Allowed	Not allowed
Other uses:				
Groundwater recharge	Allowed under special case-by-case permits by RWQCBs****			
Flushing toilets and urinals	Allowed	Not allowed	Not allowed	Not allowed
Priming drain traps	Allowed	Not allowed	Not allowed	Not allowed
Industrial process water that may contact workers	Allowed	Not allowed	Not allowed	Not allowed
Structural fire fighting	Allowed	Not allowed	Not allowed	Not allowed
Decorative fountains	Allowed	Not allowed	Not allowed	Not allowed
Commercial laundries	Allowed	Not allowed	Not allowed	Not allowed
Consolidation of backfill material around potable water pipelines	Allowed	Not allowed	Not allowed	Not allowed
Artificial snow making for commercial outdoor uses	Allowed	Not allowed	Not allowed	Not allowed
Commercial car washes excluding the general public from washing process	Allowed	Not allowed	Not allowed	Not allowed
Industrial boiler feed	Allowed	Allowed	Allowed	Not allowed
Nonstructural fire fighting	Allowed	Allowed	Allowed	Not allowed
Backfill consolidations around non-potable piping	Allowed	Allowed	Allowed	Not allowed
Soil compaction	Allowed	Allowed	Allowed	Not allowed
Mixing concrete	Allowed	Allowed	Allowed	Not allowed
Dust control on roads and streets	Allowed	Allowed	Allowed	Not allowed
Cleaning roads, sidewalks, and outdoor work areas	Allowed	Allowed	Allowed	Not allowed
Flushing sanitary sewers	Allowed	Allowed	Allowed	Allowed

Source: WateReuse Association of California 1997

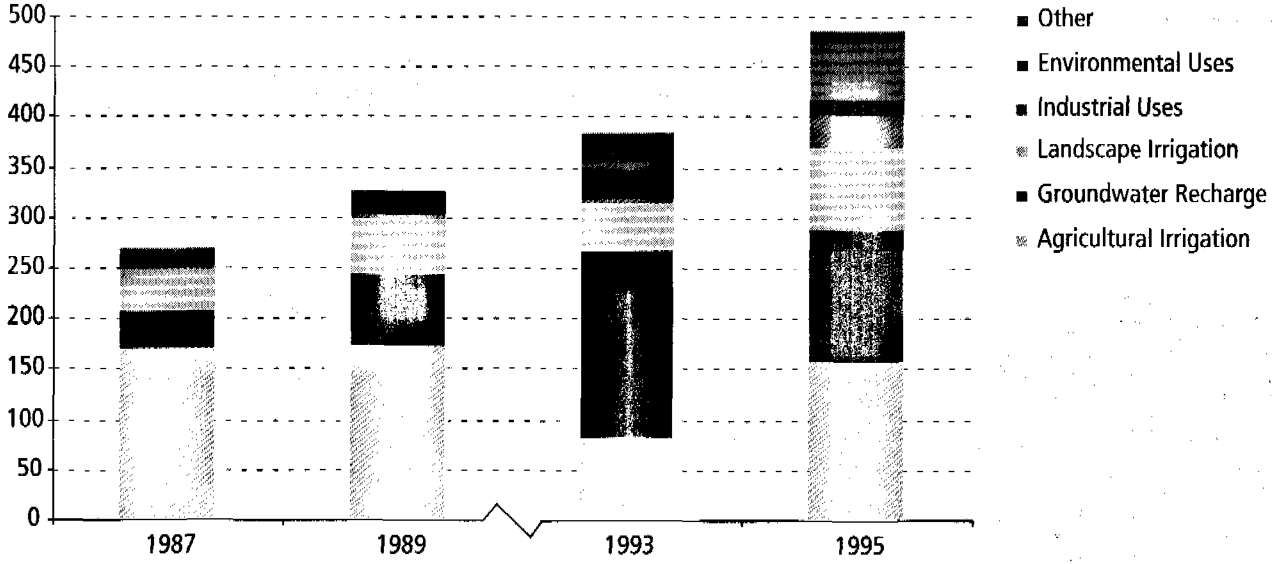
**Refer to the full text of the latest version of Title-22: California Water Recycling criteria.*
***With "conventional tertiary treatment." Additional monitoring for two years or more is necessary with direct filtration.*
****Drift eliminators and/or biocides are required if public or employees can be exposed to mist.*
*****Refer to Groundwater Recharge Guidelines, California Department of Health Services.*

Table 11-2
Use of Recycled Water by Category for Survey Years

Amounts in Thousands of Acre-Feet

	1987	1989	1993	1995
Agricultural Irrigation	168	173	80	155
Groundwater Recharge	39	70	185	131
Landscape Irrigation	40	54	47	82
Industrial Uses	6	6	7	34
Environmental Uses	10	18	29	15
Other	4	4	36	68
Total	**267**	**325**	**384**	**485**

Figure 11-1
Comparison of Reuse Activities for 1987, 1989, 1993, 1995



Sources: The 1987 and 1989 data are from Water Recycling 2000, 1991.
The 1993 data is from Survey of Future Water Reclamation Potential, WateReuse, 1993.
The 1995 data is from a survey conducted by DWR as an update of the 1993 WateReuse survey. Data is used in the Draft Bulletin 160-98 report.
The surveys conducted used different methodologies and received different response rates, and thus are not directly comparable.
However, as four different snapshots in time, they do offer a reasonable overview of water reuse volumes in recent years.

New uses can be spurred by new technology, innovative applications, or new studies that demonstrate the safety of expanded applications. Slow regulatory response can stymie new or expanded applications.

Institutional issues arise from the many agencies and authorities necessary for successful implementation of water recycling projects—wastewater managers, water retailers and wholesalers, cities and counties, regulatory agencies, and planning agencies, as well as the customers and the public. These various institutions must cooperate to implement water-recycling projects—providing the wastewater treatment, undertaking project construction, meeting regulations, identifying and marketing customers, and operating and maintaining service. Another institutional issue is the separation of wastewater and water supply functions. If the relationship between reducing wastewater discharges and reducing demand for fresh water is not taken into account in benefit-cost analyses of proposed water-recycling projects, the costs tend to be borne by one entity, making it difficult to move projects forward.

The need for education about recycled water applies to policymakers, water agencies, regulators, customers, and the public. While perceptions about the safety of recycled water have improved, there remains a need to strengthen the ethic about the feasibility and desirability of undertaking water-recycling projects.

Conclusions/Lessons Learned

It is estimated that California produces 2.5 to 3 million acre-feet of wastewater each year (WateReuse 1993). Incidental reuse occurs all the time as wastewater is discharged into California waterways, and used downstream. Planned recycling projects provide the opportunity to divert and reduce some of the discharge, as well as provide a substitute for potable supplies, stretching current potable supplies further by better matching use with water quality needs. These projects provide water agencies with greater flexibility and reliability in managing supplies and meeting demand. Support for reuse has grown as the need for making better use of our existing supplies has grown. The past decade has seen a growth in the volume of water recycling taking place, as well as an expansion of uses for recycled water. As California continues to grapple with the challenges of meeting current and future water demands, water recycling has an important role to play. The following two cases provide detailed examples of agencies or cities developing recycled water projects to meet urban and agricultural needs.

References

California Department of Water Resources. 1998. *Draft: The California Water Plan Update, Bulletin 160-98.*

Sheikh, B. et al. 1998. "Accounting for the Benefits of Water Reuse." Proceedings, AWWA-WEF Joint Conference: Water Reuse 98, February, Orlando, FL.

State Water Conservation Coalition et al. 1991. "Water Recycling 2000: California's Plan for the Future." WateReuse Association.

Tchobangolous, G. and E. Schroeder. 1987. *Water Quality.* Reading, MA: Addison Wesley Publishing Co.

WateReuse Association of California. 1993. "Future Water Recycling Potential." Los Angeles, CA.

WateReuse Association of California. Undated brochure.

West Basin Municipal Water District (WBMWD). 1994. "West Basin Water Recycling Project." Carson, CA.

Using Recycled Water in Urban Settings: West Basin Recycling Project and South Bay Water Recycling Program

Arlene K. Wong

Introduction

Interest in recycled water continues to grow, given its wastewater reduction, water supply, and environmental benefits. As documented in *An Overview to Water Recycling in California*, water recycling projects have grown in number and scale in the last decade. A significant amount of this growth has taken place in urban areas. Two examples of the current trend in urban recycling projects are described here. While earlier projects were dominated by wastewater treatment plants serving neighboring users, many of today's projects have taken on a larger scale, delivering water to multiple users in numerous cities and retail service areas. Even larger projects are underway or being planned, including regional wastewater distribution systems (WBMWD 1994), such as those being studied by the U.S. Bureau of Reclamation (USBR).[1] The following two cases offer examples of recycling for multiple users in both Northern and Southern California. The West Basin Water Recycling Project will ultimately provide 100,000 acre-feet of recycled water annually (approximately one-half of the district's demand) for its 17-city service area. The South Bay Water Recycling Program will serve the cities of San Jose, Santa Clara, and Milpitas. The first two phases are expected to provide over 16,000 acre-feet each year.

The Projects

West Basin Recycling Project

Introduction

The West Basin Municipal Water District (WBMWD or the District) was in the midst of the 1987–1992 drought when the board of directors decided, in 1990, to establish a plan to drought-proof the basin. A key part of that plan was an over $200 million water-recycling project that would ultimately provide 100,000 acre-feet of recycled water annually, or nearly half of the basin's water needs.

The West Basin Recycling Project's treatment facilities were dedicated in October 1994, four years after project conception. Its first customer was connected in March 1995. Phase I of the project was completed in June 1996, and construction has commenced on Phase II. Phase I provides 15,000 acre-feet of tertiary-treated water annually to over 100 industrial and landscape customers. Another 5,000 acre-feet of water undergoes additional treatment and is provided to a seawater intrusion barrier operation. Phase II expands the tertiary-treatment plant capacity, and will provide for another 22,000 acre-feet of recycled water deliveries annually, as well as an additional 2,500 acre-feet of advanced-treated water to the seawater intrusion barrier project. Future phases will continue to expand deliveries. Developing this project required multiple partnerships, not only for financing, but also to carry out construction of facilities, market the recycled water, and even operate and maintain the facilities and infrastructure.

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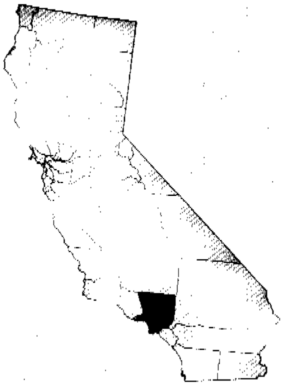
[1] USBR is currently involved in two efforts—the Bay Area Regional Water Recycling Program and the Southern California Comprehensive Water Recycling Study—aimed at coordinating reuse in Northern and Southern California, respectively.



Background

The WBMWD was formed in 1947. It is a public agency that provides wholesale water to local water utilities and municipal water departments. It provides about 80 percent of the water used in the District, providing imported and recycled water for 17 cities and unincorporated areas of southwest Los Angeles County in a 185-square-mile area, and serving a population of 827,000 people (WBMWD 1996). The remaining water needs are met with local groundwater supplies.

The West Coast Groundwater Basin is an adjudicated basin,[2] though groundwater pumping levels established by the court were not sufficient to meet the water demands of the region. WBMWD was formed largely in response to the need to provide supplemental water to meet growing demand. In 1990, about 80 percent of the District's supplies were imported (Atwater 1998). All imported water is purchased by the District as a member agency of the Metropolitan Water District of Southern California (MWD) and includes both Colorado River water and State Water Project water from Northern California. These imported sources were increasingly expensive during dry periods, and the District was seeking ways to develop drought-proof supplies.

Goals

The water-recycling project is expected to benefit both the economy and the environment. Full implementation of the 100,000 acre-feet per year (afy) recycling project will:

- Reduce dependence on imported water by 50 percent;
- Provide an alternative, drought-proof, dependable water source;
- Provide recycled water for injection into the West Coast Basin Seawater Intrusion Barrier, preventing further salt water contamination of the groundwater basin; and
- Reduce treated wastewater discharged by the city of Los Angeles into the Santa Monica Bay by 25 percent.

Description

The decision

By 1990, the city of Los Angeles's Hyperion Wastewater Treatment Plant produced about 400 million gallons of wastewater per day and discharged it into the Santa Monica Bay. The idea of using this wastewater as a local non-potable supply had floated around for some time. Acting on this idea required leadership with a shared vision of creating an alternative, drought-proof, dependable water source. In 1990, WBMWD's board of directors adopted a plan to respond to persistent droughts and to reduce dependence on imported water from MWD. A focal point of that plan was to develop a drought-proof supply through a $200 million (for Phase I) water-recycling project. Leadership and commitment from the board were matched by the District's management and staff.

Project design and components

The project design includes three phases of expanded service, with plans to ultimately provide 100,000 afy of recycled water. To expand uses, two levels of treatment were planned. First, tertiary treatment meets Title 22 standards for the broadest level of 40 specified non-potable uses. Two nitrification plants were required to meet additional treatment needs for industrial use at two of the District's oil refineries. Second, an advanced treatment facility treats the tertiary water further, using reverse osmosis membranes, to drinking water standards for potable use. The water from this facility is used for direct injection into the basin for the West Basin Seawater Intrusion Barrier and must meet the higher standards required for water entering potable supplies. Phase I facilities produce about 20,000 afy of recycled water. Future phases would involve increasing treatment plant capacity and expanding the distribution system to bring more customers on-line.

Key to the design was identifying high volume users to ensure a high flow rate of water in the system, reduce operational difficulties, and allow planners to build for capacity. Small-

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[2] A fuller description of the adjudication of the basin is provided in *Comprehensive Groundwater Management,* Chapter 27.

Table 12-1
West Basin Water Recycling Project: Project Components

	Construction Features	Expected Delivery (Acre-Feet)	Service Area
Phase I	Three miles of 60-inch secondary effluent force main for delivery of wastewater; water-recycling treatment facilities for tertiary and advanced treatment; two nitrification treatment facilities; 48 miles of pipeline for distribution.	20,000	Inglewood, Lennox, Hawthorne, Gardena, Lawndale, El Segundo, Manhattan Beach, Hermosa Beach, Redondo Beach
Phase II	Modifications to treatment plants for enhanced capacity; additional distribution pipeline.	22,000	Carson, Torrance
Phase III	Upsizing plant capacity; additional distribution pipeline.	58,000	Lomita, Palos Verdes, and the Los Angeles harbor area; Los Angeles International Airport and nearby communities, as well as the Santa Monica, West Los Angeles, and Culver City areas

er users could then be easily attached. Phase I is thus anchored around three primary users—the Chevron and Mobil refineries and the West Basin Seawater Intrusion Barrier—that total 15,000 afy of the anticipated 20,000 afy use.

Meeting stakeholder concerns: partnerships and new institutional arrangements

Developing this project required multiple partnerships, not only for financing, but also to carry out construction of facilities, market the recycled water, and even operate and maintain the facilities and infrastructure. The District had the benefit of following and learning from the efforts of the neighboring Central Basin Municipal Water District, which had embarked on its own water-recycling program just two years prior.

An early partner in the project was MWD. MWD established its Local Projects Program in 1982 to assist the development of recycled water supply projects. It was premised on the belief that MWD needed to help its member agencies develop local supplies to meet its own mission of providing adequate supplies to those agencies. Under the program, MWD provides financial support to local agencies that develop recycled water projects that reduce the demand for imported water and improve regional water supply reliability. Thus, in 1990, MWD partnered with West Basin to initiate planning studies for the water-recycling project, by co-funding the initial Concept Planning Report.

In July 1991, the city of Los Angeles agreed to be a partner in the project by providing secondary-treated wastewater from the Hyperion Treatment Plant. WBMWD would purchase the wastewater from Hyperion at $7.50 per acre-foot, and in exchange, the city reserved the right to purchase up to 25,000 afy of recycled water at its discretion, as the project came on-line. With sufficient notice to WBMWD, Los Angeles could opt to receive more than 25,000 acre-feet.

As a wholesaler, WBMWD required partnerships with the various cities, water utilities, and other water retailers to market recycled water to customers. The District established wholesale rates for recycled water well below potable water rates and urged utilities to pass the economic savings on to customers. WBMWD also worked directly to market recycled water to customers offering design, construction, and financial services to assist customers with retrofits. As mentioned above, early commitments by large volume users were key to bringing construction of major distribution system branches on-line.

For the most part, utilities and customers were receptive to the idea of using recycled water, but required varying degrees of education about its use, impacts on operations, and other regulatory and institutional requirements. Other than safety, health, and operational considerations, the prime concern was cost. Although recycled water would be marketed below potable water rates, and even though it offered clear savings, retrofit costs could prove prohibitive, particularly for cash-strapped school districts and other commonly-targeted municipal users. Thus, it was important for WBMWD to offer financial assistance as well as design and construction services to assist with the retrofits. Financing the capital costs of retrofits for public entities is recouped through the base rate, which requires customers to pay at the potable water rate (above the recycled water rate) until the loan is repaid.

Other than the oil refineries and the seawater intrusion barrier, nearly all customers to date use the water for landscape irrigation. Other industrial and commercial uses require considerably more retrofit work and sometimes additional water quality treatment. Delivering recycled water to a customer can take anywhere from two weeks to over two years, depending on the complexity of the operation and the need to negotiate formal agreements. Phase II of the project will continue to service landscape irrigation needs and will also expand industrial service to include other oil refineries and several fabric dye houses in the Torrance and Carson areas.

Another major education and planning effort was carried out through the District's Drought-Proof 2000 Plans. The District targeted and worked with cities to establish plans for water-efficiency measures and to quantify water savings, availability, and reliability goals. Water-efficiency measures included residential water conservation programs, connections of large facilities to recycled water, landscape ordinance planning, and distribution system leak detection. This helped cities and utilities accept recycled water as part of a larger plan to improve service reliability.

Construction of the necessary facilities, including a secondary effluent force main, which connects the Hyperion plant with the reclamation facility and tertiary-treatment plant, treatment facilities, and distribution pipelines, required cooperation with affected areas. Building the treatment plant in the city of El Segundo, for example, required over one year of construction. Laying the secondary effluent force main required the excavation of a 25-foot-deep trench along a major traffic thoroughfare. WBMWD partnered with the city and local businesses to keep construction on schedule while also mitigating for the disruption to the city and its residents. The District held frequent neighborhood meetings along the construction route to identify concerns and solutions. In response, WBMWD worked to fine-tune traffic detours, schedule construction hours, and undertake safety measures. The District helped businesses and residents by installing sound barriers, providing cordless phones so employees could conduct business in a less noisy environment, and providing portable air conditioning and fan units when ventilation was affected (WBMWD 1994).

The newly built treatment facilities are currently staffed by a private sector operator, and the distribution system is maintained by the private and public water suppliers who already maintain water systems in these areas.

Implementation

In four years, WBMWD brought a recycled water project from concept to groundbreaking ceremonies and actual delivery. The District completed the final design for the treatment facilities in December 1992, two and one-half years after completion of the concept report for the project. Construction commenced in 1992, and treatment facilities were dedicated in October 1994. The first user was connected the following March. Today, the project delivers its Phase I capacity of 20,000 afy, and planning, design, and construction to increase the capacity of the treatment plant to 42,000 afy have recently been completed. Design for Phase II pipelines has been completed, construction is underway, and customers in Carson and Torrance have already been identified. The largest customers are expected to be an Arco refinery in Torrance and several fabric dye houses in Carson.

Financial considerations

The $200 million Phase I of the project is supported by a $50 million grant from the Bureau of Reclamation (25 percent of the project costs),[3] and a $5 million low-interest loan from the State Water Resources Control Board, and the remaining costs are funded by the sale of revenue bonds. The debt service is largely supported through a per parcel standby charge which has been passed by the District board each year since 1991. The standby charge is a parcel tax charged to District landowners.[4] Additional revenue is raised through fixed charges against the Chevron and Mobil oil refineries for the cost of the nitrification treatment and delivery facilities, and a seawater barrier surcharge[5] applied to the imported water sold to the Water Replenishment District for the West Coast Seawater Intrusion Barrier. Revenues from recycled water sales and the rebate from MWD currently cover the project's operating and maintenance costs. It is expected that as more customers are brought on-line, water sale revenues should cover the cost of the program, including the debt service.

Evaluation of Success

Replacing potable water use

The project has substituted recycled water for potable water for use in landscaping, industrial uses, and the seawater intrusion barrier. The project's large volume customers are the West Basin Seawater Intrusion Barrier, and the area's oil refineries, which together account for 17,500 acre-feet of the recycled water use. Users targeted for landscape irrigation are large turf areas, including school sites, city parks, and public and private golf courses. As of February 1998, over 20,000 acre-feet were being delivered annually to 102 sites (Table 12-2).

> "We actually go through more water than oil here. About 10,000 gallons per minute. So obviously, water reliability is an important issue for us. It's the main reason we use recycled water. And we got an unexpected bonus. By understanding better how recycled water interacted with our facility, we were able to get improved performance."
>
> — Chris Spurrell, Chemical Coordinator,
> Chevron
>
> "At the Mobil-Torrance refinery, we use West Basin reclaimed water in our cooling towers rather than potable water. In the cooling towers, the water is recycled many times before it's discharged. In doing this, we estimate that we're conserving about 2,800 acre-feet per year of drinking water. That translates to about 2,900 gallons per minute."
>
> — Joseph Papia, Support Supervisor
> MOBIL-Torrance Production
>
> *Source: Quoted in 1996 Annual Report, West Basin Municipal Water District*

Table 12-2
Sites Connected to West Basin Water Recycling Project, February 1998

Type of Use	Number of Sites	Number of Acre-Feet Per Year
Landscaping		
Public	88	2,117
Private	10	951
Industrial	2	10,000
Seawater Intrusion Barrier	1	7,500
Other	1	2
Total	**102**	**20,570**

Source: West Basin Municipal Water District 1998 Scorecard

Environmental benefits achieved

Environmental benefits are achieved through reduced wastewater discharge. Wastewater deliveries from Hyperion decrease the discharges into the Santa Monica Bay. Further,

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[3] Federal support was achieved through establishment of PL 102-575, Title XVI. The case study on Mono Lake provides a brief discussion on passage of this bill.

[4] The parcel standby charge has remained unchanged since 1992 and is $16, $24, or $120 per parcel depending upon the land use of a given parcel.

[5] This charge has been controversial. The Water Replenishment District (WRD) considered the surcharge an additional financial burden that increased the cost of using recycled water, and had threatened to purchase imported water for the barrier elsewhere. WBMWD brought suit against WRD to prevent such action and WRD sued to force WBMWD to reduce its charges for recycled water. The parties have since settled. Part of the settlement concerns the cost of the recycled water project and how it is distributed. WRD has agreed to pay the surcharge on imported water ($90/af) and purchase 7,500 afy of recycled water for the barrier operations. WBMWD agreed to a one-time lump sum payment to WRD as a share of the MWD rebate West Basin receives for its recycled water project.

increasing local supplies through water recycling reduces demand on imported sources and groundwater. The environmental benefits of this project prompted endorsements from environmental organizations throughout the county. The Mono Lake Committee was an ardent supporter of the project because of its ability to provide replacement water for the Mono Basin supplies Los Angeles lost (see *Finding Mono Basin Replacement Water,* Chapter 25).

> "This project is near and dear to my heart. And it's not just because it provides replacement water to protect Mono Lake. It's the remarkable combination of all the benefits for our community—the reliable water supply for our businesses, the drought proofing for our economy, jobs for our community, and protection of the Santa Monica Bay.
>
> This is a winning combination for the Santa Monica Bay, the Mono Lake Committee, and all of Los Angeles County."
>
> — Martha Davis, Executive Director,
> Mono Lake Committee
>
> *Source: Quoted in West Basin Municipal Water District's 1996 Annual Report*

Searching for an equitable distribution of costs

Because cost is such a large obstacle to recycled water development, supporters have long argued for the need for state and federal financial support. The broader benefits of developing recycled water as an alternative to new freshwater supplies would seem to justify public support, particularly when one considers that state and federal water projects are likely to bear the costs of developing additional supplies. Thus, the financial assistance from both USBR and the State Water Resources Control Board provided key funds to undertake the capital costs of the project.

Initially, the debt service on the capital is borne by the District's property owners since the debt service is recovered through the per-parcel standby charge. Eventually, the standby charge will be dropped when revenues from water sales are enough to cover the debt service. Some residents have chafed at this burden, and there is pressure on the District's board to drop the parcel charge. However, this is unlikely, since without the parcel charge, the District would have to raise all water rates to meet debt service.

Some costs are shared by the utilities and MWD through recycled water sales and MWD's rebate. WBMWD's wholesale rate structure and retailer agreements to pass savings on to customers offer an economic incentive to switch to recycled water. Even with the economic incentive, the revenue from sales and the MWD rebate cover operation and maintenance costs. Thus, revenue from the rate base follows the "user pays" principle in apportioning operation and maintenance costs.

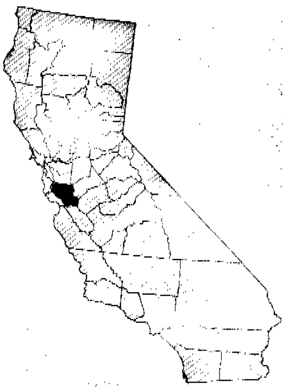
Planning and management coordination

The project has spawned partnerships for the District with the city of Los Angeles's Hyperion Wastewater Treatment Plant, and the District's cities, utilities, and customers. Not all cities or utilities are prepared or willing to take on a new service or deal with the new operational, institutional, and regulatory requirements of using or delivering recycled water. However, for many the partnership makes sense. An additional source of water improves ability to plan and manage resources in the future. As a drought-proof source, it offers greater flexibility and reliability during otherwise water-short periods. Planned deliveries of recycled water to the city of Los Angeles (part of the agreement with Hyperion) create an additional source with which the city can meet its water needs in light of reduced deliveries from Mono Basin (as a result of the Mono Lake decision). Recycled water is one part of larger water-efficiency and conservation plans for the District and individual cities, utilities, and customers.

South Bay Water Recycling Program

Introduction

The South Bay Water Recycling program was undertaken by the San Jose/Santa Clara Wastewater Pollution Control Plant in response to a Cease and Desist Order issued by the San Fran-



cisco Regional Water Quality Control Board (RWQCB). The order required that the wastewater plant reduce its discharges into the San Francisco Bay to protect a salt marsh that provides habitat for two federally-listed endangered species. Though spurred by a regulatory mandate, the South Bay Water Recycling project is an impressive effort to develop a program to meet present and future wastewater management and water supply operations needs for the region.

The project involves building the distribution system and establishing the necessary partnerships with cities, water agencies, and customers to deliver up to 15 million gallons per day of recycled water in Phase 1, at the cost of $140 million. Phase 2 would expand deliveries to up to 30 million gallons per day.

Background

The San Jose/Santa Clara Wastewater Pollution Control Plant (WPCP) is a jointly-owned regional wastewater treatment plant[6] operated by the city of San Jose. The plant serves over 1.2 million residents, businesses, and industries in Santa Clara Valley. In 1997, it discharged about 135 million gallons per day (mgd) of tertiary-treated effluent into the southern end of San Francisco Bay. The southern part of the bay is considered an environmentally sensitive area, and the area of discharge, a salt marsh, is habitat for two federally designated endangered species—the salt marsh harvest mouse and the California clapper rail. According to the RWQCB, freshwater effluent from the plant is converting the salt marsh into a brackish or freshwater marsh, destroying the natural habitat. In 1989, the RWQCB issued a Cease and Desist Order that specified that the Plant must either reduce freshwater discharge to the South Bay, create or enhance salt marsh, relocate the plant discharge, or find other means to mitigate for impacts of plant discharge on salt marsh in South San Francisco Bay.

The U.S. Environmental Protection Agency (EPA) and RWQCB ordered WPCP to divert flows over 120 mgd from the South Bay during dry weather months to prevent further marsh conversion.[7] The plant has a capacity of 167 mgd during dry weather months; thus the cap requires that ultimately 47 mgd must be diverted to operate at full capacity. The plant does not currently run at capacity, but regional growth plans were developed with expectations of having full capacity available, and the wastewater flows at the time of the Cease and Desist Order were over the 120 mgd cap. The city faced several alternatives: build an outfall to avoid discharge into the marsh, reduce outflow into the marsh, purchase salt flats for reconversion to salt marsh, and/or limit future growth (i.e. ban future wastewater hook-ups).

Goals

The South Bay Water Recycling Program (SBWR) is a joint effort by three cities (San Jose, Santa Clara, and Milpitas), five sanitation agencies (West Valley Sanitation District, Burbank Sanitary District, Cupertino Sanitary District, Sunol Sanitary District, and County Sanitation District No. 2-3), the San Jose Water Company, and the Great Oaks Water Company, with financial assistance from the Santa Clara Valley Water District and USBR. The program is designed to meet federally mandated water quality standards by reducing the flow of effluent into the salt marsh during dry weather months. Phase 1 will divert 15 mgd of treated effluent for approved recycled water uses in San Jose, Santa Clara, and Milpitas, with deliveries to expand to 30 mgd in Phase 2 and up to 50 mgd in the future.

In addition to meeting the mandate, expansion of recycled water use provides an alternative water supply to meet the demands of planned growth; reduces sensitivity to decreased quantities of local and imported water during drought years; and prevents overdraft-

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[6] The plant services the cities of San Jose, Santa Clara, and Milpitas, and the five sanitation agencies that service these areas.

[7] The dry weather months were specified since that is when grasses associated with the endangered species habitat seed and establish themselves, and thus habitat formation and maintenance is most vulnerable. Dry weather months are May through October.

ing of groundwater and potential subsequent ground subsidence by providing alternative supplies (SBWR undated).

Description

The decision

Faced with the RWQCB's order to prevent further destruction of the salt marsh habitat, the city of San Jose developed an Action Plan, approved by its city council, with three main elements:

- The purchase and restoration of South Bay marsh properties to mitigate past conversion.
- The development of potable water conservation programs to reduce influent flows.
- Water recycling to reduce effluent discharge to the Bay.

The other alternative to taking no action (which, in the face of the permit requirements and the discharge levels, was clearly unacceptable), was building a deep water outfall beyond the sensitive area. This alternative was similarly considered in the 1970s when the water quality of effluent was at issue. Back then, the decision was made to treat the effluent to tertiary levels rather than build the outfall. The outfall alternative was estimated to cost between $100-200 million (depending on the size), comparable in cost to the $140 million Phase 1 of the water-recycling program that was ultimately conceived. Beyond the immediate cost considerations, the multiple and long-term benefits of water recycling were compelling. This decision came at the height of the drought when it was clearly desirable not to let any water resource go to waste. Water recycling offered a future revenue stream (in recycled water sales) and provided disposal and water supply benefits as well. There were also serious concerns that an outfall would only postpone further regulatory action since discharges would not be decreased, but only moved. Thus, future mandates could seek to reduce discharges yet again.

Refining the design

Early conceptions of the project proposed bringing customers closest to the plant on-line first and radiating outwards to virtually all large irrigation customers in the service area. Cost projections put that design at about $500 million. The city commissioned a Blue Ribbon Committee and a Value Engineering Study to review the preliminary design and evaluate the viability, cost-effectiveness, and implementability of the plan. The Blue Ribbon Committee was composed of experts from engineering firms, academia, and water districts and allowed the planners to learn and benefit from the many recycling activities already in practice. Both studies largely concurred with each other in their findings and resulted in redesign of the project.

The Value Engineering Study produced three major findings that resulted in redefining the project design:

- Small volumes are not cost-effective; it is best to connect the large customers first.
- A single "trunk" system is easier to operate than a "hub and spoke" system with several dead-end branches.
- *Anticipate demand* for higher quality water and thus adjust the pipeline size to increase capacity and decrease operating complexities.

The Blue Ribbon Committee (which also reviewed the Value Engineering Study) had similar findings regarding the scope of the design, and, in addition, noted that educating and signing up users required a great deal of effort. The committee recommended that staff be dedicated to public education and outreach and that the effort start immediately.

As a result of the two studies, the project was redesigned to expand Phase 1 service to include a larger area and to target larger customers first. Smaller customers could then attach to the larger trunk line. Thus, instead of constructing the distribution as a hub radiating out, each main spoke would be developed separately.

Table 12-3
South Bay Water Recycling Project: Project Components

	Construction Features	Expected Delivery	Service Area
Phase 1 (1998)	60 miles of pipeline for distribution; two pumping stations and storage reservoir	15 mgd[8] or 8,000 afy	Cities of San Jose, Santa Clara, Milpitas
Phase 2 (2002)	Distribution pipeline, additional pumping stations, and storage reservoirs as needed	15 mgd or 8,000 afy	In-fill in the above three cities plus extensions to additional industrial and agricultural customers

Meeting stakeholder concerns: partnerships and new institutional arrangements

In undertaking the water-recycling project, the WPCP was entering the water supply business, quite different from its original mandate as a wastewater treatment plant. As a new entrant into wholesale service, SBWR needed to establish and develop new relationships with regulatory agencies, cities, water retailers and wholesalers, potential customers, and the public. In some cases, new legal vehicles were required, such as formal agreements with retailers and wholesalers already servicing the area. Key to the success of this project was identifying stakeholder concerns and coordinating and cooperating with these other actors.

SBWR needed to establish partnerships with the various retail agencies serving the cities. These included municipalities and private water companies. The cities—San Jose, Santa Clara, and Milpitas—represented multiple interests. On the one hand, these cities represent the tributary sanitation agencies and districts serviced by the plant. On the other hand they represent the water retailers that provide potable service to those municipal areas. The motivation for the cities was quite clear: their sanitation districts needed to assist the plant in meeting the wastewater discharge mandate, and this required the cooperation of retail water agencies to provide recycled water to customers. As retailers, cities and private water companies were primarily concerned with loss of revenue from potable water sales; thus, it was important to develop a revenue-neutral rate system for retailers. Agreements with the cities took approximately a year to negotiate and finalize. Negotiations with private water companies took significantly longer, as these private entities did not have the additional motivation the cities had.

SBWR agreed to index wholesale rates to the price of untreated water from Santa Clara Valley Water District ($240 per acre-foot in 1997). An additional discount would be offered provided the retailer passed the discount onto the customer. The steeper discount was designed to make recycled water available at a cost comparable to the customer's currently available water supply and to compensate for "start-up" costs of retrofits and additional operating expenses. Customer classes were established for landscape irrigation, industrial processes, and agricultural irrigation. Landscape irrigation was discounted by 25 percent; industrial processes and agricultural irrigation by up to 92 percent. The industrial discount reflected expectations that recycled water could require substantial additional treatment and therefore additional expense. The discount for agricultural users reflects the fact that most agricultural users were dependent on well water that is much lower in cost than potable deliveries.

Even though SBWR wholesales the water to the retail agencies, it also took responsibility for marketing the water to customers directly. Par-

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[8] SBWR generally measures delivery in terms of required in-pipe capacity for peak demand. These maximum deliveries are expected during the six dry weather months when irrigation use is highest, and when the Plant is required to meet the RWQCB mandate. Thus, on an annual basis, the recycled water actually delivered is closer to one-half the average flow during the six-month peak use period.

ticipation in the project is voluntary at this time, and the SBWR timetable for implementation is very short. Thus, providing incentives was of utmost importance. Customers were largely concerned about costs and the impacts of recycled water on their operations. The discounted wholesale rates allow recycled water to be priced significantly below potable water. SBWR offered grants and loans to assist with retrofitting costs. SBWR customer marketing teams, staffed from two engineering firms, target customers and pay individual visits to businesses to begin the process of educating them about recycled water and the program. Once a letter of interest is signed by a customer, the team works on the customer's specific requirements for switching to recycled water use. The team assesses physical needs, compatibility of existing systems, modifications, and cost estimates for conversion. Because each customer's site is different, every retrofit is developed individually. The process of identifying customers paralleled the planning and design process. By the time Phase 1 construction began in 1996, numerous customers had already been secured.

Keeping the recycled water pricing structure competitive with potable rates also enables cities to mandate recycled water use if they determine mandates are necessary. As part of the state's attempt to encourage development of water recycling, Section 13550 of the Water Code defines the use of potable domestic water for non-potable uses as waste or an unreasonable use of such water when suitable recycled water is available with adequate quality and at a reasonable cost. Retrofit costs to connect customers to the system can be considerable and to date, no city in the service area has felt it necessary to invoke this mandate. However, some cities have passed ordinances requiring all new developments with over one-quarter acre of irrigation to design their plumbing to allow for hook-up to recycled water service.

Additionally, following the recommendations of the Blue Ribbon Committee, a Citizens Advisory Committee was established by SBWR to establish links with the broader public and community stakeholders. Twenty-seven members were selected and convened in December 1994 during the design phase of the project. The committee included representation from environmental groups such as CLEAN South Bay, the Silicon Valley Toxics Coalition, and several stream preservation interests. Two local universities and the League of Women Voters have active participants on the committee, as do youth sports programs, senior citizens, and neighborhood associations. The committee was designed to provide a forum for exchange of information between the program and the public. SBWR was able to explain the program goals and implementation plans and, in return, receive stakeholder input. One committee member commented that SBWR staff were very receptive to listening to committee ideas and very good at providing the committee with a background on recycled water issues and the project in particular. However, she also felt that the committee was established after the project design and was therefore limited in its ability to affect the project. The committee became an important part of public outreach activities, providing valuable input regarding public concerns about the project and in particular the construction disruptions. In addition, the committee developed its own outreach tools, often making use of its member organizations.

In 1993, the Santa Clara Valley Water District (SCVWD or the District) established a rebate policy to assist water-recycling projects in its service area, in recognition that recycled water offered an alternative water supply that avoided the need to acquire new supplies to meet increasing customer demand. SCVWD would offer a rebate equivalent to the difference between the cost of the recycled water and its next alternative source, at that time calculated to be $93 per acre-foot. In 1996, the SCVWD's board adopted an integrated resource plan that recognized that future water supplies for the region must, in part, be met with recycled water. The board also updated the recycled water rebate policy to increase the contribution to $115 per acre-foot. The policy revisions also increased SCVWD's flexibility and interest in becoming more involved in water-recycling projects. With the rebate, the Santa Clara Valley Water District should be an important financial partner in the SBWR project. As the primary wholesale water agency for the region, SCVWD is in a position to link water supply and wastewater issues through its active participation in water recycling. SCVWD expects to continue to be involved in SBWR's Phase 2 efforts, as well as other water-recycling projects throughout its service area.

Implementation

Construction began in July 1996, and the project delivered water through new pipelines in October 1997, with about one-third of the pipeline complete. Pipeline construction was completed in June 1998, and the two remote pumping stations were commissioned in September 1998. Prior to construction, a few customers had been serviced by the city of Santa Clara since 1989. The city undertook a pilot program, which used about 1,000 afy of recycled water for landscape irrigation during the 1987–1992 drought, and was continued thereafter. This system has been joined with the newly constructed distribution pipeline. SBWR has already identified over 300 customers in the Phase 1 area, substituting recycled water for over 9,500 acre-feet of potable water. At this writing (September 1998), about 100 customer connections have been completed or are under construction; the remainder are under development. On-line demand is about 8 mgd. The project expects to deliver up to 15 mgd by summer 1999. This summer's deliveries were lower than anticipated for a number of reasons: overall irrigation was reduced, due to cooler, wetter conditions following the *El Niño* rains, and certain agricultural customers opted to plant low-water-using crops and thus lowered water demands for summer irrigation (Rosenblum 1998).

Financing

The $140 million for Phase 1 is financed with the assistance of a grant from the USBR that covers 25 percent of the project costs. The remainder was funded through the sale of revenue bonds and a low-interest loan from the state. The revenue bonds are backed by the sewer rate charges. Since 1989, sewer rate charges have increased by more than 50 percent. These increases were necessary to cover the cost of the recycled-water project and the costs of complying with the discharge permit established by the RWQCB.[9] Revenue from recycled water sales is expected to be sufficient to cover annual operating and maintenance costs but not annual debt service on the capital costs.

Evaluation of Success

Making connections: linking water supply and wastewater

Simply speaking, this project was motivated by a regulatory mandate. However, the project selection was largely due to the multiple benefits water recycling offered over building an outfall. The water-recycling program, in combination with conservation programs, offered a long-term solution to the discharge problem as well as an alternative water supply. The recycled water project is thus both a wastewater and a water supply project. This connection lays the foundation not only for evaluating the project based on both benefits, but also for establishing the new agency partnerships and cooperation necessary for implementation.

SBWR is an example of increased agency cooperation and coordination with cities and agencies. It is an example of a wastewater treatment plant taking on water supply activities, requiring local interjurisdictional agreements with water wholesalers and retailers. Expansion of the program into Phase 2 is expected to increase use for recycled water by extending the system to other large landscape, industrial, and agricultural customers, especially those located near the southern edge of the service area. A master plan is now under development to provide for reuse of up to 100 mgd by 2020 (Rosenblum 1998). SBWR has become an active participant in investigating the potential for regional water recycling in the Bay Area, through staff involvement in the Bay Area Regional Water Recycling Program. The pro-

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[9] The RWQCB required, among other things, that the San Jose/Santa Clara Water Pollution Control Plant reduce its copper mass discharges, implement a source control program to reduce metals, perform wetlands mitigation, and establish a water conservation program.

Table 12-4
Estimated Customer Use: Phase I

	Number of Sites	Average Annual Usage (Acre-Feet)
Landscape		
Public	72	2,928
Private	211	2,460
Industrial	10	1,260
Agricultural	18	2,335
Total	**311**	**9,533**

Source: SBWR 1998

gram also provides the potential for expansion into indirect potable reuse activities through joint investigations with the SCVWD.

Substituting for potable supplies

As with all recycled water projects, SBWR promotes a better match between water quality and end use, substituting recycled water for potable water in landscape irrigation and industrial uses. The current customer list projects a near-term savings of up to 10,000 afy in substituted potable water. The majority (90 percent) of the Phase 1 customers use recycled water for landscape irrigation (Table 12-4). A significant number of the Phase 1 customers are using recycled water in place of groundwater.

Affordability/equity

SBWR has taken full advantage of state and federal assistance, and has spread the remaining costs over its own sewer rate base and its water sales to retailers. Revenue from sales and the rebate offered by the SCVWD will offset the plant's operating and maintenance costs. While in the shorter-term, project revenue fails to pay for all costs,[10] the SBWR project was undertaken with the long-term benefits in mind. Recycled water offers a long-term stream of revenue, and the value of recycled water is expected to increase as potable supplies become more scarce.

On the water supply side, recycled water projects can be part of a cost-effective strategy, provided that recycled water is properly valued. Again, this relies on valuing the multiple benefits of the recycled water, including reduction of the wastewater stream, provision of alternative supply, particularly in drought conditions, and environmental benefits.

Water users benefit from lower recycled water rates as compared to potable water rates and the improved reliability of supplies during times of drought.

Conclusions/Lessons Learned

As these two cases indicate, water-recycling projects continue to be motivated both by water supply enhancement and wastewater reduction goals. Both cases also illustrate some of the elements common to successful implementation, many of which focused on working with the numerous stakeholders throughout the process and bringing them in as early as possible. Both projects spent considerable time identifying the stakeholders and working with them to address their various concerns. Particular attention was paid to working with the retailers and customers to address cost and revenue concerns. Each also established different forums to communicate and coordinate with stakeholders and keep everyone on track. Education played an important role in bringing actors together, marketing services, and engendering support. It was particularly important in gaining the agreement of utilities and retailers to support the incentives and in promoting water recycling among customers. And, both projects relied on large volume users to support more cost-effective designs.

On the financial side, benefits of recycled water projects are clear, but not always easy to value in a purely economic fashion. The sharing of costs continues to be difficult. Most often the costs are borne by those undertaking the project. While the long-term benefits may be clear, they do not always accrue to the entity financing the project, nor can the organization always afford the initial capital costs. In the case of SBWR, the federal mandate helped

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[10] Water sales are not expected to cover the debt service on the capital costs.

change the economic equation by requiring that the treatment plant solve the discharge problem. Finding partnerships can help share costs, and this is where it is particularly important to make the connection between wastewater and water supply and the benefits that accrue to both. Water recycling may not be the least-cost alternative, but it offers long-term economic benefits of future reliability and/or environmental benefits that other alternatives may not offer. For SBWR, the water-recycling project offered the long-term benefits of reducing the wastewater stream and providing a future stream of revenue from recycled water sales that building the outfall did not offer. In Southern California, WBMWD compared the long-term benefits of a drought-proof supply to purchasing additional imported water. Both projects additionally provided environmental benefits in reducing wastewater flows and substituting for potable supplies. WBMWD's project helps Los Angeles replace water previously supplied from the Mono Basin and reduce purchases of imported water from MWD, and SBWR's project helps maintain scarce salt marsh habitat for endangered species. Overcoming traditional institutional barriers that separate wastewater and water supply functions is important not only for cost-sharing reasons, but also to allow for better identification of benefits and cooperative exploration of a more comprehensive alternative that can serve both wastewater and water supply needs.

Given the emphasis on overcoming institutional barriers and engaging in a broad education process, it is important to recognize the leadership roles taken by actors involved in these projects. WBMWD's board supported a broad plan for improving drought reliability that included water recycling, and the board was willing to establish the parcel standby charge to finance the project. For SBWR, the city of San Jose responded to the RWQCB's order with a long-term plan involving water recycling and water conservation to reduce discharges. Staffs working on each project were then able to successfully carry out these mandates. Each had strong leaders—in Richard Atwater, general manager at WBMWD, and Eric Rosenblum, program director at SWBR. These men were advocates for recycled water use and were willing to work with the different constituencies necessary to make the project work, to educate them, and to convince them of the benefits of participation.

Contacts

West Basin Water Recycling Project

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South Bay Water Recycling Program

Eric Rosenblum, Program Director, South Bay Water Recycling

John Newby, Senior Engineer, South Bay Water Recycling

References

Rosenblum, E. 1997–1998. South Bay Water Recycling Program. San Jose, CA. Personal communications.

Ruhl, D. 1997–1998. West Basin Municipal Water District. Carson, CA. Personal communications.

Sheikh, B. et al. 1998. "Accounting for the Benefits of Water Reuse." Proceedings from AWWA-WEF Joint Conference: Water Reuse 98. February 1998, Orlando, FL.

South Bay Water Recycling (SBWR). 1995. *Connections*. San Jose, CA. Fall.

SBWR. 1995. *Connections*. San Jose, CA. Winter.

SBWR. Undated. Unpublished materials. San Jose, CA.

State Water Conservation Coalition et al. 1991. "Water Recycling 2000: California's Plan for the Future." WateReuse Association. Sacramento, CA.

West Basin Municipal Water District (WBMWD). 1994. "West Basin Water Recycling Project." Carson, CA.

WBMWD. 1996. *Annual Report*. Carson, CA.

Using Recycled Water for Agricultural Irrigation: City of Visalia and City of Santa Rosa

Megan Fidell and Arlene K. Wong

Introduction

As fresh water becomes increasingly scarce and valuable, alternative sources of water, such as reclaimed wastewater, will become more and more attractive. In Israel, some water analysts believe continued population growth and urbanization will lead to the nearly complete transfer of water from agriculture to the cities, with agriculture increasingly dependent upon treated wastewater as its only reliable supply (Shuval 1994). While the water situation in California is unlikely to ever be that severe, the intelligent use of recycled water in agriculture will increase options for many farmers and offer agencies another way to manage existing potable supplies.

California agriculture already uses reclaimed wastewater in two ways, depending on the level of treatment the water receives. Most common is the use of secondary-treated wastewater on fodder and fiber crops. Irrigating fruit and vegetables with tertiary-treated water is less common, but increasing throughout the state. Agricultural use of reclaimed water is an attractive option for agricultural lands close to wastewater treatment plants. Proximity of suitable lands to the wastewater treatment plant has been an important factor in the decisions of both Visalia and Santa Rosa to undertake agricultural water reuse projects because it reduces the costs of delivering water over long distances.

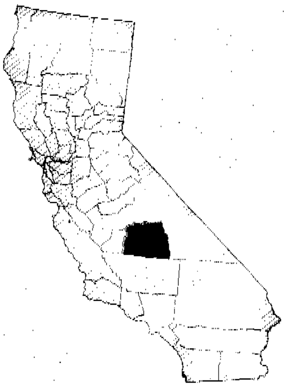
The city of Visalia has developed a project to irrigate a walnut orchard with its secondary-treated wastewater. Visalia sees three benefits from the project: it alleviates groundwater contamination caused by the previous disposal method; it provides a means of disposing of part of the effluent from the rapidly growing city; and it has doubled the yields of the walnut orchard.

The city of Santa Rosa uses its tertiary-treated water to irrigate about 6,000 acres of land in and around Santa Rosa. A principle that guides their recycled water reuse is to help support an agricultural greenbelt around the city that includes dairies, vineyards, and farms. Recycled water is also being used in an organic vegetable farm and a constructed wetlands project.

The Projects

City of Visalia

Background



Visalia is located in Tulare County, southeast of Fresno. In the early 1990s, the city was examining ways to expand the capacity of its wastewater treatment plant in anticipation of an annual population increase of three and a half percent. At the time, Visalia was disposing of 10,000 acre-feet of secondary-treated wastewater in two ways: 8,000 acre-feet were discharged into Mill Creek, where downstream users were withdrawing it for irrigation; and 2,000 acre-feet were put into the groundwater basin through percolation ponds.

The Central Valley Regional Water Quality Control Board established monitoring and discharge quality standards for the city of Visalia's 16.6 million gallons per day (mgd) wastewater-treatment plant in 1991. The plant's standard treatment processes keep its discharges to Mill Creek cleaner than regulatory limits, but samples from 12 monitoring wells around the treatment plant revealed that salts and nitrates were leaching into the groundwater from the percolation ponds. As a partial response, the city and local food processors began pre-treatment programs that decreased the amounts of salts sent to the water-treatment plant. Visalia also began looking for agricultural lands that had the capacity to use treated water and could perhaps benefit from the very constituents that were causing groundwater contamination. In 1992, Visalia bought a 900-acre walnut orchard known to have poor soil permeability and excess free lime that could be serviced with water from the treatment plant. The city then leased the orchard to a walnut grower who is responsible for selling the crop.

Project Goals

Visalia began its water reuse project to divert water from percolation ponds that were contaminating underlying groundwater. One of Visalia's primary goals was to prevent costly expansion of the wastewater treatment plant or conversion to tertiary treatment. The Visalia City Council is strongly opposed to measures that will increase sewer rates for their constituents. Although Visalia's primary interest was avoidance of expansion costs, it also wanted to generate revenue from the lease of the orchard, which could contribute to a sanitation construction fund. Once Visalia chose the walnut orchard as its site for wastewater disposal, two secondary goals became clear: Visalia was interested in whether treated reclaimed water could improve poor soil conditions; and it wanted to provide the orchard with an assured and constant water supply.

Project Description

In 1992, when Visalia wanted to redirect the water it was discharging into Mill Creek to the walnut orchard, it petitioned the Water Rights Division of the State Water Resources Control Board (SWRCB) to allow the diversion. The SWRCB required a public hearing and notices were sent to all downstream users of record. The SWRCB approved the diversion after receiving no public complaints or protest. The Regional Water Quality Control Board (RWQCB) reviewed and approved discharging the recycled water into the orchard. The RWQCB also determined that Visalia had met its California Environmental Quality Act (CEQA) obligations for the project with its Wastewater Treatment Master Plan, which discussed disposal of recycled water through agricultural reuse.

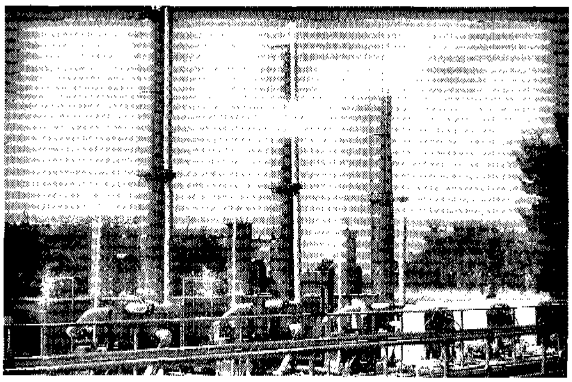
Title 22 of the California Health and Safety Codes limits the use of secondary-treated water to fodder and fiber crops. Visalia needed special dispensation from the State Department of Health Services (DHS) and the Tulare County Environmental Health Department (TCEHD) to irrigate walnuts with their wastewater. This dispensation was granted after Visalia demonstrated that walnut meat intended for human consumption is initially protected by its shell, and then further washed and bleached during processing. Nevertheless, DHS requires that all irrigation be stopped 30 days before harvesting the walnuts, which are shaken to the ground where they might contact recycled wastewater. Drying out the orchard soil before harvest is a common practice for walnut growers, and does not affect yield or inconvenience the grower.

Starting the project required a new pump, purchasing and installing 1,800 feet of delivery pipeline, two new 15 foot standpipes, three gypsum solution machines, three sulfur-burning acid generators, and sulfur and gypsum prepared for dissolution. To comply with Title 22, all pipes delivering recycled water to the orchard were painted purple, and signs saying "Do Not Drink" in English, Spanish, and universal symbols were posted.

(Courtesy of City of Visalia)

Beginning in 1993, Visalia withdrew 2,700 acre-feet of wastewater previously discharged to Mill Creek for application on 900 acres of walnuts. It then closed the percolation ponds and transferred the 2,000 acre-feet of percolation pond water that were contaminating groundwater into Mill Creek. The ponds are still used occasionally. In 1995, the treatment plant was unable to meet discharge requirements as it replaced old filters, and was forced to put the water in its ponds. During winter, recycled water is sent to percolation ponds when Mill Creek is dewatered for weed maintenance. In 1997, the plant again put water in the percolation ponds as the walnut orchard took surface water that would otherwise have gone to the flooded Tulare Lake Basin.

One of the initial goals of the project was to investigate the possibility of improving the orchard soil. Like many soils in the area, the orchard soil had poor permeability and poor nutrient content. The surface and well waters of the region leach calcium from the sandy soil until all calcium remaining in the soil is bound in calcium carbonate. The resulting soil structure is essentially impermeable; water will run off the surface rather than infiltrate the soils. To counteract this effect, the water treatment plant has added soil amendments to its treatment process. The reclaimed water has gypsum dissolved in it, to distribute calcium evenly over the field; growers receiving traditional surface water spread solid gypsum on their soils, a less effective means of calcium delivery. The recycled water also has residual potassium and other nutrients that the local soils lack. The walnut grower describes the water he gets from the treatment plant as full of fertilizer and nitrogen.



Gypsum tanks and sulfur burners. (Courtesy of City of Visalia)

City of Santa Rosa

Background

The Laguna Wastewater Treatment Plant (WTP) treats wastewater collected from the cities of Santa Rosa, Rohnert Park, Cotati, and Sebastopol, from the South Park County Sanitation District, and septic systems from most of Sonoma County. The city of Santa Rosa is the managing partner of this sub-regional wastewater reclamation system. The city's first reuse system was developed in 1974, at the West College Plant in downtown Santa Rosa. In 1978, the city's wastewater treatment system was merged with the Laguna WTP. Upon expansion, Laguna WTP provided secondary-treated water to about 3,000 acres of fodder and pasture for local dairies. In 1989 it expanded and upgraded its treatment process to tertiary treatment to increase disposal options.

The city of Santa Rosa has grown rapidly since then, and meeting wastewater discharge regulations continues to be an issue. The Laguna WTP is currently permitted to treat 18 million gallons per day (average dry-weather flow), and its annual average flow was 7,000 million gallons in 1994. It currently uses a combination of reuse and discharge for disposal of its effluent. It discharges into the Laguna de Santa Rosa and Santa Rosa Creek, which flows 10 miles to the Russian River. The plant is only allowed to discharge to the Russian River when river flows are a minimum of 1,000 cfs (usually by November), and then only up to one percent of the river flow. Flows that exceed the discharge requirement are stored. Laguna WTP has storage facilities that can hold about 1,500 million gallons of reclaimed water. The plant is not allowed to discharge into the Russian River at all from May 15 to October 1. Thus, during this period, tertiary-treated wastewater from the Laguna WTP irrigates about 5,000 acres of agricultural land that contribute to a greenbelt around the city of Santa Rosa and 500 acres of parks and schools in Rohnert Park and Santa Rosa. A portion of the recycled water is also used for the management of a small, created wetland area (Kelly Farm demonstration project); second and third wetland areas are under construction (Joint Wetlands and Alpha Marsh).

In fact, during the Oct 1 to May 15 discharge season, Laguna WTP has regularly sought a temporary increase to discharge up to five percent of Russian River flows. Difficulty meeting the current regulations (one percent of flow limitation) and concerns about future growth (the plant expects wastewater flows to increase to over 8,000 million gallons per year) led the city to develop a long-term wastewater plan to address those needs. Maximizing reuse and water conservation were part of all long-term alternatives under consideration. In the spring of 1998, the city council approved the Geysers recharge alternative. This will involve providing an average of 11 million gallons per day of recycled water for injection and recharge at the Geysers steamfield located in the Mayacamas Mountains northeast of Healdsburg, which is used as a source for geothermal energy. Provision of recycled water year-round would limit discharges into the Russian River to peak wet-weather events.

Project Goals

The city of Santa Rosa reuse projects have always been primarily guided by wastewater disposal requirements. However, in the introduction to its draft environmental impact report, city officials also recognize the additional benefits reclaimed water can provide:

> *"The City's purpose in maximizing water reclamation, recycling and reuse is consistent with the State of California's Water Recycling Act of 1991.*[1] *Thus, an important purpose of the project is to benefit agriculture, greenbelts, and recreation and to protect and enhance fisheries, wildlife habitat, and riparian areas through provision of reclaimed water, an acknowledged valuable resource." (City of Santa Rosa and U.S. Army Corps of Engineers 1996)*

Project Description

Laguna WTP's conversion to tertiary-treated water in 1989 increased the range of agricultural uses for its recycled water. The treatment plant now provides water to about 4,100 acres of fodder, sod, and pasture, 500 acres of urban landscaping, 700 acres of vineyard, 250 acres of row crops, and seven acres of organic vegetables. The row crops are primarily several varieties of squash; they are started with recycled water, and then switched to well water when the fruit sets.

Fields irrigated with recycled water. (Courtesy of City of Santa Rosa)

Agricultural water users take the recycled water free of charge. In fact, some of the earlier contracts were written with incentives—farmers were paid to take a specified amount of recycled water for irrigation. Urban irrigators are provided recycled water at a rate set at three-fourths the potable rate. To date, the demand for the plant's recycled water during the summer months is greater than the supply. The plant is able to store water (up to 1,500 million gallons) during the spring to provide additional recycled water during the irrigation season and provides an average of 3.6 billion gallons per year for irrigation. New requests for service can only be granted if users are willing to provide for storage of the water during the wet season.

Santa Rosa's recently approved Geysers project will provide the city with a large year-round user for its recycled water supplies. The Geysers project, in fact, will compete for recycled water currently available for irrigation and will probably limit future agricultural uses.

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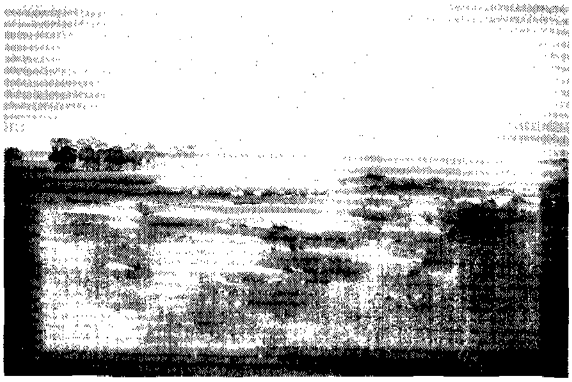
[1] California Water Code, Division 7, Water Quality, Chapters 1-10; California Porter-Cologne Water Quality Act, Sections 13576 and 13577.

However, the project was conceived to continue to emphasize the benefits of wastewater reuse and ensures that wastewater will be reused rather than discharged.

Kelly Farm demonstration marsh

The Kelly Farm demonstration marsh is one of several wildlife reserves that the city of Santa Rosa manages. In 1989, nearly 12 acres of marsh in a 25-acre setting were established as a test site to study additional beneficial uses for tertiary-treated reclaimed water. Reclaimed water was provided to create and continues to support over eight acres of freshwater marsh, three acres of open water, and about an acre of seasonal wetland. The demonstration area also includes riparian woodland and shrub, grassland, and oak woodland. Water quality is monitored every two weeks. The tertiary-treated water meets all state and federal standards and is not expected to adversely affect wildlife at the wetland. However, it was feared that the recycled water contained constituents that could be toxic, accumulate in organisms, or over-stimulate the growth of aquatic life. Preliminary results of the chemical monitoring of water, sediment, and biological quality suggest no adverse effects. Toxic substances (primarily heavy metals) have not been found in elevated levels in the plants, animals, or sediments in the wetland.

As a disposal option, evaporation of recycled water in wetlands is considered beneficial. Moreover, unlike irrigated pasture, wetlands use water year-round. Based on the positive results from the demonstration project, the city has undertaken two more wetland projects that will be supplied with recycled water.



Kelly Farm demonstration marsh (Courtesy of City of Santa Rosa)

Left Field Farm

In 1994, Ann Austin and Lawrence Jaffe approached the city of Santa Rosa seeking to lease land for their Left Field Farm and to use recycled water to grow organic vegetables for direct human consumption. Their lease was approved by the Santa Rosa City Council, in a public hearing. Jaffe and Austin must apply 1.5 acre-feet of water per acre annually, since the city's interest is wastewater disposal. As part of the lease, the city delivers pressurized reclaimed water directly to a sprinkler irrigation system that came with the land. In addition to the seven acres it leased in 1994, the city just agreed to lease an additional three acres that will also be served by recycled water.

Left Field Farm's neighbors are dairies, a cattle farm, and a poultry plant, which also receive tertiary-treated water from Laguna WTP. The poultry plant gives chicken manure to Left Field Farm. Left Field Farm also takes compost from Sonoma Compost, the company that composts Santa Rosa's green waste. Sonoma Compost is considering using tertiary-treated water to irrigate its compost. Left Field Farm prides itself on "closing the loop" between city and farm, by using reclaimed urban water and composted urban green waste to grow vegetables that it then sells directly back to the community.

Left Field Farm grows 47 varieties of vegetables with recycled water. The local climate allows the farm to grow "spring" crops throughout the year, and the recycled water supply is sufficient to grow broccoli and cauliflower nearby growers can't produce because of limited water. Eighty percent of Left Field Farm's sales are retail. The farm sells its vegetables at the Santa Rosa and Berkeley Farmers' Markets and through Community Supported Agriculture. CSA is an arrangement wherein customers subscribe to a farm for a weekly basket of food throughout the growing season. For a fixed price, the purchaser receives freshly harvested fruits and vegetables delivered to a drop-off site. Left Field Farm includes a newsletter in its vegetable basket, and believes

CSA helps build a connection between farms and the local community.

Left Field Farm is registered with the state's Department of Food and Agriculture as an organic farm, in accordance with the California Organic Food Act of 1990. If Left Field Farm wants its produce to be certified organic (as opposed to simply being labeled "organic"), the farm must be inspected and approved by an independent certifying organization. The largest certifying body in the state, California Certified Organic Farmers, has a policy denying certification to a farm where tertiary-treated water comes into contact with the edible portion of the crop. Another certifying organization, Scientific Certification Systems (Nutri-Clean), has accepted Left Field Farm's application for certification, and is checking that the water used and the crops grown on the farm meet all organic standards. When Left Field Farm's certification is complete, it will be the first certified organic farm to use tertiary-treated recycled water.

Organic Foods and Reclaimed Water

The California Organic Foods Act of 1990 defines standards for organically grown foods in California. Permissible and prohibited materials, purity of inputs and products, types of record-keeping, and procedures for registration are defined or listed as quantitatively as possible. A grower or rancher who meets all organic standards can register with the state as organic, but the state has no verification or enforcement capacity. The California Organic Foods Act does not directly address the use of recycled water.

There are now a half-dozen established third-party agencies that inspect farms and certify that a grower is meeting the terms of the California Organic Foods Act. Independent certification is voluntary for an organic grower, but many processors and customers restrict their purchases to certified organic foods. Some of these certifying organizations say they have no defined policy about the use of tertiary-treated recycled water, and would evaluate applications involving recycled water on a case-by-case basis. Others suggest they would require more rigorous testing of farms using recycled water. However, if a farm using recycled water met all organic standards, an organic certification would be issued.

The largest certifying organization in California, California Certified Organic Farmers (CCOF), has a policy limiting organic certification to farms on which use of recycled water is restricted. Their policy parallels Title 22 regulations, except for tertiary-treated water. If a farm met their organic standards, they would certify pasture irrigated with secondary-treated water, and crops grown with tertiary-treated water that does not come into contact with the edible portion of the crop, such as strawberries irrigated with subsurface drip systems. However, the membership and certification committee of CCOF is more restrictive than California's Title 22 about application of tertiary-treated water to the edible portion of a crop. A root crop or vegetable crop irrigated by a sprinkler system using tertiary-treated water meets Title 22 restrictions, but cannot be certified by CCOF. CCOF says that although there is room for negotiation and mutual education with every application, such a certification would not be issued without a policy change.

Evaluation of Success

After several years of experience, both cities consider their recycling projects successful. Six years of monitoring groundwater quality and walnut yields have proven Visalia's walnut orchard an agronomic, economic, and environmental success. Since the city of Santa Rosa's wastewater is treated to tertiary levels, its disposal and reuse options are quite broad. The city's use of recycled water was guided by the community's choice to surround the city with agricultural open space. Santa Rosa has been able to extend uses of recycled water to creating wetlands and supporting an organic farm. Both wastewater treatment plants expect no problems finding farmers or ranchers to take additional future supplies of recycled water because of the advantages of a reliable supply of pressurized water.

Walnut yields since Visalia began delivering recycled water to the orchard have been higher with reclaimed water than with surface water supplies (Table 13-1), but the relation between walnut yield and water source is not yet clear. Walnut crops usually alternate between high and low yields. Using recycled water may have shifted this orchard's regular pattern of alternation by a year. It will take several more years of monitoring to clarify the correlation between water source and walnut yield. It is evident, however, that using recycled water has not diminished yield, and it is beginning to appear that it increases yield over the use of regular surface water.

Visalia's project has been an unqualified economic success. The city of Visalia spent an initial $93,400 in capital costs for the project. The first-year operating costs were $95,600, primarily for gypsum and sulfur. The city's lease with the grower is for 40 percent of the gross revenue from the sale of the walnuts. In the first year of operation, Visalia made a *net* profit of nearly $750,000. In the first five years of the project, annual profit for the city has ranged between $300,000 and $750,000, as the size of the harvest and prices for walnuts have fluctuated. Not included in these direct economic benefits, however, is the added benefit to the city from deferring expansion or upgrade of its water treatment plant. The city has also been able to maintain low disposal fees for its residents.

Table 13-1
Walnut Yields for Visalia's Reclaimed Water Program

Year	Walnut Yield in Tons	Water Source
1992	718	well
1993	1,308	reclaimed
1994	1,005	reclaimed
1995	686	surface
1996	1,100	reclaimed
1997	373[a]	surface

[a] 1997 yields were affected by poor weather.
Source: Nelson 1997

Had Visalia not started this project, it would have been out of compliance with groundwater discharge regulations strengthened by the Regional Water Quality Control Board three years ago. The city of Visalia monitors effluent quality as it leaves the treatment plant, and monitors groundwater quality with a series of monitoring wells. Irrigating the walnut orchard helped to mitigate groundwater contamination from the original percolation ponds by applying the effluent over a much larger area, and by applying the effluent at a slower rate determined by the uptake rate of the walnut trees.

Similarly, Santa Rosa maintains its reuse projects to remain in compliance with its discharge permit. However, supplying low-cost water and leases to agricultural users also helps the city maintain a greenbelt that contributes to the cherished rural character of the area. If reclaimed water was not available, an alternative source of supply would have to be located, at substantial cost. The community also appreciates the availability of locally grown crops that freshwater supplies in the area could not support. Recycled water also allows for the formation of waterfowl habitat (duck ponds and other wetlands) that otherwise would not be possible for lack of adequate supplies.

Reuse projects in both cities resulted in a more efficient use of water. Not only is water used more than once, but using recycled water for agriculture lessens some of the demand for surface or groundwater. In Santa Rosa, farmers along the creek banks previously pumped irrigation water directly from the creek or from private wells. Providing these farmers with reclaimed water has improved the natural flow of the creek. Reclaimed water has allowed farmers inland from the creek to irrigate and farm year-round instead of being restricted to dry-land-cropping. The degree of treatment offers an opportunity to match water quality with end use. Secondary-treated recycled water goes to crops not intended for direct human consumption, while tertiary-treated recycled water irrigates high-value vegetable crops.

Conclusions/Lessons Learned

Both cities initially undertook water recycling projects as a means to dispose of wastewater, rather than to stretch freshwater supplies. Visalia needed to meet water quality standards issued by the Central Valley Regional Water Quality Control Board and to reduce use of the percolation ponds. Santa Rosa uses recycled water to limit discharges to the Russian River. In both cases regulatory requirements played a role in bringing the wastewater issue to bear, and each city chose to explore reuse options to solve its discharge problem.

Both projects pushed current boundaries of acceptable uses for reclaimed water and have met almost no resistance. Visalia was able to get a permit from the health department to use secondary-treated reclaimed water on its walnuts on the basis that the water will not come into contact with the walnut meat. There have been no public complaints or marketability problems. The city of Santa Rosa's projects have been accepted by the local communities. Left Field Farm has developed a direct market for its vegetables with its participation in the Community Supported Agriculture program, and the city's research in wetlands applications has demonstrated the compatible uses for recycled water in habitat preservation and restoration. The success and continued monitoring of these projects will continue to support the viability and acceptability of water-recycling projects.

Though each project was primarily designed to reduce wastewater discharge, both cities have gained from the water-supply benefits that recycled water offers. The city of Visalia, in fact, profited financially. The city of Santa Rosa is able to support its agricultural greenbelt and offer farmers a reliable supply of water.

Contacts

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References

City of Santa Rosa. 1997. Fact Sheets.

City of Santa Rosa and U.S. Army Corps of Engineers. 1996. "Santa Rosa Subregional Long-Term Wastewater Project: Introduction and Summary to the Draft Environmental Impact Report/Environmental Impact Statement." Santa Rosa, CA. July 31.

Dixon, C. 1997. City of Santa Rosa. Personal communications.

Jaffe, L. 1997. Left Field Farm. Santa Rosa, CA. Personal communications.

Nelson, L. 1997. City of Visalia. Personal communications.

Piazza, R. 1997. City of Santa Rosa. Personal communications.

Shuval H. 1994. "Proposed Principles and Methodology for the Equitable Allocation of the Water Resources Shared by the Israelis, Palestinians, Jordanians, Lebanese and Syrians," in Issac/Shuval (eds.), *Water and Peace in the Middle East.* Elsevier Science B.V., Amsterdam, The Netherlands.

Tchobangolous, G. and E. Schroeder. 1987. *Water Quality.* Reading, MA: Addison Wesley Publishing Co.

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Crop Shifting In California: Increasing Farmer Revenue, Decreasing Farm Water Use

Peter H. Gleick

Introduction

In 1997, California agriculture contributed nearly $27 billion to the state's gross domestic product, and the state led the nation in agricultural production. Many kinds of crops grown in the state are grown nowhere else in the country. The agricultural sector accounts for 80 percent of the water resources withdrawn for human use. How much water is actually consumed by agriculture depends on many factors, including climate, soil characteristics, irrigation technologies and practices, and crop types. All of these factors change over time as economic, social, and physical conditions change.

Water policymakers and planners are often reluctant to discuss the role of crop types and patterns in state or regional water policy debates, yet relatively modest changes in cropping patterns can have significant effects on water use. Moreover, California farmers regularly change crop types and patterns based on their perceptions of food markets, knowledge about farming methods, new technology and crop types, and the relative costs and prices of different choices. These factors, in turn, are affected by federal, state, and local actions, and sometimes even by foreign food demands and markets.

Equally important, land availability and quality, economic conditions around the state, and land-use policies will play roles in future decisions about cropping patterns. These factors all make it difficult to project future agricultural production, which explains why efforts to do so by the California Department of Water Resources, farm agencies, and others (including the Institute) often meet with some skepticism. Despite the reluctance among policymakers to delve into these issues, there has been a growing discussion in recent years of the potential for small changes in cropping patterns to affect agricultural water use. A number of irrigation districts, individual farmers, and farm extension services have begun to explore alternative cropping patterns, spurred on by concerns about the reliability of water supply, new and developing markets for particular crops, and improvements in precision irrigation technology that make it possible to grow different crops profitably.

California farmers grow different crops every year depending on known or anticipated conditions. There have, however, been consistent trends over the past several decades in both individual districts and throughout the state. There has been a substantial decrease in acreage planted in grain and field crops statewide and a corresponding increase in acreage planted in more permanent or valuable crops such as vegetables, fruits, and nuts. These trends have been occurring with no adverse impacts on the productivity of California agriculture, measured by income or crop production per acre-foot of water applied. Indeed, both total farm revenue and net farm income have continued to improve, measured in 1997 dollars per acre-foot of applied water. If these trends continue, the overall water productivity of California agriculture can continue to rise.

Growers don't usually change crops to reduce water use, but to take advantage of new crop types, new technology, opening markets, or a perceived imbalance in supply and demand for particular products. As a result, there should be no assumption that crop switching will reduce water use or water productivity. Nevertheless, the overall trends show that growers are switching more to trees, vines, and vegetables, with some significant water savings.

Background: Water Savings from Crop Switching

A significant fraction of irrigation water applied to crops is lost to evapotranspiration, and different crops have different water requirements. Most agricultural water assessments or projections tend to look at evapotranspiration (ET) as a single and fixed form of depletion, but it is, in fact, made up of two distinct processes—evaporation and transpiration. Molden (1997) and others distinguish these types of depletions based on their beneficial use. "Process depletion" is defined as that amount of water diverted and depleted to produce an intended good, such as water transpired by crops and incorporated into plant tissue. "Non-process depletion" is when water is depleted, but not by the process for which it was intended. Examples are unproductive evaporation from soil and free water surfaces and evaporation of spray drift. All transpiration is typically considered process depletion; not all evaporation is non-process depletion. Separating evapotranspiration into its component parts permits separate analysis of the beneficial and non-beneficial uses of irrigation water and can permit the user to reduce non-beneficial losses or to measure the benefits of water use more accurately.

Transpiration is the water used by crops during growth and depends on climate, soils, the type of crop grown, the growth cycle, and cropping patterns and extent. Different crops transpire different amounts of water. Reductions in transpiration can reduce both total applied water and consumptive use of water. Table 14-1 shows a typical range of ET estimates for some of the crops grown in California. As this table shows, changing a field in the Sacramento Valley from alfalfa to grapes can reduce the applied water requirement by between 0.7 and 2.3 acre-feet per acre. Similarly, simply shifting crop types from one region of the state to another can also reduce water requirements, though it may also limit production of crops to a less profitable time of year. Growing tomatoes in the Sacramento Valley rather than the Colorado River region of California can save 0.8 to 1.3 acre-feet of water per acre.

Evaporation occurs in several ways, including water lost from soils, soil surfaces, crop and weed surfaces, and during irrigation water application, as wind drift and direct evaporation. Some of this evaporation is unproductive: reducing it does not affect crop production, soil quality, or yields. A portion of this evaporation produces cooling, which in turn may reduce transpiration. Reductions in unproductive evaporation directly reduce both total applied water and the consumptive use of water. Changing crop types can also permit a change in irrigation method to a more efficient technology,

Table 14-1

Evapotranspiration Ranges in Different California Regions (Acre-Feet per Acre)

	North Coast	Sacramento	Colorado
Grain	0.3–1.5	0.2–1.6	2.0
Rice		3.0–3.4	
Cotton			3.3
Sugar Beets	2.4	1.7–2.7	3.8
Corn	1.0–1.8	1.4–2.3	1.7–2.6
Safflower	0.6	0.4–0.6	
Other Field	0.9–1.8	1.2–2.0	2.0–3.5
Alfalfa	1.5–2.8	1.8–3.2	4.3–6.6
Pasture	1.4–2.6	2.1–3.3	4.3–6.6
Tomatoes		1.6–2.1	2.9
Other Truck	1.0–1.7	0.6–1.8	1.3–5.4
Almonds		1.6–2.7	
Other Deciduous	1.4–2.1	1.3–2.7	2.3–4.4
Grapes	0.5–0.8	0.9–2.0	2.4–3.3

Source: DWR 1993. "Agricultural Water Use: Biennial Report." Division Of Planning, Sacramento. May.

which in turn permits reductions in non-beneficial evaporative losses.

Both transpiration and evaporation can be reduced with different technologies, water policies, and agricultural practices. Reducing or eliminating surface water exposure, evaporation from soils, and misapplication of irrigation water can all reduce evaporation losses. Changing crop types, introducing more water-efficient varieties of a crop, land fallowing, and land retirement can reduce transpiration. For the purposes of this review we exclude land fallowing and land retirement as methods of improving agricultural productivity, though they may have a place in water policy and planning.

Reducing Transpiration Losses

By separating evaporation and transpiration, different conservation options become more apparent. As described above, reductions in transpiration losses can be achieved through changes in cropping patterns, locations, and types. Traditionally, the agricultural community has argued that decisions about these changes should be left completely to the discretion of growers and irrigation districts, even though numerous existing federal, state, and local policies already play an important role in influencing these decisions. In particular, pricing policies for water, federal crop subsidies and land policies, local land-use regulations, and other public policy actions already affect decisions by growers. Changes in these policies will continue to affect cropping decisions, based on real and perceived public policy benefits.

In the long run, California and federal water policymakers will have to determine the extent to which policy should be used to further or more intentionally influence cropping decisions. Such decisions have a direct and immediate impact on water demands and consumption. Policies aimed at reducing transpiration losses could have large long-term benefits for the California water balance without adversely affecting farm income.

The purpose of this success story, however, is not to argue for or against such cropping changes, but to review the past and recent history of actual crop shifts in California. There has been a clear trend over the past 40 years in California away from grain and field crops toward more profitable vegetable, truck, and orchard crops, and there is no reason to believe that this trend will stop. Similar trends away from grain and field crops and toward permanent or vegetable crops can be seen in regional or district data. Indeed, there are many reasons to believe these kinds of shifts will continue or even accelerate:

- Growing pressures on water availability may encourage growers to plant crops with lower water demands or permanent crops likely to be given higher water priority during droughts;
- Higher profits will be seen for growing vegetable, truck, and orchard crops which can be grown productively on California farmland; and
- Precision irrigation, which is more suited to orchards, vineyards, and row crops than field and grain crops, can better control evaporative losses.

Reducing Evaporation Losses through Crop Switching

While most assessments focus on the fact that some crops require less (transpired) water than others, it is also possible to reduce evaporative losses through crop switching. Water savings are possible if the new crop permits growers to change irrigation frequency or method, to mulch or shade, or to do other things that affect evaporation (Burt et al. 1997; Molden 1997; Gallardo et al. 1996; Hillel 1997). For all crops, some fraction of the water is consumed non-productively (evaporates without entering the plant) and any irrigation method that minimizes this loss will increase the water-use efficiency of the crop and decrease overall water consumption. Similarly it is possible to maintain overall water consumption while increasing overall crop yield—also an improvement in crop productivity per unit of water.

One of the components of evaporation from agricultural lands is soil evaporation. This reflects water that enters the vapor phase after being taken up by the soil and is lost to direct productive use by crops. Some fraction of soil evaporation, however, must be considered a productive use, since it either directly or indirectly reduces crop transpiration requirements. Thus, part of any reduction in evaporative soil losses may simply be accompanied by a comparable increase in transpiration. Despite the fact that these changes do not produce "new" water, they typically lead to increases in agricultural yields—thus they increase the overall crop productivity per unit water (Lascano 1998). Some fraction of soil evaporation is unproductive loss, however. A reduction in this fraction leads to a reduction in both the applied water requirement and the consumptive loss fraction—leading to "new" water supply.

Another significant component to evaporation is immediate wind loss during and following water application. Changing irrigation technology has been shown to have a major effect on reducing wind evaporative losses, while maintaining or improving crop yields. Irrigation methods that introduce water directly into the root zone, such as drip irrigation, without sprinkling the foliage or wetting the entire soil surface, minimize deep percolation, surface runoff, and unproductive evaporative losses, while surface application induces depletion by evaporation. Drip irrigation offers the additional benefit of keeping the soil surface between the rows of crop plants dry, discouraging the growth of weeds that compete with the crops for nutrients and moisture (Hillel 1997). Evaporation can also be reduced by improving irrigation timing and providing the crops with water when they need it most. For example, there is a greater potential to reduce ET during the midday when transpiration is reduced and evaporation is at its highest. Improvements in irrigation technology and irrigation management can both decrease evaporative losses.

Because of these advantages, much of the irrigation in the High Plains region of the U.S. is now shifting away from inefficient sprinkler technology toward low-energy precision application (LEPA) sprinkler technology or drip systems. True LEPA systems are considered to be 95 percent efficient compared to furrow systems at 60 percent efficiency, with a significant fraction of the gain coming from reduction in immediate wind loss (Carver 1998). These precision irrigation methods cannot be used on certain types of crops because of higher cost or characteristics such as planting patterns and harvesting requirements. As crops switch toward more permanent or valuable types, however, the use of more efficient irrigation methods becomes possible. This is already happening in California and will have a definite effect on reducing unproductive evaporation losses.

Historical Crop Shifts Statewide

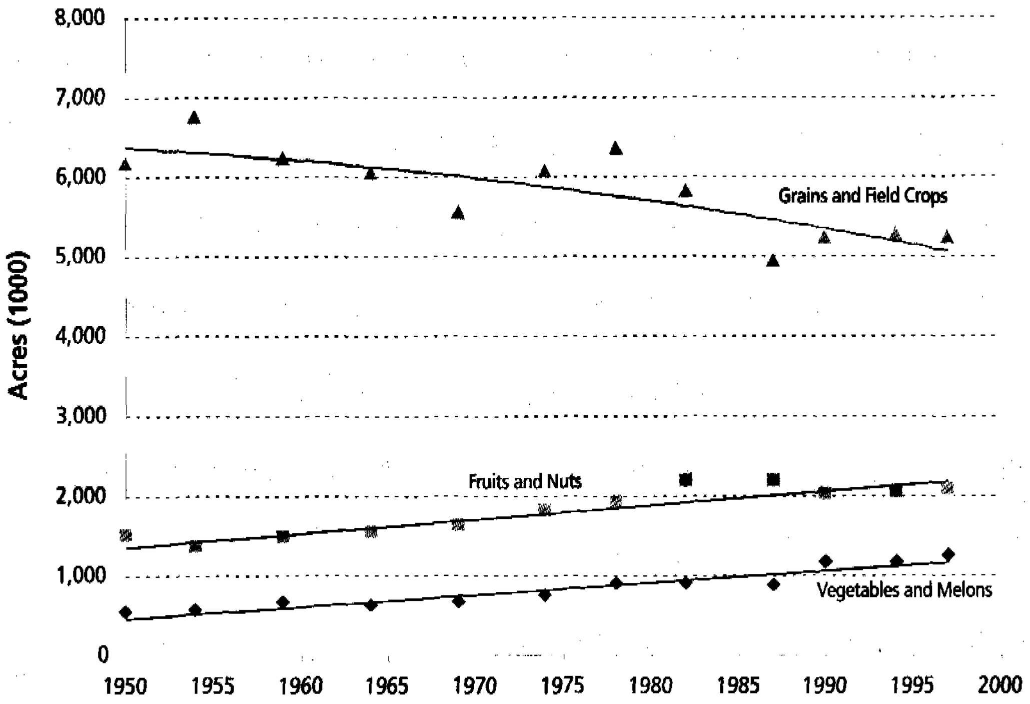
There are many different ways to categorize California's remarkably diverse crop production. Each of the major agencies involved in tracking crop statistics uses different sets of data and categories. As a result, we include here each of the major assessments separately. Three separate figures show the historic trends in California cropping patterns over time using data from the California Departments of Water Resources, Food and Agriculture (DFA), the U.S. Departments of Agriculture (DoA) and Commerce (DoC), the California Agricultural Statistical Service, and the Bureau of the Census, Census of Agriculture. Figure 14-1 includes data for major crop types approximately every five years from 1950 to 1997 from the U.S. Department of Commerce, Census of Agriculture.

Figure 14-2 shows annual data for the same crop types from 1960 through 1997 from the California Agricultural Statistics Service.

Figure 14-3 includes data from the California Department of Water Resources (DWR) prepared for their regular Water Plan series up to 1995, with projections from DWR and from the Pacific Institute through 2020. (All trendlines are either linear fits or second-order polynomials.)

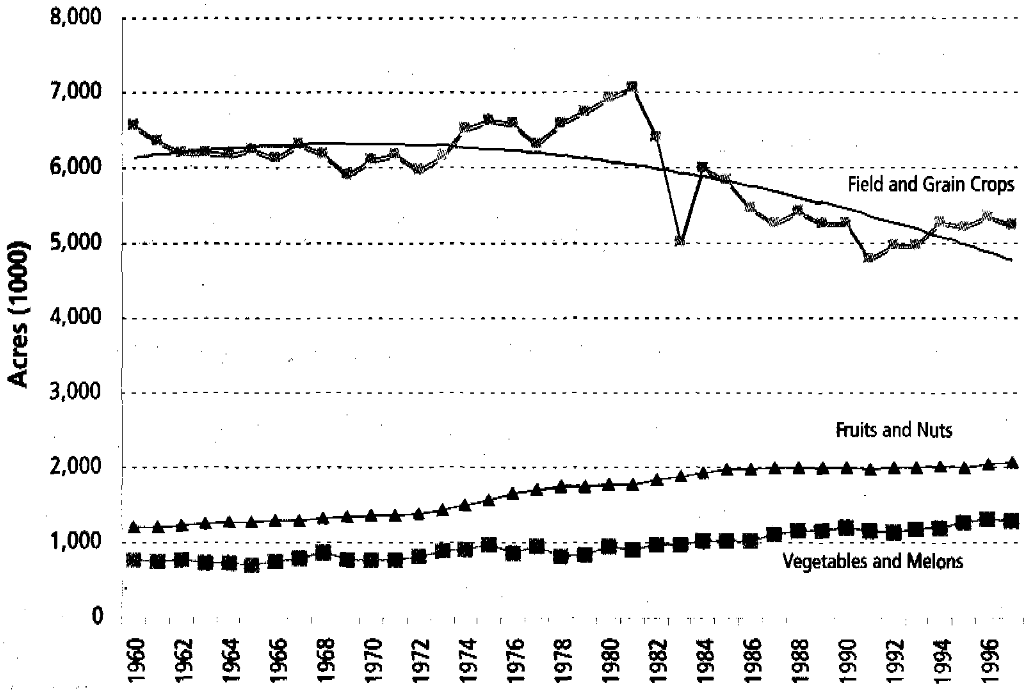
While each crop category varies slightly among sources, all show the same consistent trends: major grain and field crop areas have dropped while the area in fruits, nuts, vegetables, and truck crops has grown. Overall harvested land area in California, shown in Figure 14-4, has stayed fairly constant at around eight million acres (not counting double-cropped

Figure 14-1
California Cropping Patterns, 1950–1997



Source: U.S. DoC Census of Agriculture Data

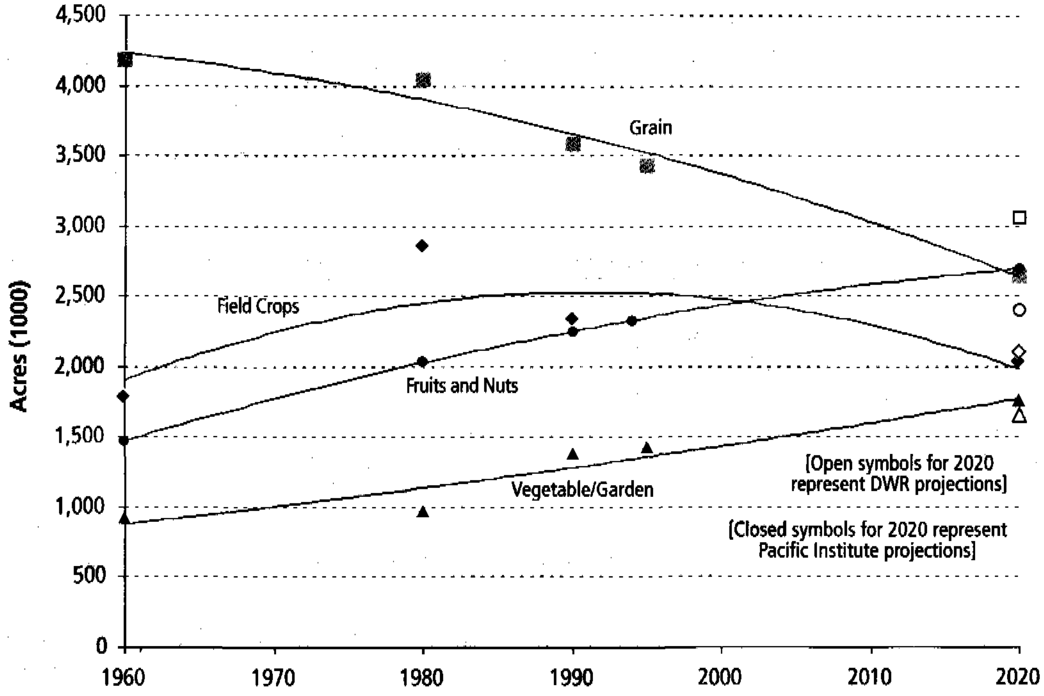
Figure 14-2
California Cropping Patterns, 1960–1997



Source: California Agricultural Statistics Service 1998

Figure 14-3

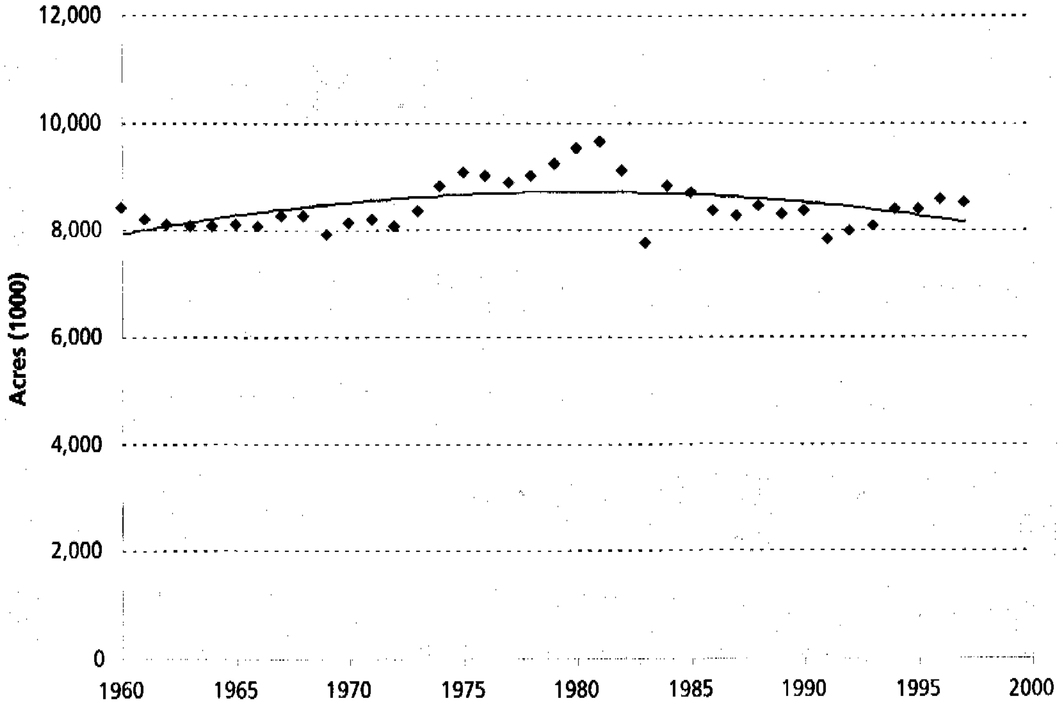
California Cropping Patterns, 1960–1995 (with 2020 projections)



Source: California Department of Water Resources data; DWR and Pacific Institute projections

Figure 14-4

Total Cropland in California, 1960–1997



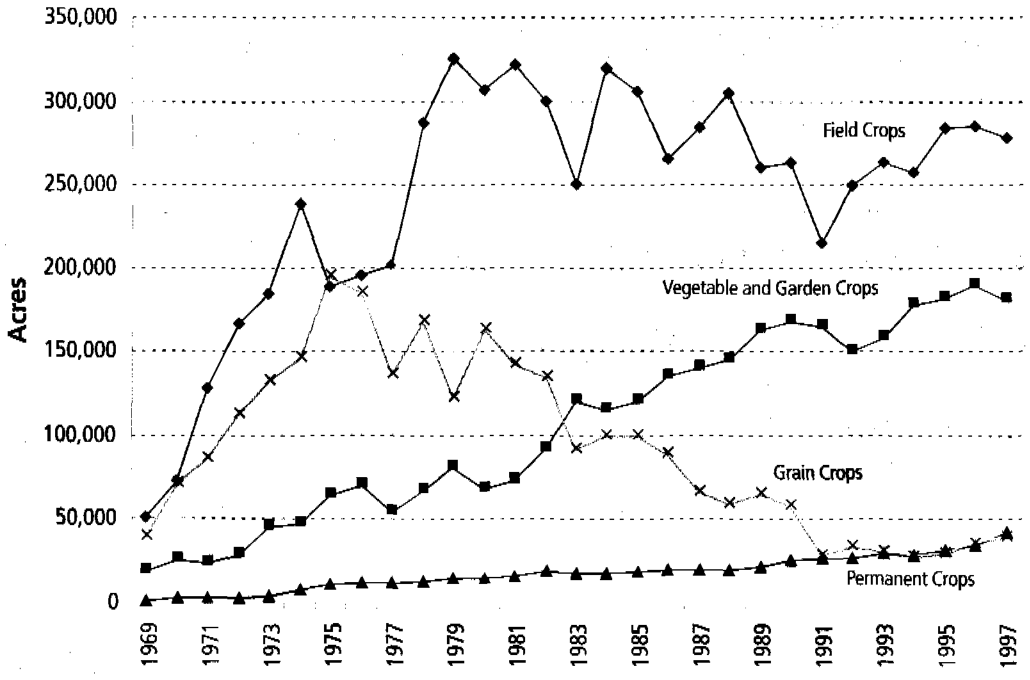
Source: California Agricultural Statistics Service 1998 acreage), with an increase in the early and mid-1980s and a return at present to slightly higher areas than were cropped in the 1960s.

DWR projects future cropping patterns using best estimates and some simple modeling in an implicit prediction of the behavior of growers (DWR 1998). These projections suggest a continuation of the trends toward vegetable and fruit crops. Trend analysis based on actual long-term trends, however, suggests even greater shifts in cropping patterns than suggested by DWR (as shown in the Pacific Institute scenario in Figure 14-3). This would lead to larger reductions in overall agricultural water use and improvements in farm income (Gleick et al. 1995). These different trend analyses are shown in Figure 14-3. There is no way to predict which is likely to be more accurate; indeed, both could be incorrect, but both suggest crop switching will continue.

Historical Crop Shifts in Regions or Water Districts

Figures 14-1–3 show various trends for crop types in the state as a whole. The trends are similar when one looks at specific major growing regions of the state. Figure 14-5 shows time-series data for the Westlands Water District for the period 1969 to 1997. In the Westlands District, there has been a dramatic decrease in acreage of grain crops, particularly alfalfa and barley, with an accompanying increase in vegetable, fruit, and nut crops, which often produce higher farmer revenue at a lower commitment of water per dollar returned or water applied per acre. Field crops remain a relatively important part of total Westlands agricultural production, though these too have decreased in area from their peak in the late 1970s and early 1980s. After a large area of land was put into production in the late 1960s and early 1970s, total acreage farmed in the district has remained relatively constant at around 570,000 acres per year, with typical fluctuations for drought or flood

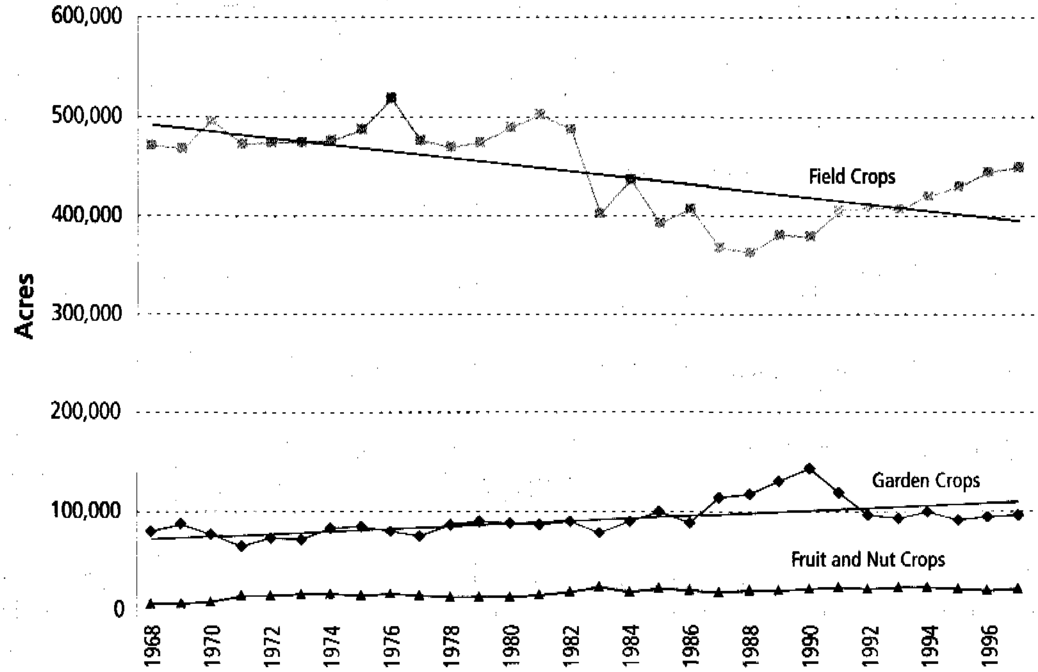
Figure 14-5
Westlands Irrigation District Cropping Patterns, 1969–1997



Source: Westlands Irrigation District 1998

Figure 14-6

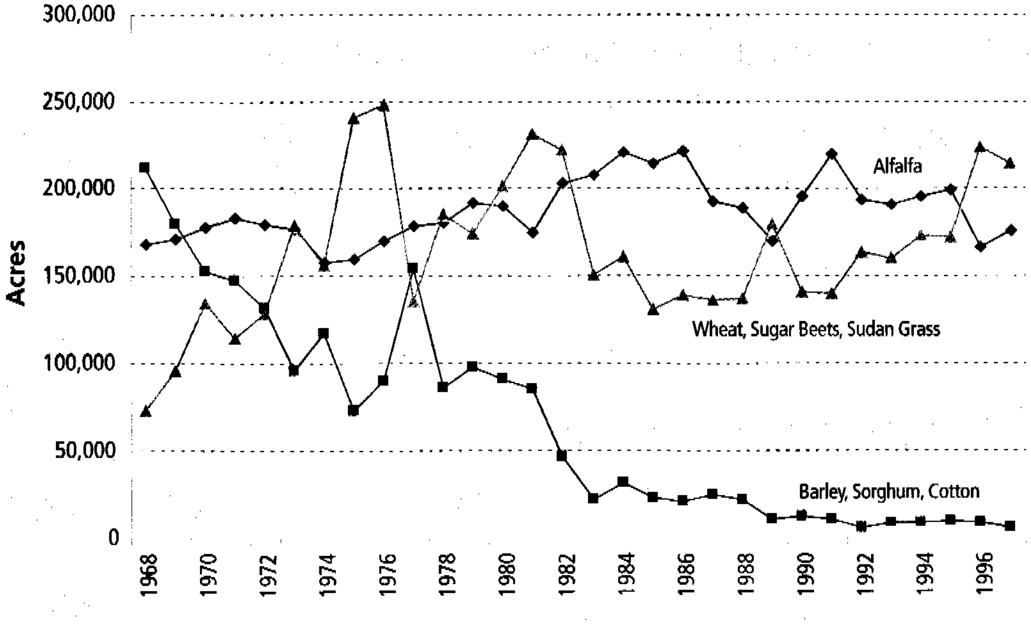
Imperial Irrigation District Cropping Patterns, 1968–1997



Source: Imperial Irrigation District Crop Reports 1968–1997

Figure 14-7

Field Crop Trends: Imperial Irrigation District



Source: Imperial Irrigation District Crop Reports 1968–1997 years (Westlands Irrigation District 1998).

Imperial Irrigation District (IID), in the southernmost part of California, has shown less of a trend in part because water prices remain very low and reliability of supply from the Colorado River is relatively high. Even here, however, the area planted in permanent crops has increased from under 6,000 acres in 1968 to over 21,000 acres in 1997. Garden crop area has increased from 78,000 to around 100,000 acres in 1997, though it was as high as 140,000 in the middle of the drought in the late 1980s and early 1990s (see Figure 14-6).

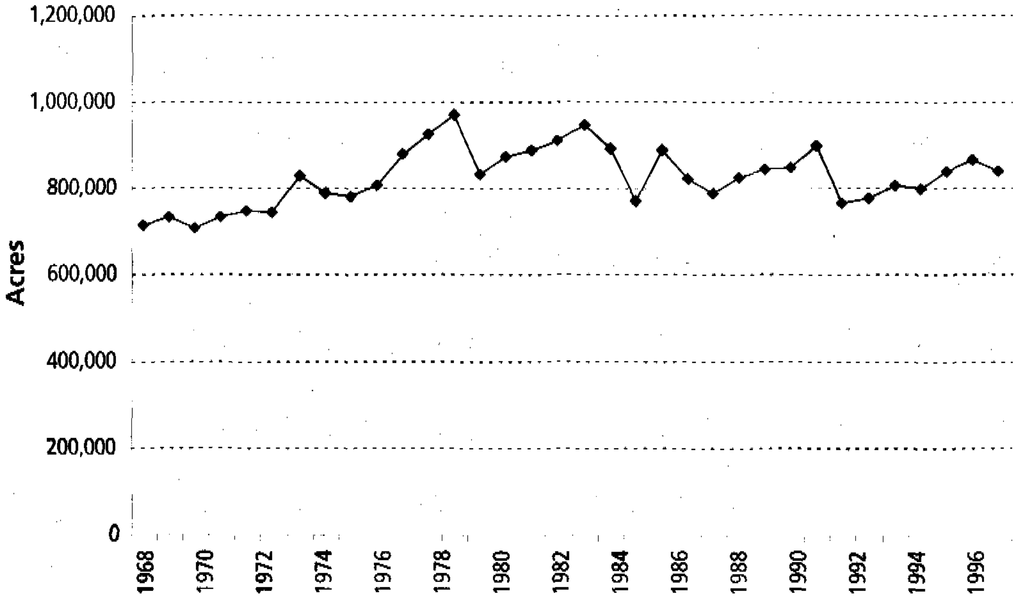
Area planted in field crops has dropped more than 10 percent from the highs seen in the late 1970s and early 1980s. Looking more closely, however, reveals significant changes within the broad category of "field" (see Figure 14-7).

In 1968, the four major field crops planted in IID were alfalfa, barley, sugar beets and sorghum (168,000 acres, 101,000 acres, 64,000 acres, and 61,000 acres respectively). By 1997, the top four field crops were alfalfa, wheat, sudan grass, and sugar beets (175,000 acres, 90,000 acres, 84,000 acres, and 39,000 acres respectively). Barley, sorghum, and cotton, which together accounted for the majority of field crops in the district in the late 1960s, are now almost completely out of production in this region. Figure 14-7 shows some of the cropping trends for field crops in the Imperial Irrigation District.

Kern County is another major agricultural area of California, with over 800,000 acres in production (Figure 14-8). As with the other regions of the state, the area planted in field crops has shown a significant decline since the early 1970s, while vegetables and fruit and nut crop acreages have steadily risen (Figure 14-9).

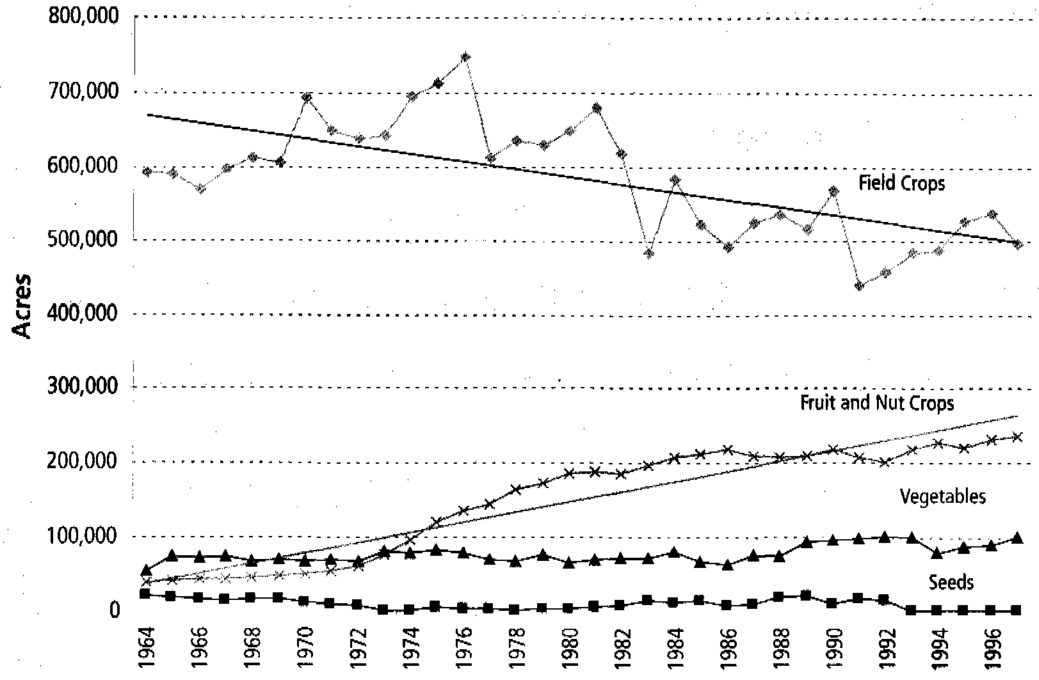
In the 1960s and 1970s, field crops were grown on approximately 80 percent of total croplands. By the 1990s, this had dropped to under 60 percent (Figure 14-10). Fruit and nut acreage rose from 6 percent to 28 percent during the same period.

Figure 14-8
Kern County Agricultural Acreage, 1964–1997



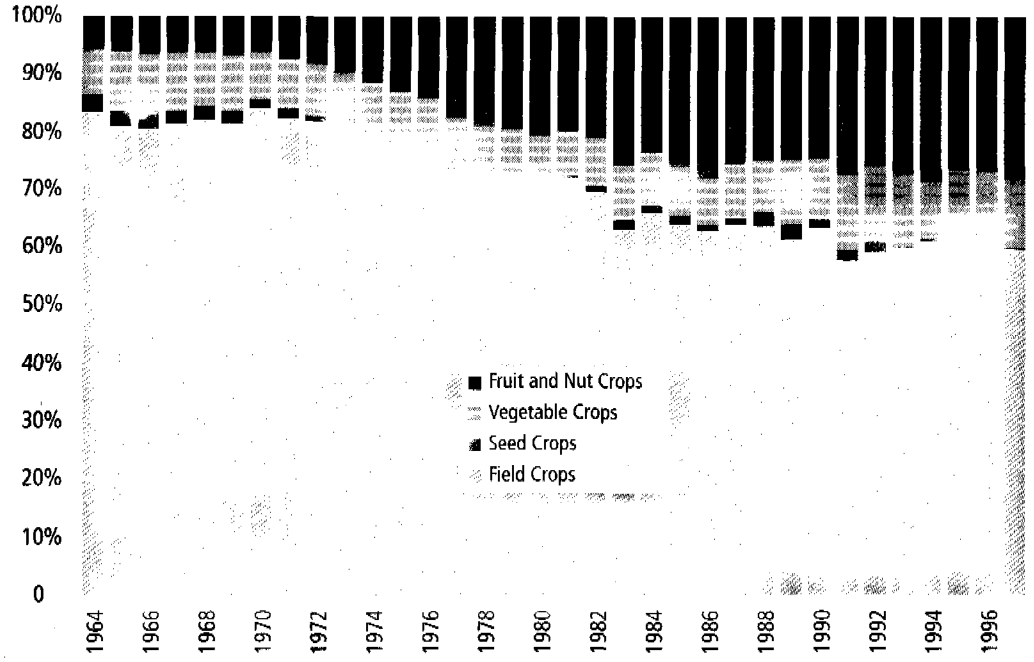
Source: Kern County Crop Reports at www.netxn.com/~agcom15/crp_idx.html

Figure 14-9
Kern County Cropping Patterns, 1964–1997



Source: Kern County Crop Reports at www.netxn.com/~agcom15/crp_idx.html

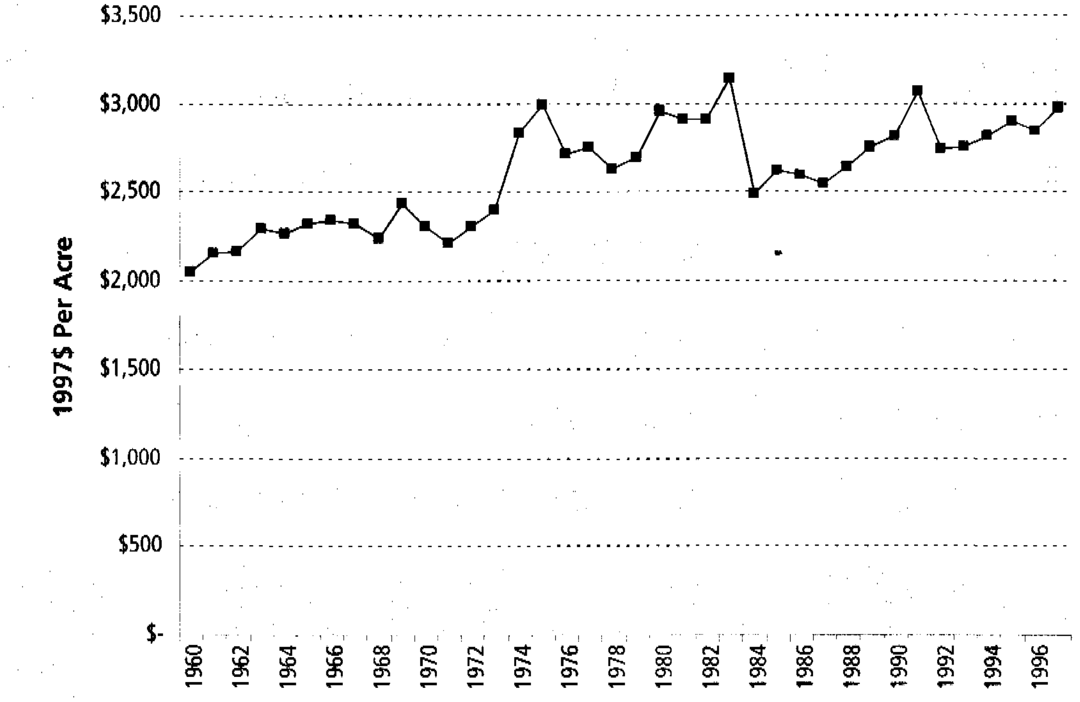
Figure 14-10
Kern County Cropping Fraction, 1964–1997



Source: Kern County Crop Reports at www.netxn.com/~agcom15/crp_idx.html

Figure 14-11

Total Farm Revenue, 1997 $/Acre



Source: Data from USDA 1998

Implications for Water Use Productivity

There are many ways to measure the productivity of water use in agriculture (see, for example, Burt et al. 1997). While overall agricultural water consumption has not changed much in the past several decades in California, the productivity measured as farm income per acre has risen (Figure 14-11 shows total farm revenue per acre, in 1997 dollars; Figure 14-12 shows net farm income per acre).

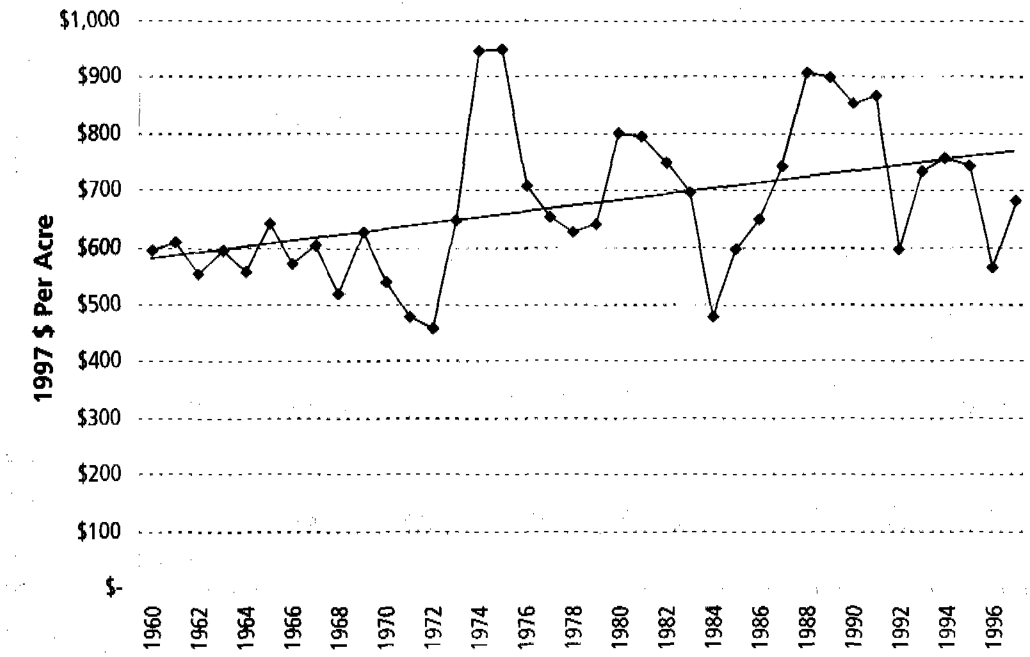
Even income per acre-foot—another measure of the water productivity—has increased (see Figure 14-13). Other measures of productivity can also be used, such as water use as a function of nutritional value in food or calories produced per acre of land. Evaluating these different measures would be a useful step toward better understanding the full implications of crop shifts.

In part, changes in water productivity result from the cropping shifts described above; in part there have also been accompanying changes in irrigation methods, permitting increased yields, increased water-use efficiency, and reduced water applied per acre for many crops. There is no evidence that this trend is slowing; indeed it appears to have accelerated in recent years, and it could be further accelerated by appropriate local or regional policies on land use, pricing, and subsidies.

Table 14-2 shows an estimate of the changes in irrigation method between 1972 and 1994 in California (Snyder et al. 1996). This survey shows that drip irrigation has been increasing at an average of 0.45 percent per year overall, and over two percent per year for vineyards. At the same time, surface and furrow irrigation has been decreasing at 0.73 percent per year, and over one percent annually for orchards and vineyards. Yet more than half of all vineyards were still not using drip irrigation in 1991; more than 80 percent of orchards have yet to implement drip.

Figure 14-12

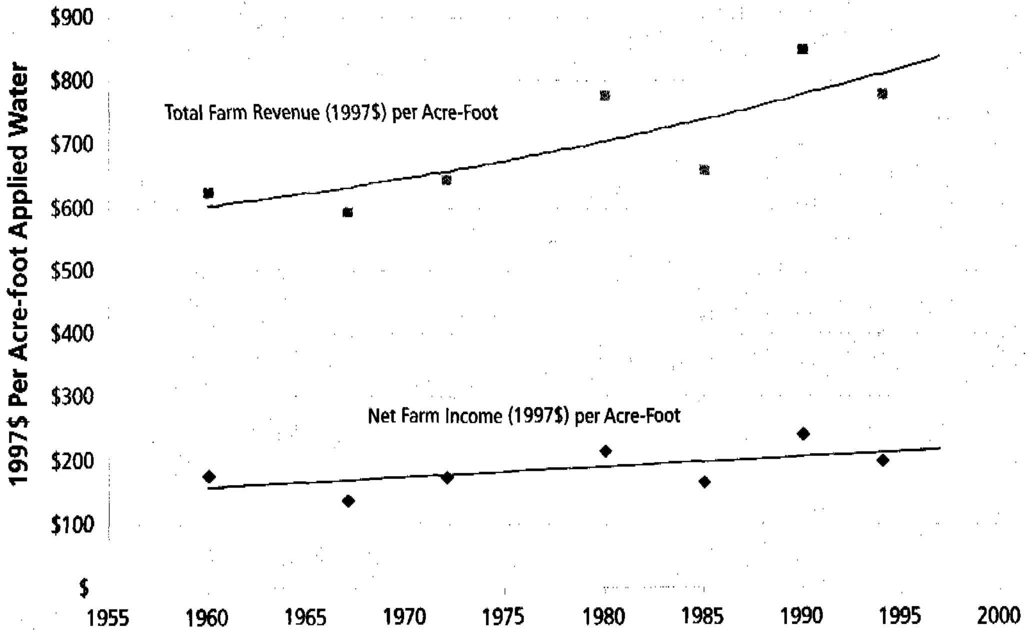
Net Farm Income, 1997 $/Acre



Source: Data from USDA 1998

Figure 14-13

Total Revenue and Net Farm Income Per Acre-Foot of Applied Water



Source: Water data from DWR; revenue and income data from USDA 1998

Table 14-2

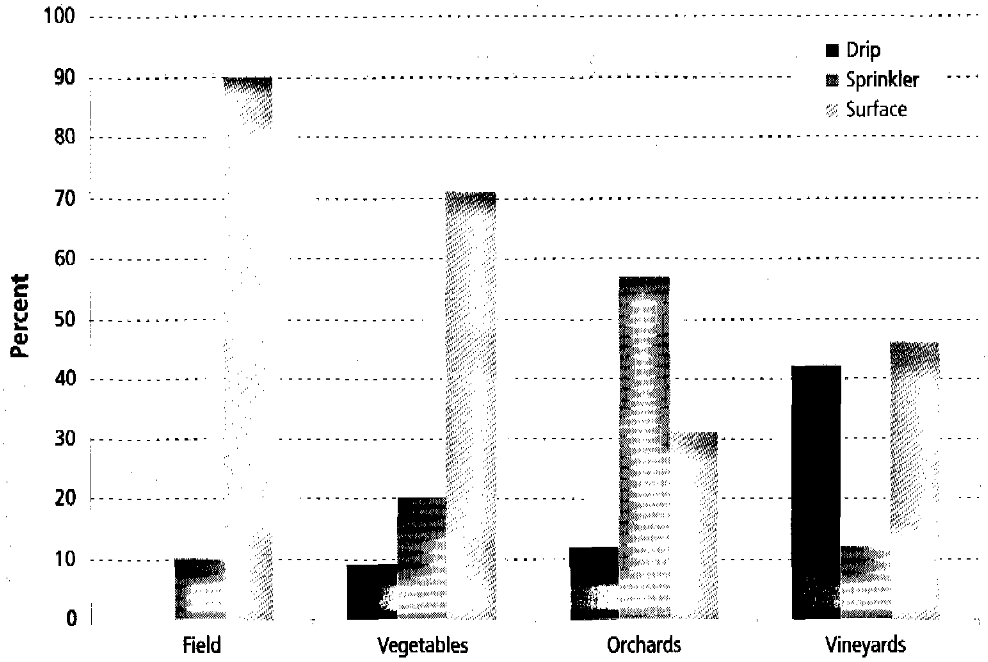
Changes in Irrigation Method in California: 1972 to Early 1990s

Crop Type	Irrigation Method	Change per year (Percent)
All Crops	Surface	-0.73
	Sprinkler	0.30
	Drip	0.45
Field Crops	Surface	0.27
	Sprinkler	-0.25
	Drip	0.01
Vegetable Crops	Surface	-0.63
	Sprinkler	0.16
	Drip	0.50
Orchards	Surface	-1.49
	Sprinkler	0.98
	Drip	0.50
Vineyards	Surface	-2.05
	Sprinkler	-0.19
	Drip	2.08

Source: Snyder et al. 1996

Figure 14-14

Survey of California Irrigation Technology, 1991



Source: Snyder et al. 1996

The same 1991 survey showed that 30 percent of orchards and 45 percent of vineyards were still using flood irrigation (see Figure 14-14). Thus, while California agriculture has begun to make progress in this area, enormous water-savings potential remains. Further changes in crop types will lead to further changes in irrigation method and will save water by reducing evaporative losses.

Factors Leading to Crop Switching

While no one in California's contentious water debates suggests that decisions about cropping patterns be made by anyone other than farmers, it is clear that these decisions depend on a large number of variables. Growers consider many different factors when deciding what crops to grow, including market conditions, soil and climate characteristics, their own experiences and preferences, new technology, and prices of inputs such as fuel, water, and chemicals. Some of these factors are influenced by public policy decisions. Subsidies for water, for example, encourage certain irrigation methods. Government research and development activities reduce the price of new irrigation technology. State and locally funded climate stations provide free information for farmers to use to schedule irrigation, planting, and harvesting (see *The Power of Good Information,* Chapter 16). District programs such as education, water delivery schedules, and pricing also affect on-farm management practices.

The recent experience of the Broadview Water District offers evidence that the price of water, market prices of crops, and the presence or absence of subsidies greatly affect grower decisions about cropping patterns. Because of concerns about the reliability and quantity of agricultural water supplies during the multiyear drought in the late 1980s and early 1990s, Broadview Water District explored various incentives and disincentives for farmers and implemented a rising block rate tariff structure. This approach turned out to be very effective at changing planting patterns and irrigation water use levels (Gleick et al. 1995).

Between 1988 and 1991, acreage planted in alfalfa, melons, wheat, and cotton (relatively water intensive crops) all dropped significantly. Moreover, the actual water applied to these crops per acre also dropped, suggesting not only crop switching but substantial efforts to use water more efficiently. For example, cotton acreage dropped approximately seven percent during this period, but water applied to cotton dropped 30 percent. Acreage planted with higher-valued tomatoes rose by six percent, but actual water used to grow tomatoes dropped nearly 12 percent (Gleick et al. 1995; Table 28). More and more irrigation districts are now beginning to apply some form of rising block rate structure[1] (King 1998).

Conclusions

Discussions of crop switching have traditionally been excluded from California water policy debates, even though changes in cropping patterns over time in California have had a great impact on total agricultural water productivity, water quality, and consumptive use. The water productivity of California agriculture has continued to rise over the past four decades as growers increasingly emphasize fruit and vegetable crops and more efficient irrigation patterns. Some measures of water productivity, such as farm revenue and income per unit of applied agricultural water, have continued to rise statewide, even as total agricultural acreage has leveled off. Future changes in crop types, water requirements, and irrigation methods have the potential to increase the water productivity of California agriculture even further.

Evaluating potential reductions in both evaporation and transpiration are critical to estimating total future demands for water in the agricultural sector. A partial discussion of these factors already occurs implicitly in (1) estimates of changing crop acreage by 2020, such as those estimates generated by the DWR for the Bulletin 160 process, (2) estimates of agricultural water use for 2020, and (3) agricultural pricing discussions. A more complete discussion of these issues is needed statewide.

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[1] According to King, all San Luis and Delta-Mendota Water Authority districts "have implemented some form of tiered pricing programs."

References

Burt, C.M., A.J. Clemmens, K.H. Strelkoff, R.D. Bliesner, L.A. Hardy, T.A. Howell, Members, ASCE, and D.E. Eisenhauer. 1997. "Irrigation Performance Measures: Efficiency and Uniformity." *Journal of Irrigation and Drainage Engineering*, 123(6):423-442.

California Department of Water Resources. 1993. "Agricultural Water Use: Biennial Report." Division of Planning, Department of Water Resources. Sacramento, CA. May.

Carver, K. 1998. High Plains Underground Water Conservation District. Personal communications.

Gallardo, M., R.L. Snyder, K. Schulbach, and L.E. Jackson. 1996. "Crop Growth and Water Use Model for Lettuce." *Journal of Irrigation and Drainage Engineering* 122(6).

Gleick, P.H., P. Loh, S.V. Gomez, J. Morrison. 1995. *California Water 2020: A Sustainable Vision*. Pacific Institute for Studies in Development, Environment, and Security. Oakland, CA.

Hillel, D. 1997. "Small-Scale Irrigation for Arid Zones; Principles and Options." FAO Development Series 2. Rome, Italy.

King, L. 1998. Presentation by Laura King, Director of Strategic Planning, San Luis and Delta-Mendota Water Authority, before the Bay Delta Advisory Council. June 18, 1998. Fresno, CA.

Lascano, R. 1998. Texas A&M University. Personal communications.

Molden, M. 1997. "Accounting for Water Use and Productivity." System-Wide Initiative for Water Management. International Irrigation Management Institute. Sri Lanka.

Snyder, R.L., M.A. Plas, and J.I. Grieshop. 1996. "Irrigation Methods Used in California: Grower Survey." *Journal of Irrigation and Drainage Engineering* 122(7/8):259-262.

U.S. Department of Agriculture. 1998. Data from the Economic Research Service. *www.econ.ag.gov* (at net farm income). Larry Traub, personal communications.

Westlands Irrigation District. 1997. *Irrigator*: Westland Irrigation District Crop Reports, California. March.

Westlands Irrigation District. 1998. *Irrigator*: Westland Irrigation District Crop Reports, California. December 1997–January 1998.

Converting to Efficient Drip Irrigation: Underwood Ranches and High Rise Farms

Megan Fidell, Peter H. Gleick, and Arlene K. Wong

Introduction

In the past two decades California farmers have made considerable progress converting appropriate cropland and crops to water-efficient drip irrigation, significantly reducing applied water requirements for many growers. By the mid-1990s, approximately 13 percent of California farmland was irrigated with drip systems, up from five percent in the mid-1980s. Much of this conversion has taken place on land planted with vine and orchard crops, and high-valued fruit and vegetable crops. Recent innovative efforts now suggest that row crops not previously irrigated with drip systems can be successfully and economically converted as well, reducing applied water needs and increasing crop yield and quality. As drip continues to penetrate California's agriculture industry, applied water requirements for many more crops seem likely to drop.

In the examples included in this case, the California Energy Commission (CEC) granted low-interest loans to two California farmers to help cover the costs of converting bell pepper row crops to drip irrigation. In 1993, High Rise Farms near Gilroy installed subsurface drip irrigation equipment on 40 acres, and Underwood Ranches near Oxnard installed subsurface drip irrigation on 50 acres. As part of the loan program, the CEC hired the Irrigation Training and Research Center (ITRC) at Cal Poly San Luis Obispo to provide technical assistance to the growers and to document resource use before and after conversion to drip.

Both farms found that subsurface drip irrigation substantially increased pepper yields, decreased water consumption, and greatly improved profits. The average *net* revenue increase for High Rise Farms was $1,100 per acre per year; the average *net* revenue increase for Underwood Ranches was $1,900 per acre per year. Initial installation and operation problems often experienced with new systems were successfully addressed and both farms have since expanded their drip irrigation systems with their own money.

Background

Benefits of Drip Irrigation

Drip or micro-irrigation systems deliver low volumes of water from a pressurized water source. Water is delivered to the plants through flexible plastic hose or "tape" laterals with small holes or emitters that can regulate the low flow rates. Filtration devices filter out smaller particles to prevent clogging of the laterals and emitters. Drip systems can either be buried or placed on the soil surface with emitters usually spaced from two to five feet apart (based upon the soil and crop type). Drip irrigation directly wets the soil underneath or surrounding the emitters, and the water moves both laterally and downward in the soil. The wetted area is somewhat spherical, with a wetted radius of up to three feet (DWR 1998). These systems require regular maintenance, including frequent flushing of pipelines and lateral hoses, to reduce clogging and scale buildup. They also require the regular addition of chemicals to kill bacteria and other life forms that can grow in the hoses and emitters. In addition to the maintenance needed for both drip and filtration systems, irrigation scheduling is also important and will impact performance. A poorly managed drip system can still result in over- or under-irrigation.

Drip systems more precisely control the delivery of water to plants. They can improve irrigation efficiency by reducing applied water and/or by increasing the amount of the applied water that is beneficially used by the plant. Because it doesn't spread water extensively over the soil surface, a drip system can reduce

Distribution Uniformity and Irrigation Efficiency

There are several methods of measuring irrigation per[illegible] which [illegible] dist[illegible] [illegible]ty (DU) and irrigation efficiency (IE). DU measures how uniformly water is applied across a field. I[illegible] how [illegible] applied water [illegible] [illegible]cially [illegible]ed. Bene[illegible]cial use normally includes water necessary for a plant's natural pr[illegible] [illegible]piration [illegible] evap[illegible]

In a simple example, imagine that immediately after an irrigation [illegible] you walk into a [illegible] push a stick into the ground at 30 sampling sites. The depth the stick reaches with little resistance is one measure of the quantity of water that entered the ground at that site. Rec[illegible] the infiltration depth [illegible] the sampling sites, and [illegible] the area of the field and [illegible] the water [illegible]ached (Figure a). Now, instead of arranging the depths by their spa[illegible] field, [illegible] the [illegible] least de[illegible] (Figure b). Smooth the bars into a line across the bottom, for a pictu[illegible] of th[illegible] Figure [illegible]

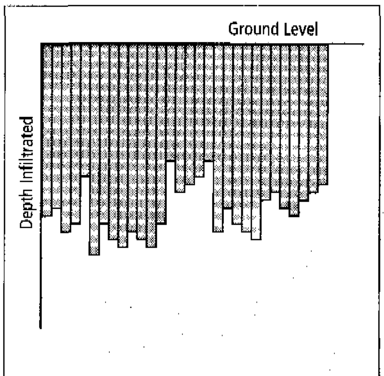


FIGURE a

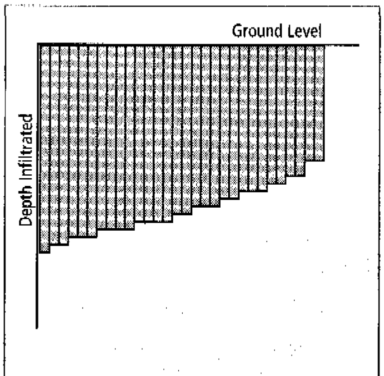


FIGURE b

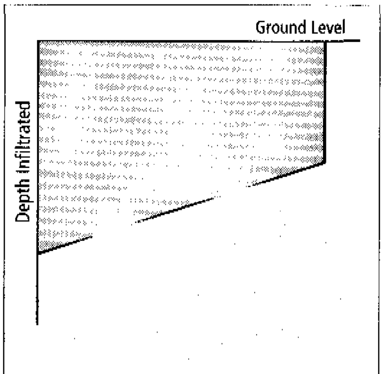


FIGURE c

Where is water in this irrigation event going? Some water won't mak[illegible] into the ground. It will [illegible] off the surface, be blown away by the wind, or evaporate before it [illegible]ts to the soil. Other water will enter t[illegible] and be held for the crop. The soil reservoir is defined by the volume surrounding the root zone of the pla[illegible] and therefore the regi[illegible] in which water will be beneficiall[illegible] used by the pla[illegible]. When the soil reser[illegible]ir is [illegible] the water is not us[illegible] by the pla[illegible] [illegible] inste[illegible] deep p[illegible] (Fig[illegible]

DU is intended to measure the variatio[illegible] depth infiltrat[illegible] throughou[illegible] area [illegible]

$$\text{DU} = \frac{\text{Least Depth Infiltrated}}{\text{Average Depth Infiltrated}}$$

A high DU (Figure e) represents a highly uniform distribution which would allow an irrigator [illegible]imize the need to overwater certain parts of a field in order to adequately water the drier parts of a field. A low DU (Figure f) indic[illegible] [illegible]gher variation, making it more difficult to apply an adequa[illegible] [illegible]nt of wa[illegible] for all plants [illegible] the field [illegible] unne[illegible]ssary [illegible] and d[illegible] [illegible]ation [illegible] a are[illegible]

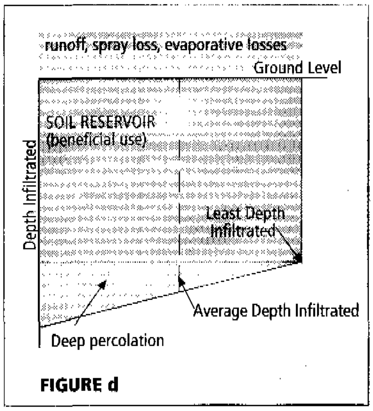
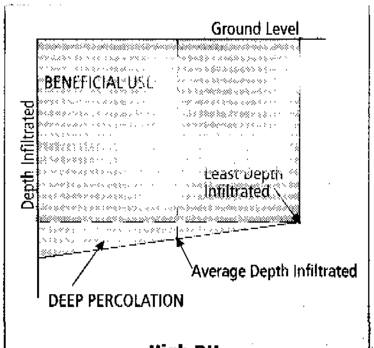
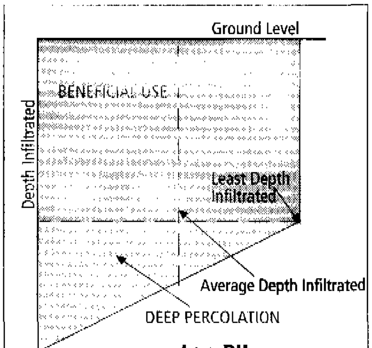


FIGURE d



High DU

FIGURE e



Low DU

FIGURE f

Some deep percolation losses from DU are unavoidable. An exceptionally well designed and installed drip system will have a DU of around 95 percent, with low deep percolation losses. All irrigation methods can achieve DUs between 80 to 95 percent, though the actual range is larger (Piper and Cappellucci 1990). In California, with its awareness of the value of water and relatively modern agricultural methods, the average DU is probably between 60 to 70 percent.

Improving DUs statewide has substantial potential for water conservation. However, DU itself is not an efficiency measure. A high DU does not necessarily mean that a grower will use irrigation water efficiently, but it does allow the grower to use as little water as technically feasible in delivering water to all parts of the field. Improving their system's DU offers benefits to growers: yields improve when better distribution can address over- or under-irrigation problems; chemical inputs are not washed away by excess water, and lower water application can reduce drainage problems. But it requires a good initial irrigation system design, and constant maintenance of irrigation systems that may cover hundreds of acres to ensure that emitters aren't plugged, nozzles aren't worn, or furrows aren't sealed by silt.

A typical definition of Irrigation Efficiency (IE) is:

$$\text{IE} = \frac{\text{Irrigation Water Beneficially Used}}{\text{Irrigation Water Applied}}$$

In California beneficial use is defined by law, and refers to water directly used to produce agricultural crops. In our simple example, beneficial use can be represented by the water that fills the soil reservoir. A grower, regardless of DU, can over- or under-irrigate his crop depending on the duration of the irrigation. Ideally, an irrigator would like to ensure that every plant receives the water that it needs; that is, that the least depth infiltrated fills the soil reservoir. Thus, there are three possible lengths for an irrigation event: too long, too short, and "perfect timing" (i.e. least depth infiltrated fills the soil reservoir). With two types of DU, high and low, six combinations of timing and DU can combine with IE (Figures g - l). An extremely high IE often indicates under-irrigation; an extremely poor IE often indicates a poor DU. Only one combination, "perfect timing" and good DU, optimizes irrigation efficiency without danger of under-irrigation.

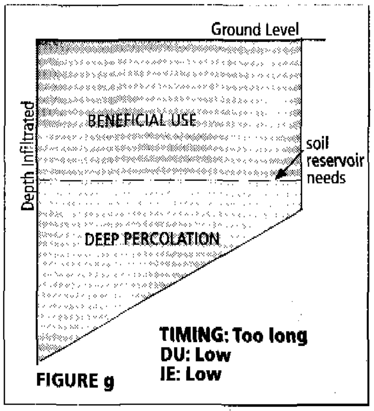


FIGURE g

TIMING: Too long
DU: Low
IE: Low

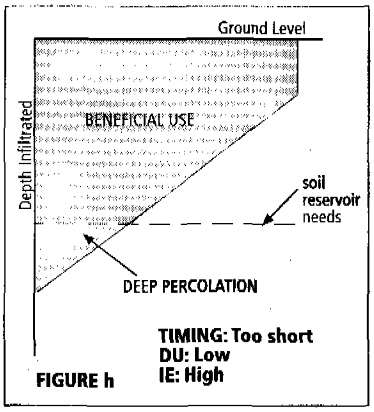


FIGURE h

TIMING: Too short
DU: Low
IE: High

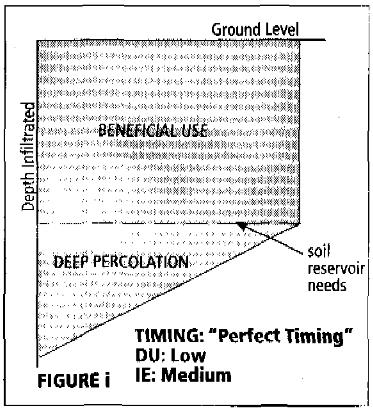


FIGURE i

TIMING: "Perfect Timing"
DU: Low
IE: Medium

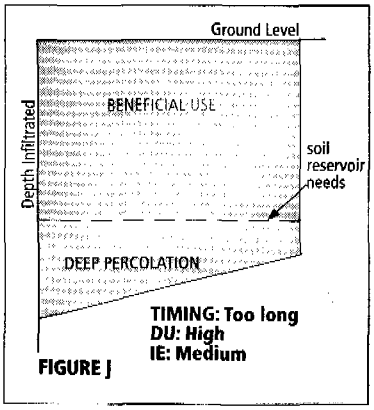


FIGURE j

TIMING: Too long
DU: High
IE: Medium

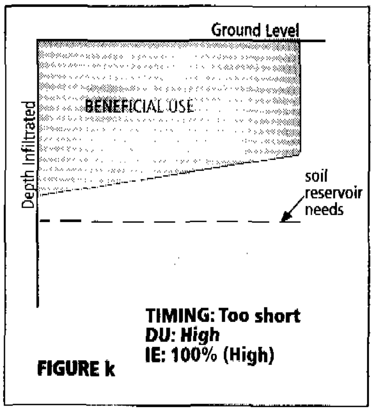


FIGURE k

TIMING: Too short
DU: High
IE: 100% (High)

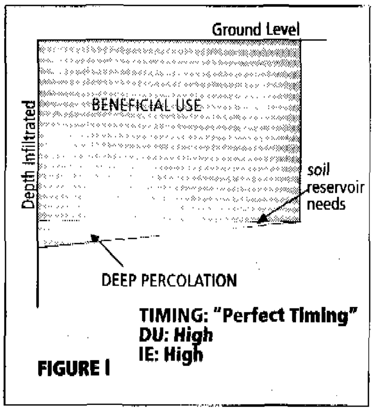


FIGURE l

TIMING: "Perfect Timing"
DU: High
IE: High

evaporative losses from standing water and reduce runoff. Drip delivery can provide high distribution uniformity (see previous pages), which minimizes the amount of water applied to adequately wet the field and reduces water lost to deep percolation. Drip systems can also improve crop yields by decreasing plant stress. The ITRC has determined that crops grown with a well-managed drip irrigation system take up almost 10 percent more water than crops grown under other irrigation systems (ETcrop increases by 10 percent), because the soil is never allowed to dry enough to stress plants (Burt 1994). With improved yields, efficiency as a measure of water used per ton of crop yield would increase even if there were little change in amount of water applied.

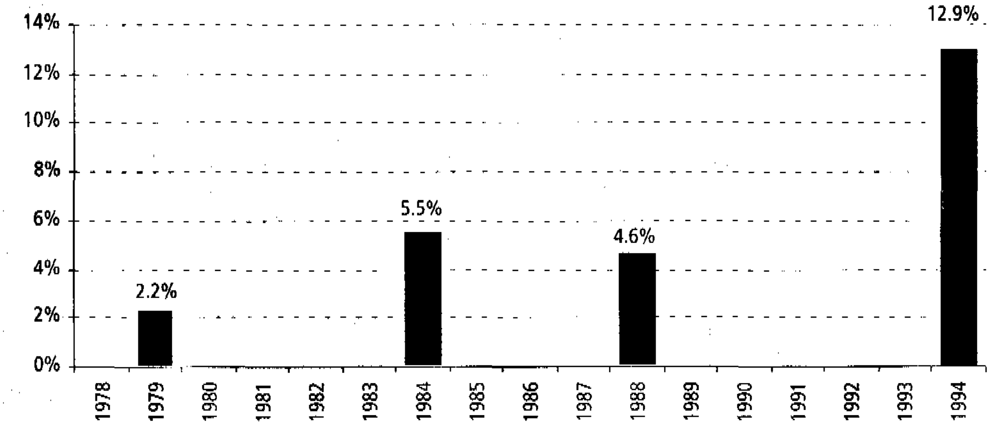
Use of Drip Irrigation in California Agriculture

Drip or micro-irrigation systems have been used in arid climates for two decades. By 1994, over 930,000 of California's 7.2 million acres of irrigated land (13 percent) were irrigated with drip or mister systems (1994 Farm and Ranch Irrigation Survey). Figure 15-1, taken from U.S. Census data, illustrates the trend of increasing application of drip technology over a 15-year period.

Drip irrigation is especially prevalent in growing high-value crops, like strawberries, or permanent crops, such as orchards and vineyards. Strawberry growers adopted drip irrigation relatively soon after its introduction, and now nearly all strawberry farmers in California

Figure 15-1

Percent of Irrigated Acreage in California Using Drip Irrigation



Source: 1979, 1984, 1988, 1994 Farm and Ranch Irrigation Survey, U.S. Census

Limits to Drip Irrigation

Drip irrigation systems are like any [illegible] operating system: the more powerful the options, the more difficult they are to learn [illegible] use. As drip irrigation becomes common, manufacturers are improving delivery technology and growers are improving management techniques. There are automated drip irrigation systems that call the local weather station daily and supply exactly the quantity of water needed to meet that day's evapotranspiration requirement for a particular crop. As at High Rise Farms and Underwood Ranches, growers are finding that yields can increase while water and chemical requirements are reduced. But there are also drip irrigation systems that [illegible] meeting the potential of this technology, and a poorly managed drip system can waste as much water as any low-tech irrigation system.

Growers that do not adopt drip [illegible] primary reasons. The first is the large initial capital cost for a drip irrigation system. Even farmers who expect a drip system to pay for itself relatively quickly may not be able to find money to convert to a drip system. Water, irrigation labor, and chemical inputs are not a large part of the cost of raising a crop, but equipment costs can only be recouped by an increase in yield. Second, growers cite local conditions as prohibiting adoption of a drip irrigation program. If the irrigation district that supplies a grower's water delivers water irregularly or on a weekly rotation system, a grower cannot put enough water into the ground with a drip system to carry the crop through to the next delivery. Growers in some areas report that coyotes and rodents can destroy an entire field's drip tape in a single season. Neither grower nor manufacturer has found a way to prevent this loss. The third objection farmers have to drip is that installing a drip irrigation system locks the farmer into a set field configuration. The benefit drip irrigation offers is the ability to maximize distribution uniformity by fine-tuning pressures and flows throughout the system. Once a system is in place and performing well, the farmer is locked into the bed configuration for which the system was designed. The grower may then be unable to change crops to respond to market demand. This is an important reason that drip irrigation systems have made much faster inroads into perennial and tree crops than row crops.

Other concerns about drip irrigation that are beginning to develop as drip systems enter their second decade of use in California involve the disposal and life of drip tape. Because drip tape and emitters are made from stabilized plastics designed not to degrade in extreme outdoor conditions, they can resist degradation in landfills. Well-treated subsurface drip tape can be expected to last five to eight years. Tape that is subjected to machinery or rodent damage will last as little as one or two seasons. Although some growers have machinery to pull and roll tape for reuse, each disturbance stresses the material. If it is not in good condition, it will not serve as the highly precise application system it is designed to be.

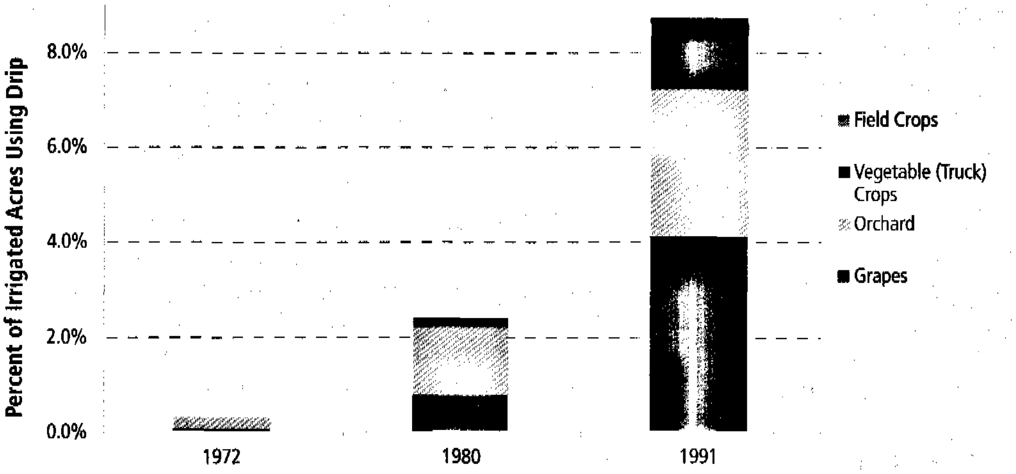
have converted to drip irrigation. The average annual acreage for strawberries in California is about 25,000 acres (Strawberry Growers Commission 1998). Drip irrigation systems are well suited for strawberry farms for several reasons. Strawberry farmers must constantly match a narrow range of soil moistures, so the precise control of applied water by drip systems appeals to them. Since strawberries are a high-value crop grown on relatively small fields, farmers can afford the initial capital costs of a drip system. Also, drip systems are well suited for delivering water to hillside fields. Strawberry farmers rarely rotate crops so that farmers do not have to reshape crop beds every year, which would require disrupting the irrigation system placement. Finally, strawberries are grown in relatively modern water districts, where the frequency of water deliveries is not limited by the district's delivery capabilities.

Statewide surveys of California farms conducted in 1972, 1980, and 1991 support the census data figures showing increased use of drip irrigation each decade, with 0.3 percent of acreage on drip in 1972, 2.4 percent in 1980, and 8.7 percent in 1991. The surveys also record irrigation methods used by crop type. In 1972, drip was being used for orchard, vineyard, and berry bush crops. Subsequent surveys in 1980 and 1991 indicated that drip had expanded to vegetable or truck crops, with a small percentage of field crop acreage on drip (1 percent). Drip irrigation has been widely adopted in vineyards, with the 1991 survey showing 42 percent of grape and bush berry crops using drip. Despite the adaptability of drip to permanent crops such as orchards, reported orchard acreage on drip, while increasing, was only 12 percent in 1991. Use of drip in row crops is not widespread, but appears to be increasing at a greater rate than orchards in recent years. Vegetable or row crops exhibited less than 10 percent of acreage in drip in 1991, but that represents a significant increase from previous survey years.

For growers who may grow crops with different spacing every year in response to weather and market forces, the relative permanence of an installed drip irrigation system is a barrier. However, as growers have worked more with drip, they have found that equipment can be modified to reduce damage when tilling fields,

Figure 15-2

Percent and Type of Irrigated Acreage Using Drip in California for Survey Years



Field crops: Alfalfa, small grains, corn, cotton, pasture, sugar beets, dry beans, sorghum, safflower, sunflower, etc.

Vegetable: Truck and vegetable crops including green beans, fresh market and processing tomatoes, cabbage, lettuce, cauliflower, carrots, strawberries, etc.

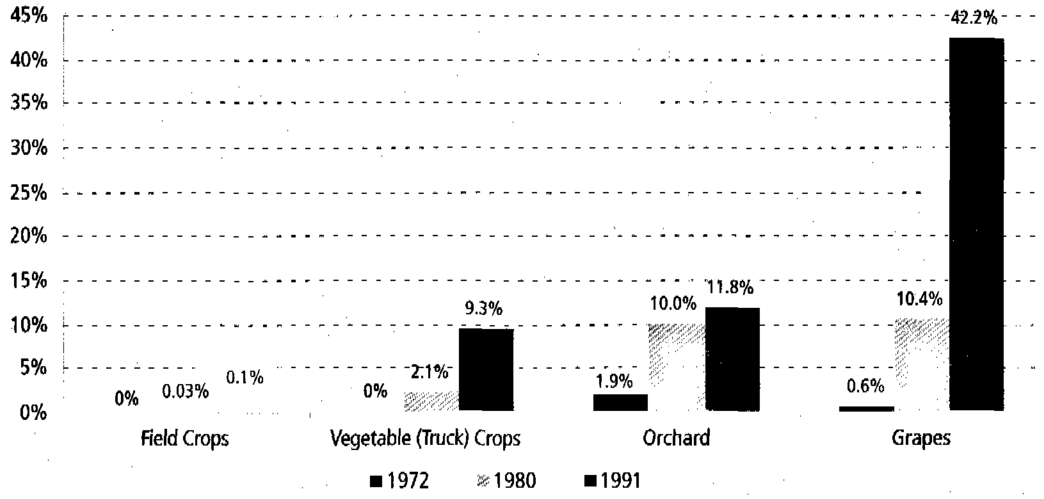
Orchard: Deciduous fruit and nut trees and Subtropical, including olives, avocados, citrus, dates, etc.

Grapes: Grape vines, bush berries.

Source: 1991 Irrigation Methods Survey Report, January 1993

Figure 15-3

Percent of Drip Irrigation by Crop Type



Field crops: Alfalfa, small grains, corn, cotton, pasture, sugar beets, dry beans, sorghum, safflower, sunflower, etc.

Vegetable: Truck and vegetable crops including green beans, fresh market and processing tomatoes, cabbage, lettuce, cauliflower, carrots, strawberries, etc.

Orchard: Deciduous fruit and nut trees and Subtropical, including olives, avocados, citrus, dates, etc.

Grapes: Grape vines, bush berries.

Source: 1991 Irrigation Methods Survey Report, January 1993 and special equipment can allow for reshaping and working beds without tilling to the depth of the tape. While there have not been more recent surveys of irrigation methods used throughout the state, anecdotal evidence suggests that all forms of micro-irrigation have continued to increase.

A collection of case studies gathered by the Natural Resources Defense Council (Cohen and Curtis 1998) on agricultural practices to improve water quality through water conservation and pesticide management featured four cases where farmers successfully implemented drip irrigation. Three of the four cases involved application of drip in row crops:

- In Los Banos in Fresno County, Trecho Farms has been using subsurface drip irrigation for fresh market and processing tomatoes for the past eight years. Trecho Farms reports that even though it took at least a year to get the drip system working efficiently, water use has been reduced by as much as 50 percent from previous furrow systems.
- At Hammond Ranch in Firebaugh (Fresno County) the owner has established subsurface drip irrigation on 560 acres of cotton, tomatoes, and asparagus. Hammond Ranch reports improvements in yield and reductions in water use. Cotton is grown with 20 percent less water than the region's average (2.1 acre-feet of water per acre, instead of 2.7 acre-feet per acre) and has produced yields of approximately 15 percent more than the region's average. Three-year old asparagus fields currently yield about 185 crates per acre, and the owner expects 300 crates per acre when the crop matures at five years. Such yields would be 50 percent higher than those typically produced using furrow or sprinkler irrigation.
- Turlock Fruit Co., also in Firebaugh, has subsurface drip systems serving 300 acres of asparagus, 150 acres of melons, and 150 acres of cotton. It began installing systems in 1993. The company reports that drip irrigation has increased yields on these fields by 30 to 40 percent and reduced water use by 20 to 30 percent, eliminating drainage. Increased soil salinity can become a problem as efficiencies increase, but Turlock Fruit has seen no increase in salinity on drip-irrigated fields.

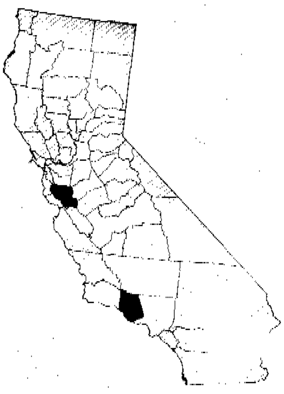
Because drip more precisely applies water and does not wash away fertilizers and pesticides as other methods can, all of the farmers reported additional savings from reduced fertilizer and pesticide costs. The latter two farmers took advantage of low interest loans from the State Revolving Fund program to pay for their irrigation improvements. Because of the capital costs involved in installing new irrigation systems, these loan programs offer valuable assistance to growers. In 1993, the CEC launched a low-interest loan program to facilitate adoption of drip irrigation systems, in large part to explore possible energy savings. The CEC is a state agency with an interest in improving energy efficiency in California. Their Energy in Agriculture Program provides technical support and financial assistance to promote the efficient use of energy resources among California's food and fiber industry. CEC's projects range from funding applied research to developing new technologies. Their grants and low-interest loans are funded by the federal Petroleum Violation Escrow Account.

The 1993 program solicited loan proposals from growers on CEC's mailing list, and through farm newspapers. Applications for projects were subjected to financial, technical, and economic analysis before approval. Technical review of proposed irrigation system designs was the responsibility of the Irrigation Training and Research Center (ITRC) at Cal Poly San Luis Obispo, which could reject or approve a proposed design, or require design changes. After applications were reviewed, the project manager from CEC visited every farm that had submitted an acceptable application before making a final decision. The entire application process took 45 days.

Underwood Ranches applied for the CEC low-interest loan program because the owner knew he wanted to expand his acreage under drip irrigation, having tried it on a very small scale. A major incentive for him was the low-interest rate offered, which made the initial cost of the project far more attractive. Similarly, High Rise Farms sought to establish drip irrigation for its pepper acreage, and obtained support to install equipment on 40 acres.

The Projects

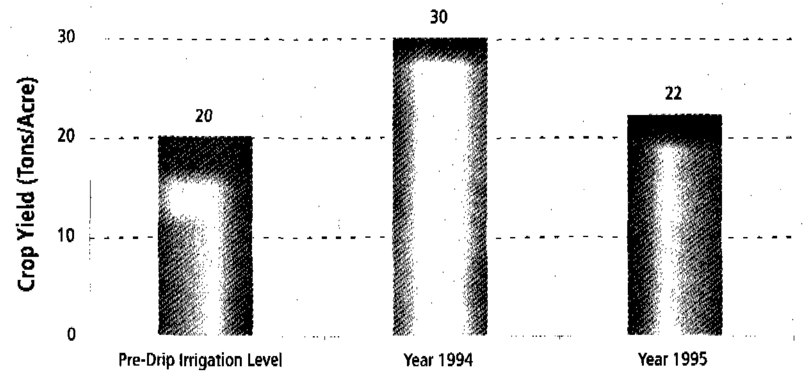
Underwood Ranches



Underwood Ranches grows vegetable crops on about 1,000 acres. Each year, some acreage is used for *jalapeno* peppers. Under this project, Underwood Ranches converted 50 acres of sprinkler irrigation to subsurface drip irrigation. Underwood borrowed $50,000 from CEC and spent an additional $16,000 of its own money. In the first operational year of the project (1994), bell pepper yields increased 50 percent over the pre-project average. In the second year, Underwood Ranches expanded the system to irrigate a total of 140 acres of peppers, and project yields were 10 percent higher than the pre-project average.

Analysis suggests that most of the change in pepper yield resulted from suppression of *Phytophthora*, a soil fungus that grows well in humid conditions. In the first year, the subsurface drip worked as designed, and the plants were kept dry. Yields increased from 20 tons per acre to 30 tons per acre.

Figure 15-4
Underwood Ranches Comparison of Crop Yield (Tons/Acre)



Source: ITRC 1996

Phytophthora was a more severe problem in the second year of the project, though pepper yields were still higher than pre-project yields. During the second year, the field was over-wetted by unusually heavy rainfall and by excess irrigation used to compensate for plugged emitters. Emitters are normally kept clean by injecting acid through the irrigation system. Underwood Ranches had used aluminum mainlines to deliver water to their drip tape and risked corroding the mainlines if they injected acid to clear the emitters. In 1995 emitter-plugging problems initially caused such severe under-irrigation that workers cut holes in the tape with pocketknives. In the parts of the field with clear emitters, water ponded on the field as the grower tried to offset the under-irrigation in plugged areas. *Phytophthora* caused a 95 percent reduction in yield on 25 acres of over-irrigated fields. The grower has since abandoned the use of aluminum mainlines, and maintaining more accurate soil moisture is now easier. Underwood Ranches now irrigates all of its peppers using drip systems. The acreage changes from season to season and peaked in 1997 at 270 acres.

High Rise Farms

High Rise Farms grows about 400 acres of bell peppers, and installed the subsurface drip system in a 40-acre field. They experienced higher yields the first year of the study, no improvement over pre-project yields the second year, and greatly improved yields the third year. Yields the first year increased primarily because the grower was able to increase the number of pickings. The furrow irrigation system he replaced had kept his field too wet for the harvester to enter, and the new drip irrigation system allowed him to harvest ripe peppers more often. During the second year, plant roots intruding into the drip tape plugged emitters and reduced yields to pre-project levels though water use still dropped more than 10 percent. In the third year, the grower cleared the plugged emitters, changed pepper varieties, and increased planting density.[1] His yields increased from 18 tons per acre to 32.5

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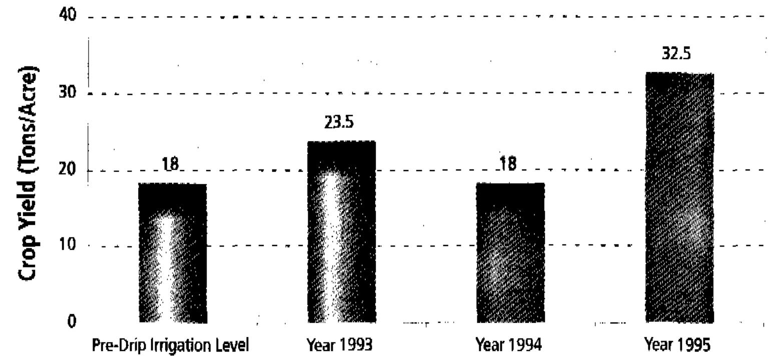
[1] The original field used for the first two years of the study was flooded and could not be used in 1995. For the third year, the equipment was used on higher ground on a 45-acre field.

tons per acre.

The experience of the first three years of subsurface drip irrigation led to modifications in High Rise's drip system. High Rise Farms converted to a surface drip irrigation system with a drip tape retrieval system, to allow for greater crop choice. The farm hopes to pull and re-install the tape three times before it must be replaced. High Rise Farms continues its commitment to drip irrigation, and at the end of the project in 1995, had plans to expand its drip-irrigated acreage by 100 acres.

Figure 15-5

High Rise Farms Comparison of Crop Yield (Tons/Acre)



Source: ITRC 1996

Evaluation of Success

The following data are provided from the IRTC analysis (1996) of changes in resources before and after implementation of the drip systems. The data show a clear pattern in improved water efficiency from both reductions in water use and increases in pepper yields. The data also show the variability of results given different weather and equipment conditions, reflecting the learning curve required to optimize results.

Underwood Ranches reports that yields in 1996 and 1997 continued to match the performance of the first year of the project, at or above 30 tons per acre, with yields well above pre-drip irrigation levels. Drip irrigation has allowed Underwood Ranches to reduce water application considerably and to improve yields by reducing the number of peppers lost to *Phytophthora*. The grower considers his drip irrigation project "a great success."

In the case of High Rise Farms, reductions in water use were not as dramatic, and, in fact, water use increased in 1995. However, yields also increased.

For Underwood Ranches and High Rise Farms, switching to drip irrigation systems has resulted in sizable economic benefits. Underwood Ranches increased its profits by almost $2,000 an acre; High Rise Farms increased its profits by $1,106 an acre.

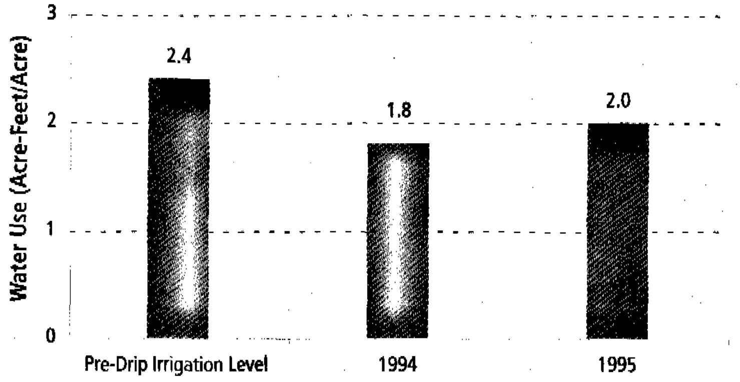
Table 15-1

Change in Water and Energy Use at Underwood Ranches, 1994 and 1995

Item	Baseline: Before Drip Irrigation	1994	Percent Change From Baseline	1995	Percent Change From Baseline
Water Use Acre-Feet/Acre	2.4	1.8	-25	2.0	-16
Energy Use MBtu/Acre	18.3	20.0	10	19.6	7
Yield Tons/Acre	20.0	30.0	50	22.0	10
Water-Use Efficiency Tons/Acre-Foot	8.5	16.5	94	11.1	31
Energy-Use Efficiency Tons/MBtu	1.1	1.5	36	1.1	0

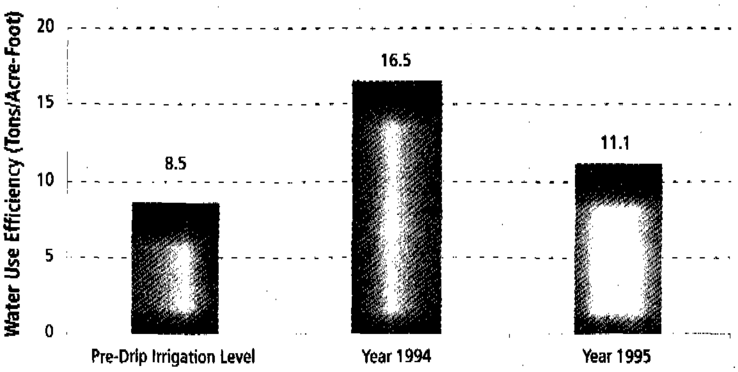
Source: ITRC 1996

Figure 15-6
Underwood Ranches Water Use Comparison (Acre-Feet/Acre)



Source: ITRC 1996

Figure 15-7
Underwood Ranches Water-Use Efficiencies Comparison



Source: ITRC 1996

The increase in water-use efficiency that drip irrigation provided at Underwood Ranches and High Rise Farms was large. Water use at Underwood Ranches decreased by almost 20 percent while yields increased by 30 percent. On average, a good drip system still uses less water than traditional irrigation because less water is mis-applied, evaporates from standing water, and/or percolates too deeply. High Rise Farms used almost the same amount of water before and after converting to drip irrigation, but was able to grow larger plants at a higher density. Yields at High Rise Farms increased by almost 40 percent.

Ironically, both farms increased energy use. At Underwood Ranches energy use increased by 10 percent; at High Rise Farms energy use increased 20 percent. However, since yields increased, energy-use efficiency also increased.

Conclusions/Lessons Learned

Conversion to drip irrigation is an option for farmers who own their farms or have a long-term lease; who have a reliable source of constantly delivered water; who grow high-value row crops; who have technical support for their drip system; and who are prepared for a two- or three-year learning process. Growers without such characteristics, or who frequently change crops and bed sizes, encounter more difficulties converting to drip irrigation. Growers who weather the first couple years required for

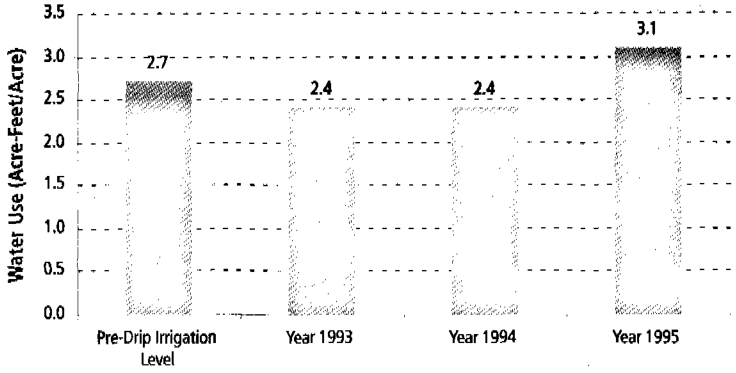
Table 15-2
Change in Water and Energy Use Efficiencies for High Rise Farms, 1993–1995

Item	Baseline: Before Drip Irrigation	1993	Percent Change From Baseline	1994	Percent Change From Baseline	1995	Percent Change From Baseline
Water Use Acre-Feet/Acre	2.7	2.4	-11	2.4	-11	3.1	15
Energy Use MBtu/Acre	21.2	24.5	16	24.5	16	27.6	30
Yield Tons/Acre	18	23.5	31	18.0	0	32.5	81
Water-Use Efficiency Tons/Acre-Foot	6.7	9.8	46	7.5	12	10.5	56
Energy-Use Efficiency Tons/MBtu	0.85	0.96	13	0.74	-13	1.12	39

Source: ITRC 1996

Figure 15-8

High Rise Farms Water Use Comparison (Acre-Feet/Acre)



Source: ITRC 1996

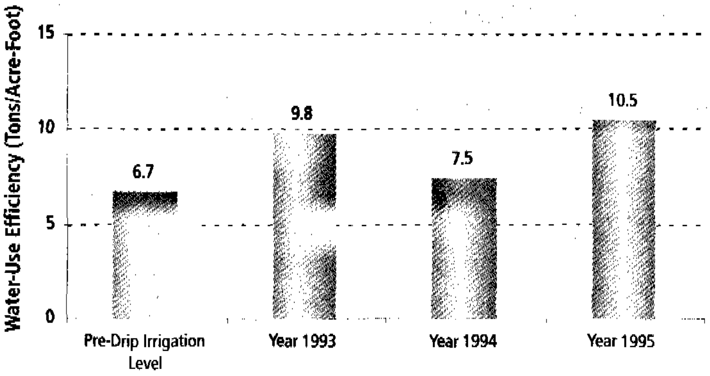
adapting to drip irrigation are generally very pleased with their new systems.

Drip irrigation requires a large up-front expenditure, which not all farmers are willing to risk or able to undertake. For Underwood Ranches and High Rise Farms, the risks imposed by the initial costs were shared with the CEC. The initial costs were quickly recovered by increased yield, and by decreased water use, chemical inputs, and irrigation labor costs. Underwood Ranches used the CEC low-interest loans to install the first 50 acres, then installed another 200 acres with private financing. In fact, Underwood Ranches repaid its loan one year early.

Once installed, drip irrigation systems shift irrigation labor from manual fieldwork to ana-

Figure 15-9

High Rise Farms Water-Use Efficiencies Comparison



Source: ITRC 1996

Table 15-3

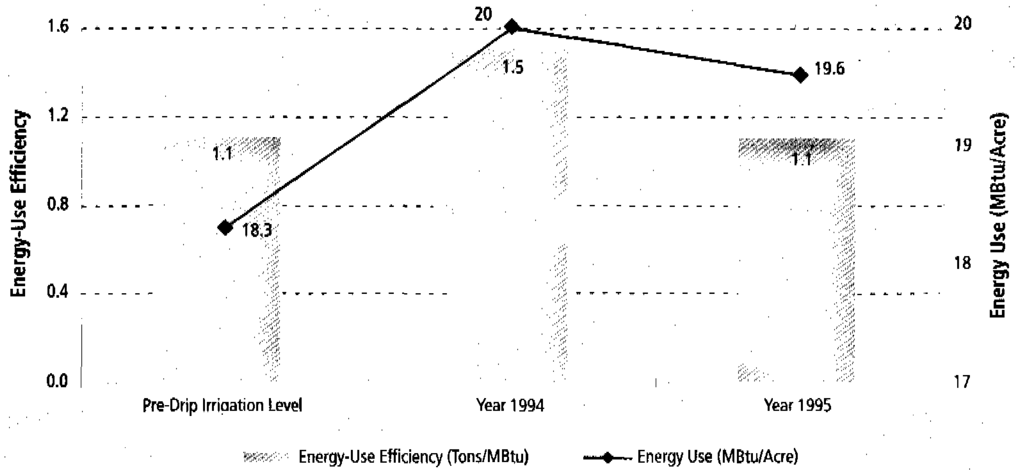
Summary Cost Figures

	Underwood Ranches	High Rise Farms
CEC Loan	$50,000	$50,000
Actual Capital Cost	$66,214	$50,000
Investment Cost (annualized)	$154/acre	$189/acre
Average Annual Net Revenue Increase	$1,890/acre	$1,106/acre
Investment Efficiency	12.3-fold increase	6-fold increase

Source: ITRC 1996

Figure 15-10

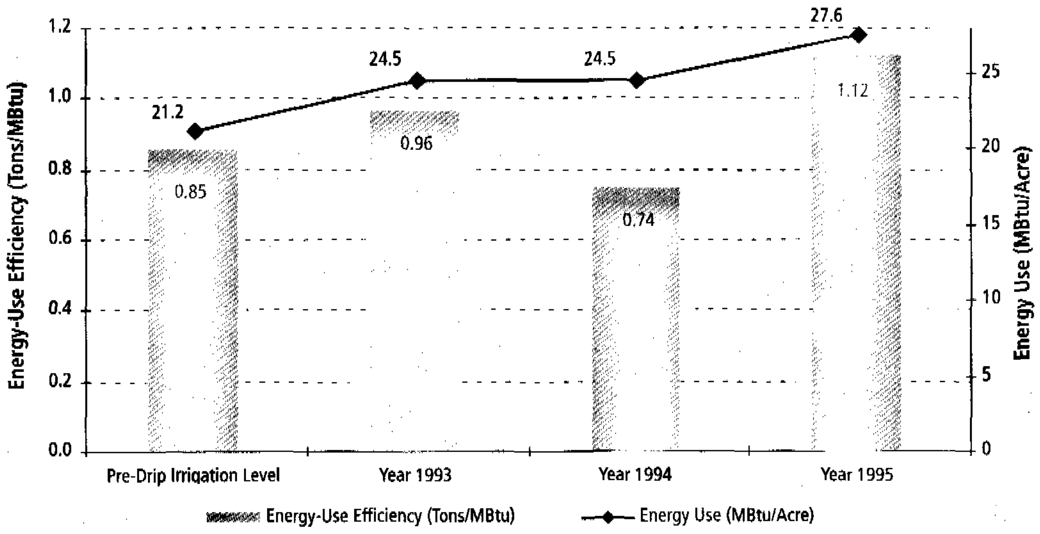
Underwood Ranches: Energy Use and Efficiency



Source: *ITRC 1996*

Figure 15-11

High Rise Farms: Energy Use and Efficiency



Source: *ITRC 1996*

lytical management. Although most farms keep a field worker to check and maintain their systems, drip irrigation systems eliminate much of the manual labor of traditional irrigation systems. However, a drip system can require more management than a grower may be accustomed to performing. Since the purpose of drip irrigation is to apply small, frequent irrigations, the grower may have to track soil moisture and irrigation scheduling more closely than is required for a system that applies large quantities of water infrequently and less precisely.

Improvements in drip technology and the ability to adapt equipment and farming practices have made drip irrigation more common in many different types of crops, including row crops. As can be seen in these cases, technical as well as financial assistance programs continue to be important parts of promoting further use.

Contacts

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Craig Underwood, Underwood Ranches

References

1978 Census of Agriculture. *Farm and Ranch Irrigation* (1979). Washington DC.

1987 Census of Agriculture. *Farm and Ranch Irrigation Survey (1988).* Washington DC.

1992 Census of Agriculture. *Farm and Ranch Irrigation Survey (1994).* Washington DC.

Amon, R. 1997. Energy in Agriculture Program, California Energy Commission. Sacramento, CA. Personal communications.

Burt, C. et. al. 1997. "Irrigation Performance Measures: Efficiency and Uniformity." *Journal of Irrigation and Drainage Engineering.* Vol. 123, No. 6, November/December.

California Department of Water Resources. 1998. *The California Water Plan Update, Bulletin 160-98 DRAFT.* Sacramento, CA.

Cohen R. and J. Curtis. 1998. *Agricultural Solutions: Improving Water Quality in California Through Water Conservation and Pesticide Reduction.* New York, NY: Natural Resources Defense Council.

ITRC. 1996. "Evaluation of Subsurface Drip Irrigation on Peppers." Report by Irrigation Training and Research Center. Unpublished. San Luis Obispo, CA.

Plas, M. et al. 1993. "1991 Irrigation Methods Survey Report." *Agricultural Water Use Biennial Report,* May 1993. Prepared for California Department of Water Resources, Division of Planning.

Piper, R. and A. Cappellucci. 1990. Presented at the July 1990 ASCE Irrigation and Drainage Conference. Paper is part of *Journal of Irrigation and Drainage Engineering.* Vol. 119, No. 3, May/June, 1993.

U.S. Department of Commerce. *1984 Farm and Ranch Irrigation Survey.* Prepared for U.S. Department of Agriculture, Economic Research Service. Special Report Series AG84-S4-1. Washington, DC.

Underwood, C. 1997–1998. Underwood Ranches. Somis, CA. Personal communications.

Chapter 16

The Power of Good Information: The California Irrigation Management Information System (CIMIS)

Peter H. Gleick

Introduction

The vast majority of water consumed in California is used to irrigate farm crops and urban landscapes. In 1982, the California Department of Water Resources (DWR) and the University of California created the California Irrigation Management Information System (CIMIS) to encourage farmers and other water users to include weather information in irrigation decisions. In theory, if growers use data on evaporation and transpiration rates for their regions, they can irrigate in a more accurate and timely manner and replace only the water actually used by crops. This approach can increase water-use efficiency and crop yields and decrease costs to growers.

In 1986, CIMIS became an official project of the DWR, with 43 stations. At present, CIMIS is comprised of more than 100 computerized weather stations throughout the state that collect and convert weather data into estimates of water needs for different purposes. DWR operates the system in conjunction with local agencies. While the overall number of CIMIS stations is still fairly limited, a recent independent assessment of the program suggested that CIMIS is used to help determine water needs of more than 370,000 acres of farmland and urban and municipal landscaping and has reduced applied water use on these lands by an average of 13 percent. At the same time, agricultural yields on these lands have increased eight percent. The costs to state and local agencies of operating the system are approximately $850,000 per year, while estimated benefits exceed $30 million per year—a hugely successful project (Parker et al. 1996). Because of state budget constraints, urban water agencies are now exploring the possibility of funding additional stations on their own.

Background

CIMIS is a network of over 100 automated and computerized weather stations in key agricultural and urban locations around the state. Weather information is collected at each of the stations and sent electronically to a central computer in Sacramento. The data are then converted into a "reference evapotranspiration" number or "ETo," which is an estimate of evapotranspiration demands for irrigated grass. These reference values of ETo can then be used to determine actual evapotranspiration numbers for different crops in different locations.

The DWR's stated objective in operating the CIMIS network is to collect and disseminate high-quality, accurate, and reliable irrigation management data to the public. To meet this objective, DWR has worked to standardize the system: all weather stations in the CIMIS network are virtually identical, with similar equipment and sensors. All stations have their equipment and sensors mounted on a mast on a tripod base. The sensors include:

- Pyranometer, to measure solar radiation
- Soil temperature sensor
- Air temperature sensor
- Humidity sensor
- Anemometer, to measure wind speed
- Wind vane, to record wind direction
- Precipitation gauge

Each station also has a small datalogger (a small microprocessor) connected to the electronic sensors. The datalogger takes readings once every minute and records the information. Each hour, the minute-by-minute data are averaged to produce an hourly value or summed to produce an hourly total, and the data stored in memory. After 24 hours, the data are used to calculate daily averages and totals, maximum and minimum values, and relative humidities (*http://wwwdla.water.ca.gov/cimis/cimis/hq/stninfo.htm*).

Once every evening or early morning the main CIMIS computer automatically downloads data from each station datalogger using telephone lines and modems. The CIMIS computer then calculates reference evapotranspiration (ETo), and the quality of the data is checked. The stations themselves are checked for accuracy on a regular basis, and sensors are replaced when necessary. All DWR-maintained stations are calibrated for accuracy by DWR yearly. Stations' sensors are compared against a set of standardized sensors used only for calibrations.

Each CIMIS station costs about $5,000 to set up. These costs are typically split by the DWR and local agencies. Operation of the CIMIS program costs approximately $850,000 annually, with the program funded by state and local agencies. Operations costs include station and land maintenance costs. CIMIS is used by a wide variety of individuals, farms, irrigation districts, property managers, homeowners, corporations, and urban water managers (see Table 16-1). Many water districts acquire CIMIS data and then distribute it to their growers as a water-management service.

How CIMIS Works

Good irrigation management is required if agricultural crops and turf are to use water efficiently. Irrigation management programs include determining irrigation dates and times and how much water should be applied to meet basic water needs. This process is referred to as irrigation scheduling. CIMIS assists in this process by providing information for basic water balance budgeting.

Table 16-1
A Partial List of CIMIS Users

- Growers
- Landscape managers
- Golf courses
- Parks
- Cemeteries
- Schools
- Housing complexes
- Irrigation designers
- Public agencies
- Water districts
- Municipalities
- Private weather services
- Public weather databases
- University researchers
- Cooperative extension researchers
- Insurance analysts
- Fire departments
- Irrigation manufacturers
- Weather equipment manufacturers
- Media

The water budget method is an accounting procedure used to track soil water content, water lost to evaporation and transpiration, and water entering through precipitation. For irrigation scheduling, soil water content is balanced. Outflows include the amount of water lost as crop evapotranspiration (ETc). Water inflows include the water that enters the soil reservoir as rain or irrigation. By keeping records of these flows, it is possible to know how much water is in the soil reservoir at any time.

The initial water balance can be determined by direct field observation. Evaporation and transpiration reduce soil moisture until additional moisture is required. At that point irrigation water should be applied in quantities equal to the accumulated losses since the last irrigation. If full recharge is not desired or possible, new balances can be determined from the net irrigation amount or by field observations. This method only works well where contributions to soil moisture are well understood and quantified.

A major goal in good irrigation management is to minimize water stress that reduces yields, by maintaining the soil water content above a certain level. Decisions about soil water content are made by the irrigation manager and depend on cultural practices, experience, labor and water availability, and other considerations.

The water budget method of irrigation scheduling can be used to determine when irrigation should occur and how much water is needed to replenish soils. It does not by itself determine how much water should be applied or how long the irrigation system should be operated to apply that water. Determining the amount of water to apply depends on the efficiency of the irrigation system as well as climate conditions and plant requirements. Water that runs off the field, evaporates directly without contributing to crop production, or percolates below the root zone due to nonuniformity of application does not contribute to the soil reservoir (see *http://wwwdpla2.water.ca.gov/cgi-bin/cimis/cimis/hq/main.pl*).

For example, if the required water for a given day is three inches, and 30 percent of the water applied runs off the field, evaporates unproductively, or percolates below the root zone, the irrigation efficiency is 70 percent, and the required applied water is calculated as follows:

3 inches / 0.70 = 4.3 inches

Therefore, the grower should apply water to a depth of approximately 4.3 inches to replenish the soils. Determining the efficiency of an irrigation system requires a system evaluation, and efficiencies vary substantially depending on design, maintenance, and management (see *Converting to Efficient Drip Irrigation*, Chapter 15, for a discussion of irrigation efficiency).

Crop Coefficients

Crop water use can be calculated with reference evapotranspiration (ETo) from CIMIS and specific crop coefficients (Kc), as ETc = ETo x Kc. These ETc estimates can be used to determine day-to-day soil water depletions and thus can be used to schedule irrigation. Crop coefficients (Kc) are used with ETo to estimate specific crop evapotranspiration rates. The crop coefficient is a dimensionless number (usually between 0.1 and 1.2) that is multiplied by the ETo value to arrive at a crop ET (ETc) estimate. The resulting ETc is used to help schedule when irrigation should occur and how much water should be applied. An example calculation follows:

If ETo = 0.25 inches/day (for July)
and Kc = 0.55 (for an orange tree in July)
then ETc = ETo x Kc
= 0.25 inches/day x 0.55
= 0.14 inches/day

Crop coefficients vary by crop, stage of crop growth, and cultural practices. For example, coefficients for annual crops (row crops) vary widely throughout the season, with a low coefficient in the early stages of growth and a high coefficient when the crop is at full cover and the soil is completely shaded. Orchards with cover crops between tree rows will have larger coefficients than orchards without cover crops. Citrus trees have smaller coefficients than peach trees at full cover.

CIMIS has developed crop coefficients to use with CIMIS ETo (with grass as the reference crop), but some studies now suggest that these general crop coefficients may overestimate actual water needs, leading to more water being applied than necessary. In a three-year study done at the Cachuma Resources Conservation District looking at the value of locally developed crop coefficients, it was determined that CIMIS coefficients could be reduced substantially without affecting crop yields or quality. If this proves to be the case in other places with other crops, substantial water savings could result from modifying the CIMIS coefficients (CIMIS/CATI 1997).

Who Uses CIMIS?

CIMIS is used in the agricultural sector on crops that use large amounts of water, such as cotton, and on high-valued crops, such as tree, vine, and vegetable crops. Table 16-2 shows estimated crop acreage covered by CIMIS. About 35 percent of this area is used to grow rice, cotton, alfalfa, and irrigated pasture, while nearly 60 percent of total California farmland is devoted to these crops. More than 60 percent of the area under CIMIS is in tree, vine, and vegetable crops (Parker et al. 1996), while these crops comprise less than 40 percent of California's total agricultural area (Gleick et al. 1995).

CIMIS surveys suggest that growers using high-cost water, growers of high-valued crops, and growers using water-efficient irrigation systems are more likely to use CIMIS resources than other users. For example, 64 percent of CIMIS users in a 1996 survey used sprinkler or a combination furrow/sprinkler system, while over 22 percent used drip irrigation. Statewide, less than 13 percent of irrigated area is under drip (U.S. Census 1994).

Table 16-2

California Crop Acreage Under CIMIS

Crop	Acres
Alfalfa	18,660
Almonds	53,430
Apples	1,462
Apricots	161
Artichokes	5,000
Avocados	2,004
Barley	0
Beans	1,343
Broccoli	402
Carrots	27,060
Cauliflower	1,024
Celery	487
Cherries	528
Citrus	13,180
Corn	1,908
Cotton	109,200
Garlic	237
Grapes	15,100
Kiwis	112
Lettuce	3,700
Melons	268
Nectarines	1,532
Nursery	870
Olives	902
Onions	75
Peaches	2,317
Pears	1,528
Pecans	41
Peppers	178
Pistachios	28,100
Plums	1,718
Prunes	1,722
Rice	700
Small grains	3,600
Sorghum grain	0
Squash	177
Strawberries	0
Sugar beets	1,630
Tomatoes, market	500
Tomatoes, processing	9,788
Walnuts	43,710
Wheat	8,198
Total	**362,552**

Some farmers who furrow-irrigate relatively low-value crops with inexpensive water also use CIMIS information. Large farms are disproportionately likely to use CIMIS. Among urban users, large institutional users such as golf courses, parks, and cemeteries with sophisticated irrigation systems are more likely to take full advantage of CIMIS information, though homeowners are increasingly being taught how to get and use the data for their own gardens and landscapes. In the Coachella Valley, around 80 golf courses make up a billion-dollar industry, and smart irrigation systems at these courses are often integrated with CIMIS (Parker et al. 1996; Harbison 1998).

CIMIS agricultural users are also more likely to pay higher water costs than the average grower. The 1996 survey shows that the average CIMIS grower paid $110.65 per acre-foot of water—far more than the average California farmer did. This suggests that as agricultural water costs increase, farmers pay more attention to both efficient irrigation technology and ways of reducing water use through information systems such as CIMIS.

Many water districts use CIMIS information and disseminate that information to their customers. Table 16-3 shows estimates of water savings from five major water districts that use CIMIS to control their customers' water use.

CIMIS is used by a far wider cross-section of people than was anticipated. Various public agencies, electronic networks, and water researchers receive and use the climatic infor-

Table 16-3

Water District Savings from CIMIS Applications

Water District	Percent Decreases in Water Use Since Adopting CIMIS
Alameda County	10
Contra Costa	20 to 28
Riverside County	10
El Dorado	10
Marin Municipal	16

Source: Parker, et al. 1996

mation provided by CIMIS. The Weather Network in Chico, a private weather service, gets ET data from CIMIS and includes those data in their forecasts. According to Parker et al. (1996), the California Department of Transportation (CalTrans), the California Environmental Protection Agency (Cal EPA), the cities of Fremont and Santa Barbara, Evergreen Community College, and the San Diego Air Resources Board are all CIMIS users.

Other CIMIS users include newspapers, turf managers, urban landscapers, and some consultants offering non-agricultural services. Approximately 20 newspapers and radio stations receive, publish, or broadcast CIMIS evapotranspiration data. Many of the newspapers and water districts supplying CIMIS information to their service areas began to do so during the 1987–1992 drought, further supporting the argument that as water becomes more scarce, expensive, and limited by service constraints, users find ways of conserving water.

Evaluation of Success

Reductions in Water Use

In a survey of some CIMIS users, the average reduction in applied water use by growers was 13 percent; for other water users, the reductions were even higher—approximately 20 percent (Parker et al. 1996). Applying those results to CIMIS users statewide, Parker et al. (1996) estimated that applied water reductions most likely exceed 100,000 acre-feet annually just in agriculture, even though CIMIS is used on only three percent of California agricultural acreage.

Additional reductions are achieved by the small number of landscape managers using CIMIS. For example, CalTrans, which irrigates 300 acres of ornamental plants in the Fresno area, reported a 20 to 40 percent decrease in applied water use after using CIMIS data to schedule irrigation. Several golf course and municipal park managers reported applied water reductions of 10 to 25 percent. A landscaper, who pays $566 per acre-foot for water, was able to decrease applied water use by 60 percent using CIMIS.

In 1990, the Escondido Union School District began a program to reduce outdoor irrigation water use on district school grounds. Local irrigation experts were consulted prior to performing an evaluation of overall irrigation needs at local schools. Irrigation systems were retrofitted, and CIMIS data were provided and used to schedule the timing of waterings. In this single school district, an average of 32 million gallons of water has been saved annually, a savings of $40,000 per year (State of California 1996). The East Bay Municipal Utility District recently applied CIMIS-related data to two high schools in their service area and decreased their landscape irrigation water use by 44 percent (Diemer 1998).

Increases in Yield

The most dramatic benefits from using CIMIS information have turned out to be increases in crop yields, rather than direct reductions in water use, for both field and permanent crops. The 1996 survey determined that average annual yield increases of eight percent were achieved, while some individual growers of row crops reported significantly higher increases. Growers have suggested that yield effects are as important to them as direct reductions in water use, though for urban landscape managers, applied water reductions remain the primary objective. Agricultural yield increases contribute substantially to overall improvements in agricultural water productivity when measured on a standard scale of acre-feet/ton of crop or acre-feet/dollar of grower revenue.

A separate survey of the National Agri-Marketing Association at UC Davis found that 23 percent of growers using CIMIS saw increased crop yields, and 28 percent saw improved crop quality. This survey found that pistachio, walnut, and almond yields increased about 20 percent (UC Davis 1993).

Row crop yields increased by between 5 and 40 percent for CIMIS users surveyed in 1996. Tree crop yields increased due to a decrease in pest damage (see below). Tomato growers in the San Joaquin Delta area reported yield increases of up to 50 percent, from 17 to 18 tons per acre to 25 to 28 tons per acre. Some cotton growers have reported 20 to 50 percent increases in yields (Parker et al. 1996). More accurate scheduling of cotton irrigation increased returns to farmers by $60 to $175 an acre (State of California 1995). Together, benefits from water savings and yield increases from application of CIMIS were estimated to average $279 per acre.

Pest Management and Other Benefits

Large numbers of pest control advisors use the system to help schedule pesticide applications (reducing pesticide use when rain is imminent), or to more precisely determine pesticide quantities to use based on crop conditions. In San Joaquin County, the University Cooperative Extension Advisor uses CIMIS for modeling pest control. CIMIS has been used to manage irrigation in vineyards in a way that helps control pests. These benefits in turn have led to reductions by some grape growers in the use of pesticides (Daane et al. 1995). A landscaping consultant who uses CIMIS for pest management reported a 50 percent decrease in pesticide use despite a 40 percent *increase* in client base.

Irvine Ranch Water District used CIMIS information to set block price rates (see *Promoting Conservation with Irvine Ranch Water District's Ascending Block Rate Structure,* Chapter 2). The District estimates annual savings of 1,500 acre-feet of water, with a value of nearly $240,000 (Parker et al. 1996).

Conclusions/Lessons Learned

Overall, CIMIS is used on an estimated 400,000 acres of farmland, turf, golf courses, and urban landscaping. The benefits of CIMIS, statewide, could be as high as $65 million per year, from applied water reductions and increased yields, with additional savings from application of CIMIS in golf courses, parks, and other urban landscaping. Reductions in applied water use statewide resulting from the information provided by this system are estimated to exceed 100,000 acre-feet annually. The authors of the 1996 survey (Parker et al. 1996) who produced these estimates say the high range of economic savings may be an overestimate, but they also note that many additional real benefits of CIMIS have been observed but cannot be accurately quantified. These additional benefits were excluded from their quantitative assessment and include decreased pest control, fire and air quality benefits, and improved crop quality. Pest control advisors working on integrated pest management programs noted a reduced need for pesticide use (in pounds per acre), fewer applications, which improves worker safety, higher quality crops, and a reduced risk of crop damage. All of these have real, but unquantified, economic benefits.

The CIMIS program shows the value of accurate and timely information in improving the efficiency of irrigation systems. CIMIS is still limited in scope; many additional stations are needed to make the program effective statewide. As better moisture monitoring develops, and as more growers better track soil moisture and crop water needs, significant cost-effective reductions in both applied and net water use will continue to result. The outcomes of the CIMIS program also show that "*Low water prices are the biggest disincentive to [the] use of CIMIS or other water efficient technologies*" (italics in original) (Parker et al. 1996). This suggests that accurate pricing of water will increase the demand for accurate information about water needs and information on how and when to apply that water. CIMIS can be a valuable tool to meet these goals.

References

CIMIS/CATI. 1997. "Update" Newsletter, Fall Issue, Publication #971001. See *http://www.cati.csufresno.edu/cati/upda/97/fall/grower_open.html.*

Daane, K.M., L.E. Williams, G.Y. Yokota, and S.A. Steffan. 1995. "Leafhopper prefers vines with greater amounts of irrigation." *California Agriculture* Vol. 49, No. 3, pp. 28-32 (May/June).

Gleick, P., P. Loh, S. Gomez, and J. Morrison. 1995. *California Water 2020: A Sustainable Vision*. Pacific Institute Report. Pacific Institute for Studies in Development, Environment, and Security. Oakland, CA.

Harbison, D. 1998. Coachella Valley Water District. Coachella, CA. Personal communications.

Parker, D., D. Zilberman, D. Cohen, and D. Osgood. 1996. "The economic costs and benefits associated with the California Irrigation Management Information System (CIMIS): Final report." Department of Agricultural and Resource Economics, University of California. Berkeley, CA.

State of California. 1995. *CIMIS: Agricultural Resource Book*. The Resources Agency, Sacramento, CA. September.

State of California. 1996. "CIMIS: Urban Resource Book." The Resources Agency, Sacramento, CA. January.

University of California, Davis. 1993. "Report from the Davis Chapter of the National Agri-Marketing Association on CIMIS Applications." University of California. Davis, CA.

Chapter 17

Improving Water Quality Through Reducing the Use of Herbicides on Rice: An Effective Collaboration Between Growers and Public Agencies

Peter H. Gleick

Introduction

California farmers grow a wide variety of crops on a wide variety of soils. For several decades, large areas of land have been devoted to the production of rice, particularly north of the Sacramento–San Joaquin Delta where conditions are especially favorable. Between 1979 and 1997, an average of 445,000 acres of land have produced an average of 1.5 million tons of rice per year. One quarter of all U.S. rice is grown in California (CRIA 1998).

Herbicides are routinely applied to rice to eliminate weeds and increase yields. In the early 1980s, however, it became apparent that large quantities of rice herbicides were entering rivers and streams, causing fish kills and adversely affecting drinking water quality in downstream communities, including the state capital, Sacramento. Public concern over these problems led to the creation of a joint government–industry group that worked to lessen these impacts without harming rice growers. This working group effectively reduced herbicide concentrations in public waterways through a combination of regulatory actions, innovations in farming techniques, and education of growers. For more than a decade, the concentrations of rice pesticides in water have been below legal limits, despite the regular tightening of those limits.

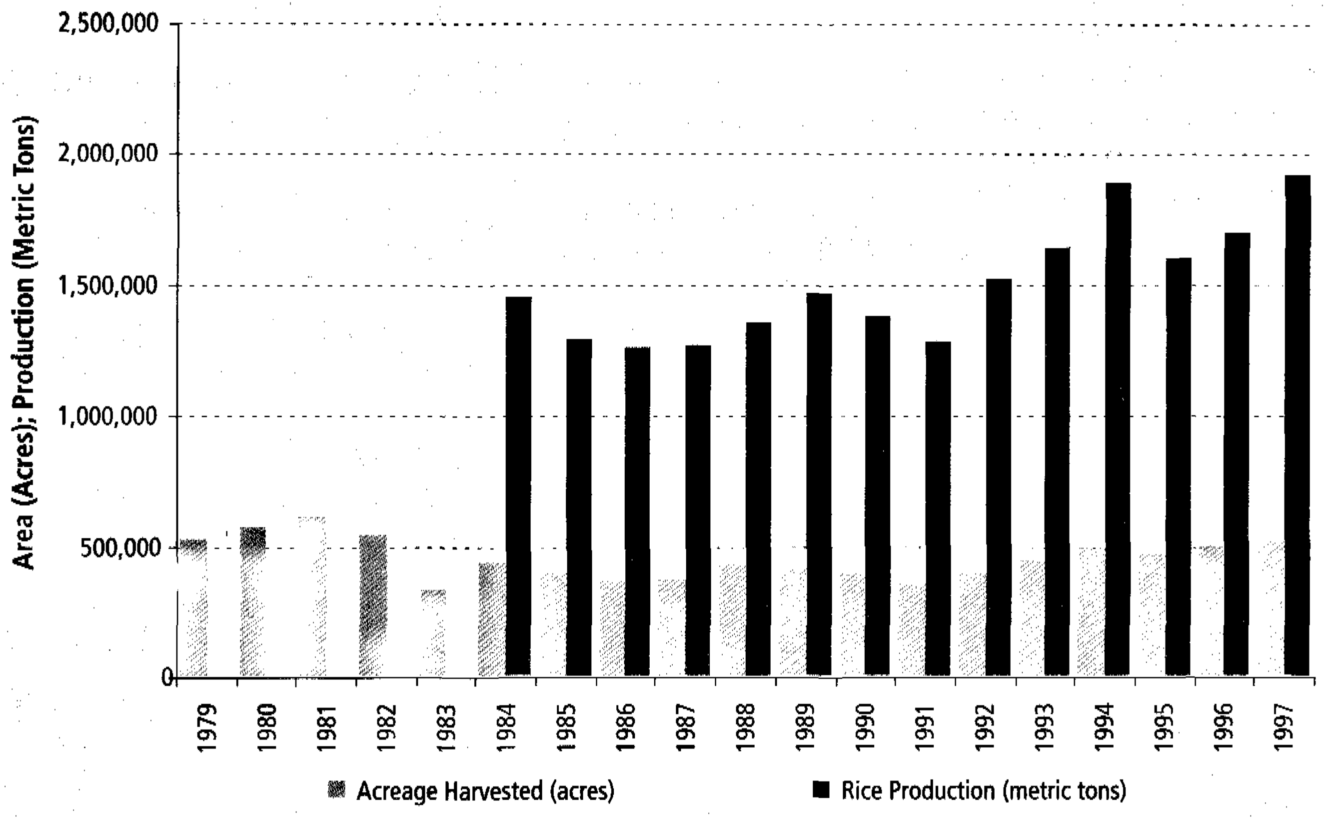
Background

California grows substantial quantities of rice. Figure 17-1 shows the area of California planted in rice, and the amount of rice produced between 1979 and 1997. In order to control aquatic weeds, rice growers use a variety of chemical and non-chemical approaches. Two herbicides that have been applied to control watergrasses include thiobencarb (commonly known as Bolero) and molinate (commonly known as Ordram). Between 1977 and 1982, the use of molinate and thiobencarb more than tripled. These herbicides were generally applied to flooded fields and then discharged to agricultural drains, eventually reaching the Sacramento River and the San Francisco Bay–Delta.

Photo courtesy of California Rice Industry Association

Beginning in spring 1980 and continuing for three years, significant fish kills from pesticide-contaminated drain waters were reported. Carp, catfish, black bass, and crappie were all affected, and investigations by the California Department of Fish and Game concluded that Ordram was responsible (SWRCB 1990). By 1982, these chemicals were also found to be responsible for a deterioration of drinking water quality in the city of Sacramento (Hill et al. 1996).

Figure 17-1
Rice Area and Production



Source: California Rice Industry Association 1998

Addressing these problems required cooperative actions on the parts of farmers, the rice industry, agricultural extension services, and government agencies. Before any action could be taken, information on safe concentrations of chemicals needed to be developed, water-quality goals and standards needed to be set, and management practices developed that could reduce the environmental impact of rice pesticides while maintaining productivity. Because of the complex, multi-party interests, the Rice Pesticide Working Group (RPW) was created, with representatives of all of the affected interests (see sidebar).

The RPW had many objectives:

- Identify the concentrations of pesticides that affect human health and aquatic life;
- Suggest quantitative targets for pesticide contamination levels;
- Develop water-quality goals for public waterways;
- Identify best management practices that could achieve these goals while maintaining productivity;
- Phase in these practices to allow rice producers to adjust over time;
- Create programs for education and cost-sharing to reduce the costs of implementation; and
- Monitor pesticides in public waterways.

Water-quality criteria were formulated by the U.S. Environmental Protection Agency (EPA), the California State Water Resources Control Board (SWRCB), and the Central Valley Regional Water Quality Control Board (RWQCB), with numerical guidelines in the form of Maximum Contaminant Levels (MCLs) developed by the

Rice Pesticide Workgroup (RPW)

- Central Valley Regional Water Quality Control Board
- California Department of Food and Agriculture
- California Department of Fish and Game
- California Department of Health Services
- County Agricultural Commissioners
- University of California Cooperative Extension Service
- City of Sacramento
- Rice Research Board
- Rice producers

Table 17-1

Performance Goals Set for Rice Herbicides Maximum Contaminant Levels (MCLs) for the Sacramento River

Molinate ("Ordram")	90 mg/L (90 ppb) (1983)
Molinate	20 mg/L (20 ppb) (1984–1991)
Molinate	10 mg/L (10 ppb) (1992–present)
Thiobencarb ("Bolero")	70 mg/L (70 ppb)
Thiobencarb (standard for drinking water)	1 mg/L (1ppb)

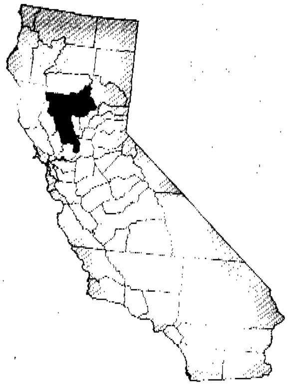
Source: RWQCB 1992; Hill et al. 1996

California Departments of Health Services (DHS) and Fish and Game (DFG).

The RWQCB has responsibility for protecting water quality in the rice-growing regions, including primary water-quality criteria developed to protect human health and secondary standards for taste, appearance, and odor. The EPA and DHS are responsible for setting drinking water standards. The DFG is responsible for protecting fish and wildlife resources. Local agricultural commissioners are responsible for regulating pesticide use, insuring that farmers comply with holding periods, and administering fines. The California Department of Food and Agriculture conducts water-quality monitoring of waterways. The University of California provides research on holding techniques, education and research on rice irrigation methods, and information on project performance.

In 1983, DHS and DFG set permissible daily intake concentrations at 1/100th of the "no observable effect level" determined by laboratory studies in rats and dogs. In 1990, the RWQCB amended the Sacramento Basin Water Quality Control Plan to conditionally prohibit the discharge of five rice pesticides and herbicides unless approved management practices were used.

These guidelines and rulings served as "performance goals" for the rice industry. If concentrations of these chemicals exceeded the goals, regulatory actions could be imposed, including withdrawal of permission to use molinate and thiobencarb on rice. The performance goals were phased in to permit time for growers to adapt to the new requirements. This regulatory "stick" offered a strong incentive for the rice industry to participate and to take action. Table 17-1 shows the MCLs developed by the state.



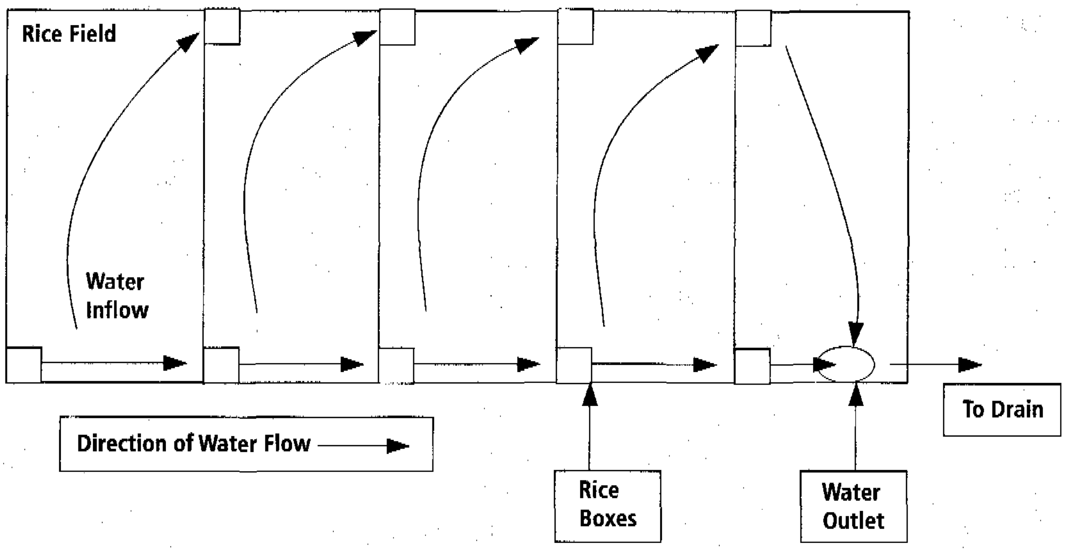
The Project: Implementing the Agreements

Traditional water management on rice farms involves flooding rice fields continuously for the period between sowing and harvesting—about 120 days. Water moves through different fields controlled by irrigation boxes between low levees (see Figure 17-2), and downstream water supplies become polluted over time as pesticides and other agricultural chemicals enter the water. The consequences of such pollution include fish kills, reductions in populations of invertebrates, and contamination of drinking water supplies (Cornacchia et al. 1984).

Conventional systems are also known as flow-through systems, because water enters a field from a topmost basin and flows by gravity through adjustable rice boxes or wooden weirs to the lower basin. Water then spills from the last weir into a drain or waterway. Precise water management in such fields can be difficult, since water can only be introduced at the top of the field and then moved through all the basins. To drain a field in the middle requires draining all the fields below it, which can be difficult and time-consuming (Hill et al. 1991).

The water needs of each field vary depend-

Figure 17-2
Conventional Rice Water-Management System—Continuous Flow



ing on soil characteristics, climatic factors, and the stage of plant growth. In the past, to avoid underwatering plants at the top of a field, excess water was often applied, which ponded up in lower parts of a field, making it necessary to spill water. This made it very difficult to use conventional systems to hold water on the fields for any long period of time and led to overapplication of water. Analysts at the Cooperative Extension, University of California (UCCE), and the Soil Conservation Service (now the Natural Resources Conservation Service) (NRCS), have estimated that 20 percent or more of the water used for irrigating rice in conventional systems is spilled.

Both of the major rice herbicides degrade over time, suggesting that if farmers hold herbicide-contaminated water on the farm for an adequate period, concentrations entering the ecosystem and water-supply system can be reduced. Accordingly, the Rice Pesticide Workgroup established "holding periods" to permit the herbicides to degrade and dissipate. Holding periods were defined as the period of time water had to be kept on a field after herbicide application. The half-life of molinate—the period over which the concentration in water decreases by 50 percent—was estimated to be two to five days. The half-life of thiobencarb is six to ten days (Hill et al. 1996).

In order to meet the official water-quality goals, the four-day holding period recommended by the manufacturer for molinate was doubled in 1984. It was gradually increased to 12 days in 1987, 24 days in 1991, and 28 days in 1992, giving farmers time to develop new methods and techniques for water management. Thiobencarb control was more difficult because of its longer persistence in water and soil. Holding periods were also set for this chemical, and overall sales were limited to the amount of herbicide required for 100,000 acres, or about a quarter of total California rice acreage.

Technical Innovations

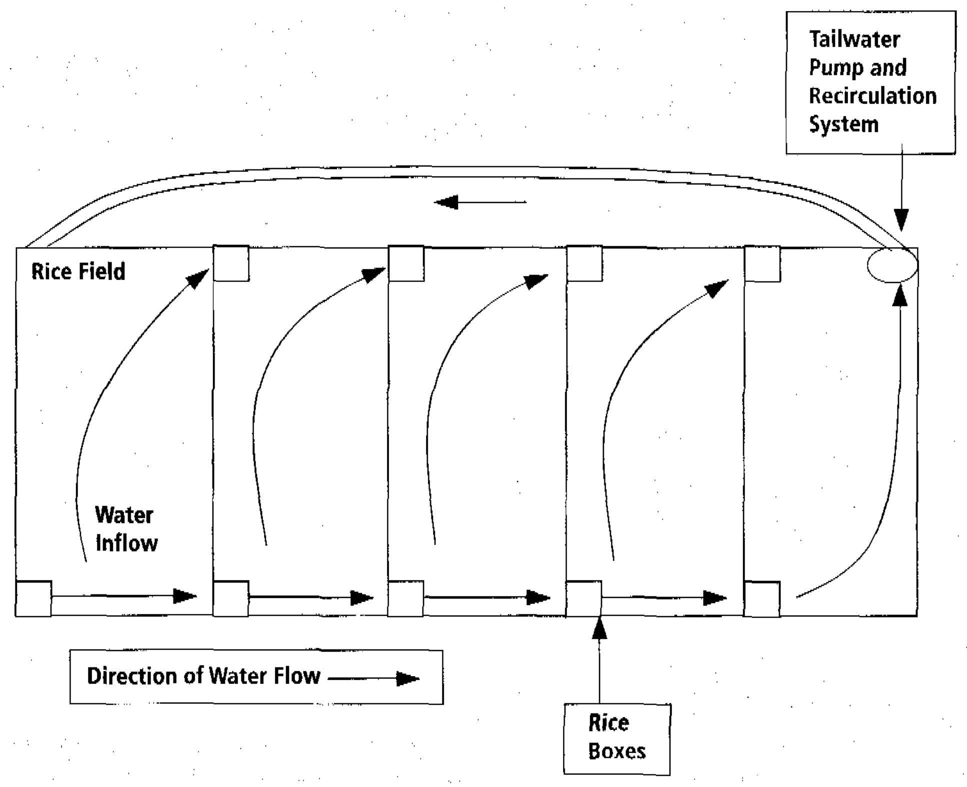
Growers initially met the holding periods by simply blocking outlets, risking deep water and problems with the establishment of rice in lower basins, where water tended to pond. Eventually, however, some growers, water districts, and university extension experts began to experiment with more flexible and appropriate systems.

Over the past decade, various methods have been developed to help growers recirculate water or recapture contaminated tailwater. In 1991, the UCCE and the NRCS initiated a five-year project to demonstrate and evaluate several feasible, alternative water-management systems that would provide greater control of water depth in rice culture and reduce pesticide loads in downstream waters. Two particular systems were studied: a tailwater recirculation system that returned water collected at the lowest point in the field to upper portions of the field; and a static system where inlet pipes independently serviced each rice basin from a main ditch or source (Hill et al. 1994).

Tailwater recirculation systems were initially developed to reduce applied water demand. When holding periods were introduced to address pesticide contamination problems, growers began evaluating recirculation systems as an option for meeting the new regulations. Tailwater recirculation systems consist of a lowlift pump that gathers water from the bottom of a field and returns it to the top (see Figure 17-3). Water then flows by gravity back down the field. These systems are relatively easy to install, reduce the amount of water required to grow rice, and permit considerable flexibility in where and how much water can be delivered to different parts of a field. Their initial capital costs are larger than simple conventional systems and more management attention is required, but they have proven to be effective at holding water on rice fields to

Figure 17-3

Alternative Rice Water-Management—Recirculating Tailwater Recovery System



reduce pesticide concentrations. Some farmers share systems with neighbors and some irrigation districts maintain district-wide recirculation systems.

Optimal performance from recirculation systems is achieved on fields that have been laser-leveled, where the depth of water on each field is carefully managed. (By 1997, the vast majority of rice fields in California had been laser-leveled.) Total costs of these systems depend on the size of the farm, the pumping costs, and the layout of the fields, which affects pipeline or ditch length. Observed costs have been as low as $20 per acre and as high as $150 per acre (Hill et al. 1991).

An alternative tailwater recapture system, with lower costs, is a gravity system that diverts tailwater from one field to the next, keeping drain water and pesticides from public waterways. This kind of system works best on farms with multiple, adjacent fields or where cooperating growers can link irrigation systems. Costs are relatively low because of limited pumping requirements.

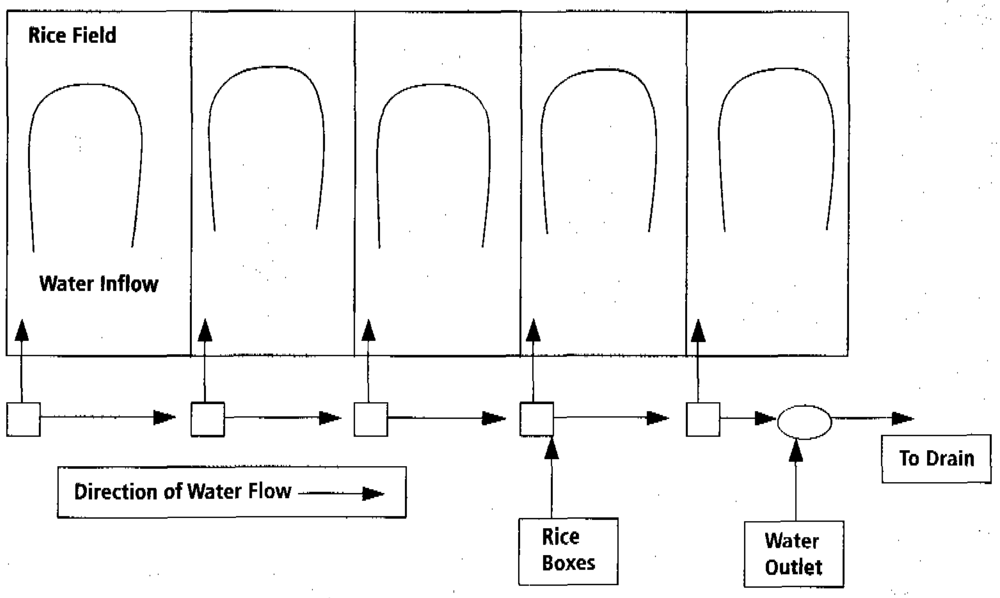
Static water irrigation systems independently control water flows into rice fields and limit them to quantities needed for evapotranspiration and percolation. No tailwater pumps are used (see Figure 17-4). In static systems, a supply ditch runs along a field, serving each basin with an independent piping system that allows water to flow when needed. Basins can thus be flooded quickly. To drain the field at harvest, farmers send the water back out the supply ditch. This system has multiple inlets, permitting rapid flooding and more precise control in individual basins. Management flexibility in individual basins is high because water levels can be changed rapidly and independently of other basins. There is some evidence that herbicide efficiency may be improved because water flow rates are reduced.

Costs are lower than those for recirculating systems because there are no pumping costs, though the fields need to be leveled to zero grade. Most of the costs are associated with construction of the supply and drainage ditches, piping, and inlet systems for each basin. Various other configurations are possible (see Hill et al. 1991), but the systems described above comprise the majority of water-management systems now in place in California.

The cost of installing new water systems to permit growers to meet the holding period

Figure 17-4

Alternative Rice Water-Management System: Static Water Irrigation System

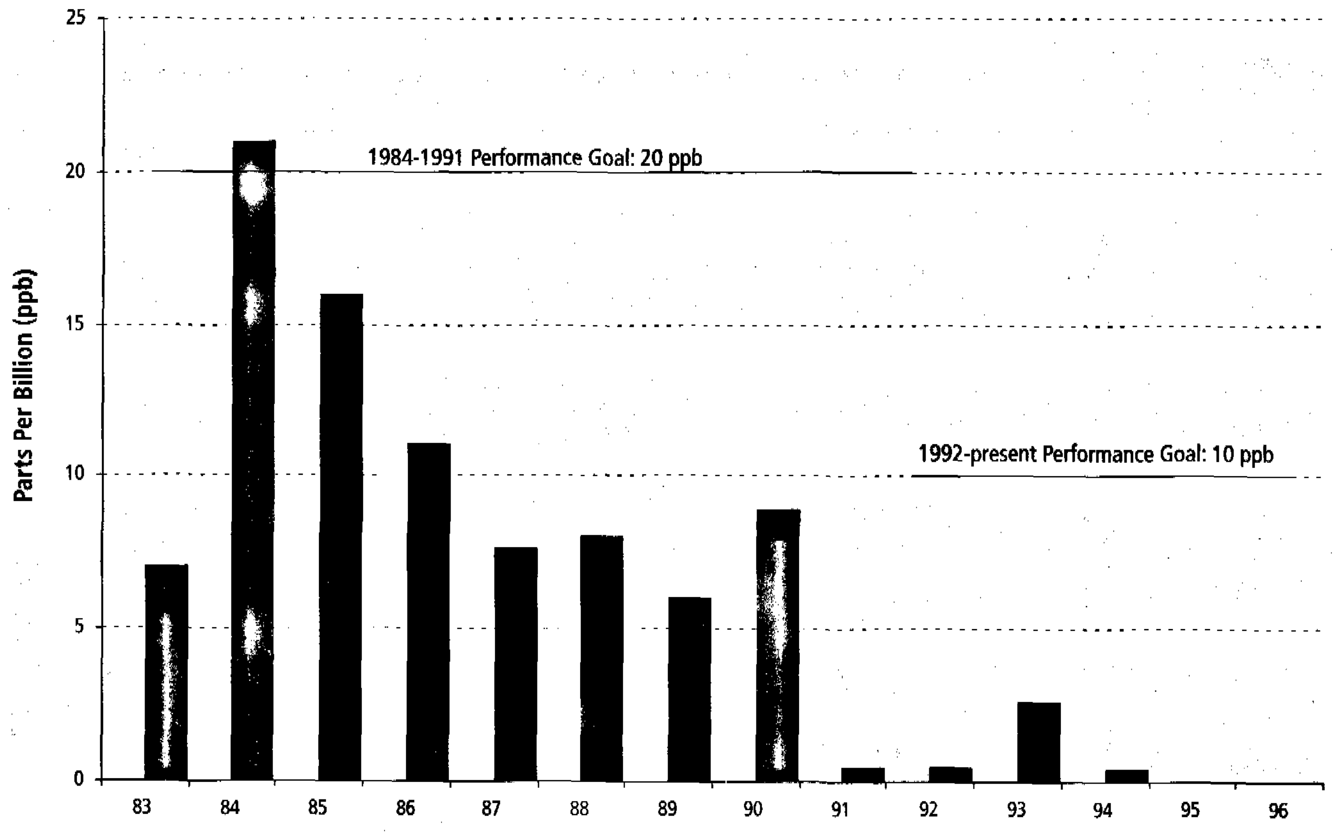


requirements is not large, and some financial support has been available. Partial funding for growers has been made available by the USDA Farm Service Agency's Agricultural Conservation Practices program, an energy savings program from the Pacific Gas and Electric Company (PG&E), and from a joint program with the Zeneca Corporation and the California Rice Industry Association. Growers in all rice-producing counties in California could apply for grants to cover up to 15 percent of their total costs up to a maximum of $1,800, with funding from Zeneca, the manufacturer of Ordram, and the cooperation of the California Rice Industry Association. While Zeneca has an interest in maintaining sales of its product, water-recycling systems are required to meet standards set by the NRCS of the USDA. Over $600,000 in assistance for closed systems has been provided through collaboration with these agencies. By 1996, half of all rice-producing areas were estimated to be in permanent closed systems that permit recirculation and water retention (Hill et al. 1996).

Evaluation of Success

Comprehensive monitoring of pesticides began in the early 1980s in major agricultural drains, the Sacramento River, and the tissues of fish. Prior to 1983, peak concentrations of molinate reached 27 parts per billion (ppb) at the intake for drinking water supply for the city of Sacramento. By 1985, the molinate concentrations had dropped to below the MCL of 20 ppb, and it continued to drop as the holding period requirements were applied to growers and as the periods themselves increased. By 1991, molinate concentrations fell to well under 5 ppb and they were under 1 ppb in 1994, 1995, and 1996 (Gorder et al. 1996). Figure 17-5 shows the concentrations of molinate measured in the Sacramento River from 1983 to

Figure 17-5
Concentrations of Molinate in the Sacramento River



Source: Data from Hill et al. 1996

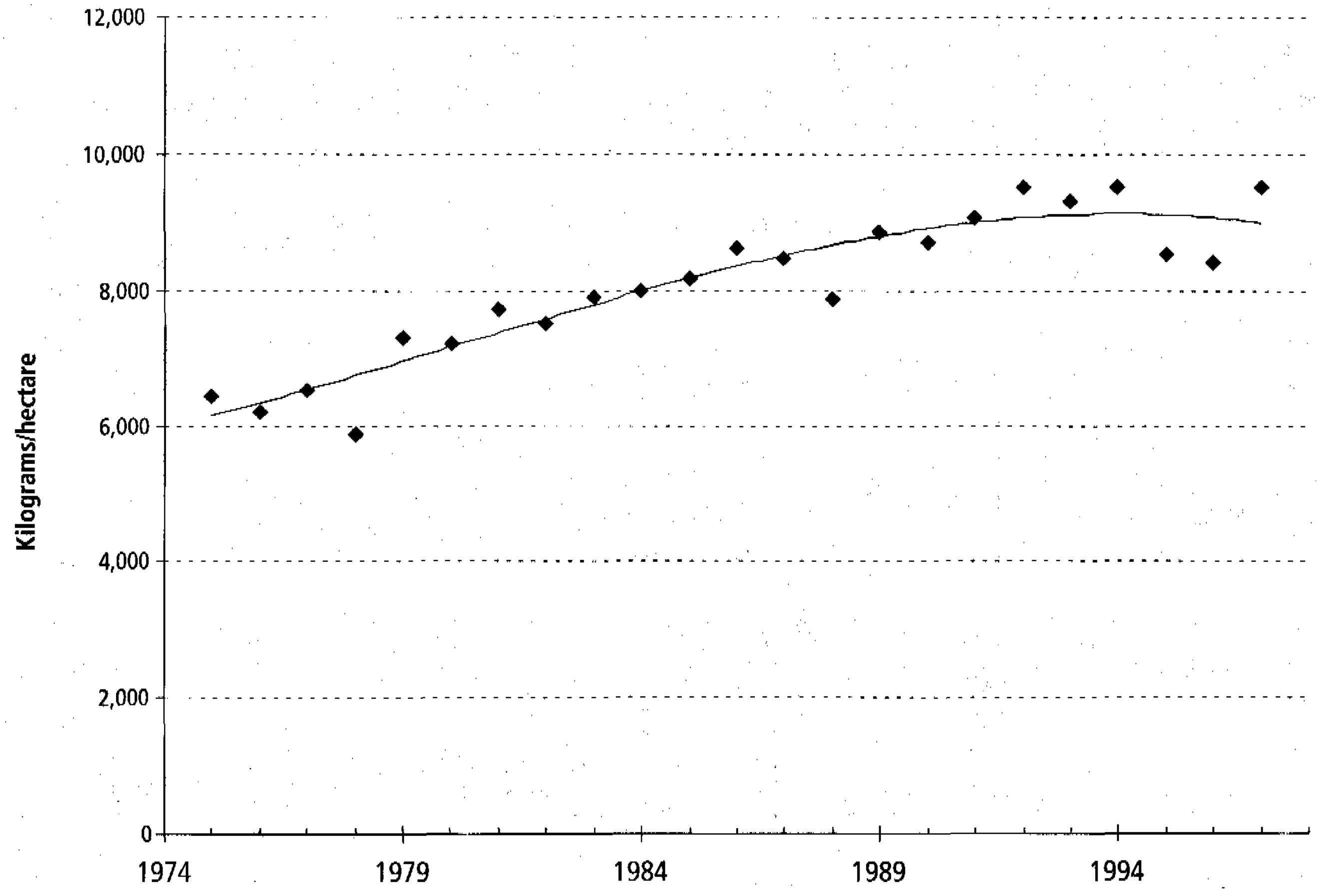
1996 (Roberts 1997).

Total mass of molinate in the Sacramento River was estimated to have dropped from over 18,400 kilograms in 1982 to 84 kilograms in 1995. Thiobencarb concentrations also dropped from over 6 ppb in 1982 to less than 1 ppb in 1991 through 1996. The mass loading of thiobencarb in 1985 was over 2300 kilograms; by 1996 the estimated mass loading approached zero. After implementation of the holding requirements, fish deaths stopped, and no fish kills have been attributed to rice herbicides since 1983 (Gorder et al. 1996; Hill et al. 1996).

During this same period, rice yields have continued to rise in California (see Figure 17-6), exceeding 9,500 kilograms per hectare (8,500 pounds per acre), while water used for rice production has actually decreased. In the Glenn-Colusa Irrigation District region, net water use per acre has decreased from an average of 6.3 acre-feet per acre during the period 1973–1982 to 4.3 acre-feet per acre between 1981 and 1990 (Brandon 1991). Much of this improvement has resulted from laser-leveled fields and recirculating water systems, which allow for more precise and efficient water management, and from improved rice varieties that need less water.

In a detailed survey of rice growers conducted in the mid-1990s, growers with the majority of their lands in alternative systems had the highest level of satisfaction with their water management. Midway through the demonstration, a survey showed that 20 percent of rice growers had already converted their entire rice

Figure 17-6
California Rice Yields



Source: CRIA 1998

area to the new systems, while more than half of the growers using conventional systems were unhappy and looking for better alternatives (Hill et al. 1994).

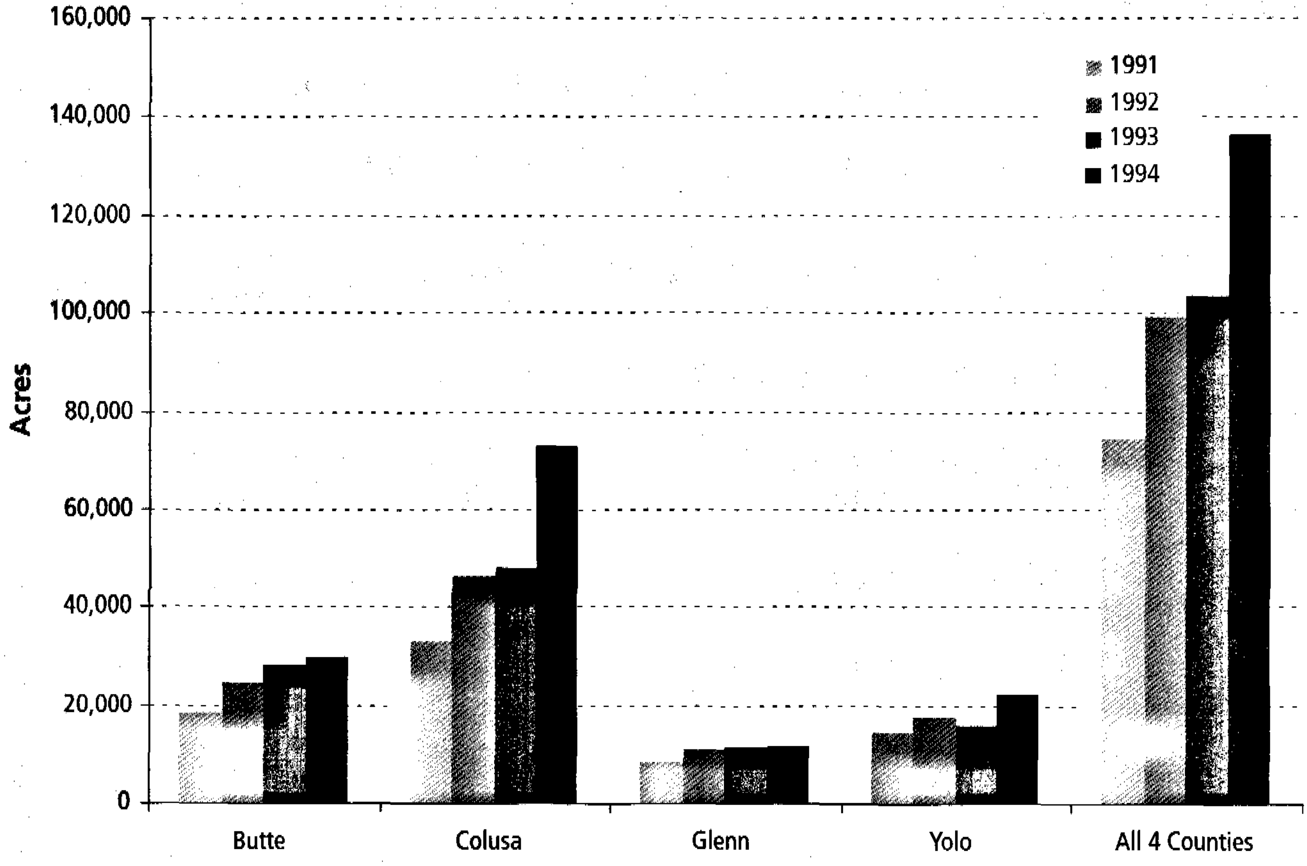
Furthermore, the majority of growers using alternative systems reported having no problems meeting the mandated water-holding requirements for pesticides or anticipated having to change their system as future, stricter performance goals became effective. Growers still using conventional systems, however, expressed the greatest dissatisfaction, and more than 40 percent anticipated having to change their current practices to meet water-quality standards (Hill et al. 1994).

An additional benefit of the alternative systems was a reduction in the amount of water applied to grow rice. Conventional water-management systems are likely to lose 20 percent of applied water to spillage (Hill et al. 1991), while the recirculation systems maintain rice yields while requiring less water. Interestingly, the 1994 survey conducted by the UCCE and the NRCS revealed that the majority of growers using alternative water systems preferred a water-pricing policy based on actual water used (dollars per acre-foot), rather than a flat-rate areal pricing policy (dollars per acre). This shows the ability of proper pricing signals to change agricultural water-management practices and encourage improvements in water-use efficiency.

Farmers from the west side of the Sacramento Valley initially opposed the holding require-

Figure 17-7

Rice Acreage In Closed Water Systems



Source: Data from Roberts 1997

ments because they thought they couldn't hold water on fields without harming rice production. Most west-side farmers are now using these new irrigation approaches successfully (Williams 1997). Figure 17-7 shows the total area of rice farms in four California counties—Butte, Colusa, Glenn, and Yolo—using closed water systems of some type.

Conclusions/Lessons Learned

In the early 1980s, the use of herbicides on rice fields in Northern California led to fish kills and contamination of downstream water resources, including drinking water for the city of Sacramento. Faced with the possibility of strict regulatory action, including the banning of certain chemicals, the rice industry developed a successful working collaboration with federal and state regulatory agencies and University of California researchers and extension workers to develop ways to reduce problems associated with herbicide use.

This collaboration has successfully addressed the problem, reducing contamination of Northern California streams and rivers and eliminating herbicides from drinking water. Concentrations of the chemicals found in water draining off the farms have decreased, water-quality performance goals have been met, fish kills have ended, and rice production has not suffered.

Several factors led to the success of these efforts. All of the interested parties participated in making decisions and designing programs for growers through the Rice Pesticide Working Group. This forum permitted different interests to be heard and different solutions to be debated. Participants were strongly motivated to reach a solution because the regulatory authority of state and federal agencies could prohibit the use of herbicides growers considered critical to their operations. The ability of growers to implement alternatives and proposed solutions, in turn, depended on valuable information about those alternatives that was made available through the University extension services, and cost-sharing provided by a variety of interested parties. All of these factors contributed to the program's success.

In the opinion of the executive office of the Regional Water Quality Control Board responsible for water quality in rice-growing areas, this effort is

> *". . . one of the most successful water pollution control programs in the United States. It has taken concerted effort by numerous state and local agencies and creative implementation by the rice industry to make this happen" (cited in CH2MHill 1992).*

Contacts

Bob Herkert, California Rice Industry Association
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Steve Scardaci, UC Davis
Jack Williams, UC Davis

References

California Rice Industry Association (CRIA). 1998. "California Rice Statistics and Related National and International Data." Statistical Report, March 27. Sacramento, CA.

CH2MHill. 1992. "Water Use for Rice Farming in California." CH2M Hill, Inc. Prepared for the California Rice Promotion Board. Redding, CA.

Brandon, D.M. 1991. "Rice Water Management." Rice Experiment Station. Biggs, CA.

Cornacchia, J.W., D.B. Cohen, G.W. Bowes, R.J. Schnagl, and B.L. Montoya. 1984. "Rice Herbicides: Molinate and Thiobencarb." Special Project Report 84, California State Water Resources Control Board. Sacramento, CA.

Gorder, N.K., J.M. Lee, and K.L. Newhart. 1996. Data from Department of Pesticide Regulation: Information on Rice Pesticides. California Environmental Protection Agency. Sacramento, CA.

Hill, J.E., S.C. Scardaci, S.R. Roberts, J. Tiedeman, and J.F. Williams. 1991. "Rice irrigation systems for tailwater management." Publication 21490, Department of Agriculture and Natural Resources. University of California. Oakland, CA.

Hill, J.E., S.M. Brouder, S.R. Roberts, J.F. Williams, S.C. Scardaci, and C.M. Wick. 1994. "A survey of water management practices of California rice growers." *Journal of Natural Resources and Life Sciences Education*, Volume 23, No. 2, pp. 119-124.

Hill, J.E., S.R. Roberts, S.C. Scardaci, and J.F. Williams. 1996. "Rice Herbicides and Water Quality: A California Success Story in Government and Industry Coordination." University of California Cooperative Extension. University of California. Davis, CA.

Regional Water Quality Control Board. 1992. "Consideration of Approving Department of Pesticide Regulations 1992 Management Practices for River Pesticides." Staff Report, Central Valley Region. Sacramento, CA.

Roberts, S.R. 1997. University of California. Davis, CA. Personal communications.

State Water Resources Control Board (SWRCB). 1990. "Sacramento River Toxic Chemical Risk Assessment Project." Final Report 90-11WQ. Sacramento, CA.

Winter-Flooded Fields Benefit Farmers and Wildlife

Lisa Owens-Viani

Introduction

California farmers are often criticized by environmentalists for using too much water and too many chemicals, and for the impacts of agriculture on water quality and wildlife habitat. However, an increasing number of farmers are engaging in sustainable farming practices that have reduced chemical and water inputs and offer much-needed wildlife habitat. As California's population continues to burgeon and agricultural and other open lands are converted to residential subdivisions and commercial developments, agricultural lands that also act as habitat will become even more crucial for many species of wildlife. This case study shows that producing food and fiber can be compatible with wildlife habitat—and that the two can even be mutually beneficial.

One wildlife-friendly farming technique being practiced by California farmers is shallow flooding dormant fields, particularly in the winter months. Each winter, more acres of farmland are being transformed into seasonal wetlands for wildlife, creating a landscape that begins to resemble the natural wetlands once so plentiful in California. Since California has lost over 90 percent of its original, natural wetlands (Vileisis 1997), these seasonal wetlands offered by farmers are particularly valuable for the millions of waterfowl and shorebirds migrating through the state on the Pacific Flyway in winter (see Figure 18-1).

Flooding in the Delta

Farmers in the San Francisco–San Joaquin Delta began winter flooding in the 1960s. In recent years, they have worked with environmental groups to refine their practices in order to provide even better quality habitat.

Over the past few decades, Jim and Sally Shanks, who manage 9,200 acres of wheat, corn, and tomatoes on Staten Island, have become increasingly convinced that flooding offers benefits both for farming operations and for the migrating birds that pass through the Delta in the winter. The Shanks say flooding prevents their rich peat soil from subsiding, eroding, and accumulating salts. Because flooding also effectively controls weeds, the Shanks have been able to reduce herbicide use. They also save on the cost of tilling, since flooding effectively decomposes crop stubble.

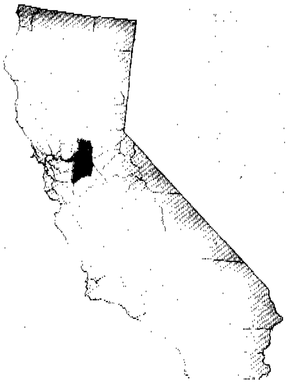
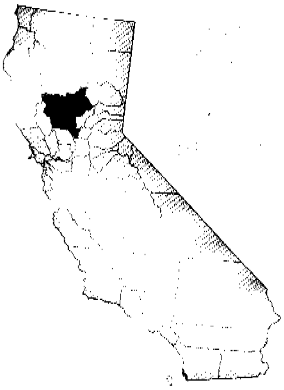


Figure 18-1
The Pacific Flyway, by Frederick Lincoln

Source: U.S. Fish and Wildlife Circular 16, U.S. Government Printing Office 1950

Although the Shanks value the on-farm benefits flooding offers them, their main motivation for flooding—their "number one value," says Sally Shanks—is to provide habitat for the birds coming through the area each winter. To maximize the habitat benefits for different species, the Shanks gradually and sequentially flood approximately 6,000 acres each year. In early fall, after harvest, they first flood their wheat fields, then the corn. Some fields may be left dry, to offer habitat for cranes, geese, and raptors. The Shanks then flood their other fields by bringing the water level up slowly, allowing the birds to follow the newly-created habitat with its "crop" of invertebrates and waste grains. Through a system of low cross-levees and gated pipes, the Shanks are able to move water from one field to another and provide different depths for different species. To mimic the mudflats and shallow pools loved by shorebirds and wading birds, some fields are flooded and then immediately drained. Over the years, the Shanks have found that this water management program has greatly increased the diversity and number of birds using their farm. A few winters ago, the Shanks counted 18,000 cranes, including the greater sandhill crane, a species state-listed as threatened, on their island.



Most of Staten Island lies below the level of the Mokelume River, which borders the island for about 25 miles. Like other Delta farmers, the Shanks have riparian rights to the river, entitling them to as much of the river's water as they need. There is still a cost to flooding, however. The Shanks estimate that to activate the siphon that pulls the water in, to operate their levee system, and particularly to pump the water off the fields when it comes time to plant, costs them approximately $40 per acre. This cost is offset by the on-farm benefits they realize from flooding—prevention of soil subsidence and erosion, inexpensive weed control, and less need for tilling—of approximately $20 an acre. So far, the Shanks have still been able to make enough of a profit farming wheat and corn to allow them to continue their commitment to wildlife-friendly farming.

The Shanks' farm has become a model for other Delta farmers, winning them the Department of Fish and Game's Wildlife Conservation Award and the Central Valley Habitat Joint Venture's Innovative Farmer Award. Other Delta farmers, inspired by the Shanks' experience, have begun flooding their fields too. Flooded fields in the Delta offered close to 30,000 acres of seasonal wetlands this past winter and were used by approximately 471,000 ducks, 38,000 geese, 19,000 swans, and 3,300 cranes (Bias 1998).

Flooding in the Sacramento Valley

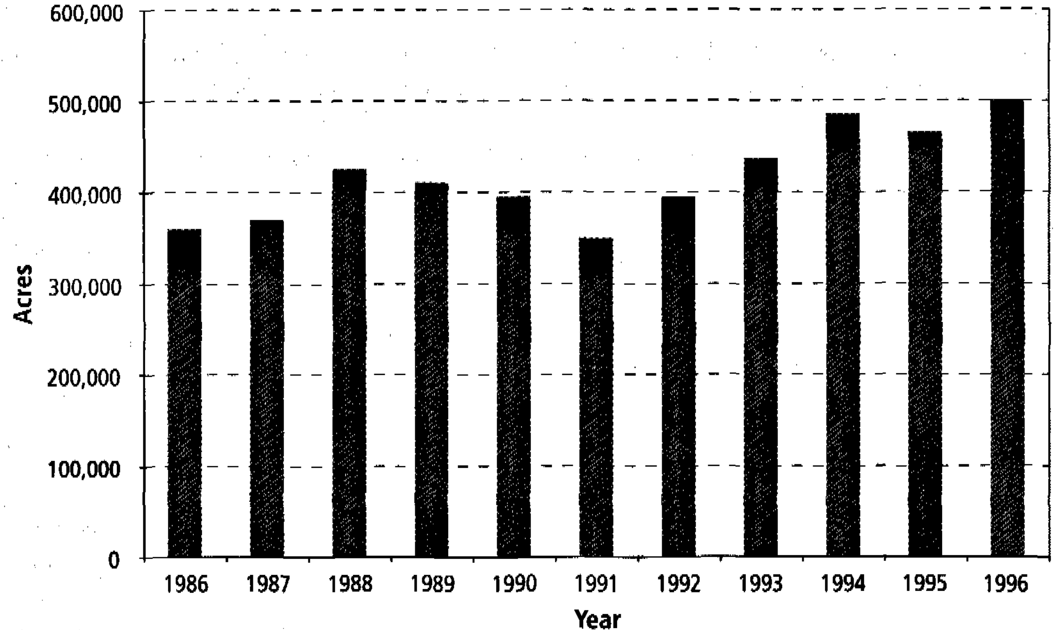
Rice and the Economy and Environment of the Sacramento Valley

In the Sacramento Valley, farmers like the Lundbergs, organic growers in Butte County, have been flooding their fields for the past three decades. Over the past few years, motivated in part by new restrictions on burning their fields, many more rice farmers have begun flooding their fields, and in the winter of 1997–1998, provided close to 150,000 acres of seasonal wetlands for migrating birds. These Sacramento Valley farmers are helping solve two of the Valley's biggest environmental problems—air pollution and habitat loss—while keeping valuable agricultural land in production and preserving an important part of the Sacramento Valley economy.

In 1996, California produced 3.8 billion pounds of rice on 500,000 acres, over 7,600 pounds per acre, one of the highest yields of any region in the world (CRIA 1997) (see Figure 18-2). Seventy percent of the rice grown in California is consumed within the United States, where rice consumption averages nearly 25 pounds per person per year (Roberts 1998).

Over 90 percent of the rice produced in California is grown in the Sacramento Valley, with four counties—Glenn, Butte, Colusa, and Sutter—growing most of it (*Valley Habitats* 1995; Roberts 1998). Rice is the economic base of many Sacramento Valley communities: growing, milling, and marketing rice generates over a half billion dollars each year, with farm workers, equipment manufacturers, seed suppliers, mill workers, truck drivers, marketing profes-

Figure 18-2
California Rice Acreage Harvested, 1986–1996



Source: CRIA 1997

The Rice Cycle

Around the first of May, after discing and leveling their fields and rebuilding levees, farmers flood their fields and sow rice seed from the air. For the next three to four months, the rice fields remain flooded as the seeds sprout and grow. In late August, the fields are drained, and in mid-September or early October, they are harvested.

Many farmers then re-flood their fields to decompose the rice straw left on the fields. (Alternatively, the fields are burned—if burning is permitted.) The fields stay flooded until February or early March when they are drained to prepare for the next season's planting. (At this point the straw has been completely decomposed.) Farmers who prefer burning to flooding (but were not able to burn their straw in the fall and chose not to winter-flood) now burn their straw to prepare for planting. In years of late rain, however, burning is not always possible because the fields may be too wet.

sionals, and others making their livings from the production and sale of rice (Prillwitz 1995).

Wildlife Habitat

One hundred years ago, the land on which rice is now planted "belonged" to the Sacramento River—and to wildlife. Between the natural levees of the Sacramento River and the uplands (the start of the Coast Range and Sierra foothills) lie low, saucer-like depressions that form shallow basins without outlets: the Butte, Sutter, and American basins to the east of the river, and the Colusa and Yolo basins to the west (see Figure 18-3).

During periods of heavy rain, the river and its tributaries would overflow, transforming these lower-lying depressions into shallow lakes and tule marshes[1] that existed for most of the year, prevented from draining by the river's natural levees (Thompson 1961). These lakes and marshes acted as sinks for the rivers when they flooded and were connected by an extensive network of sloughs and creeks (Scott and Marquiss 1984). These wetlands provided

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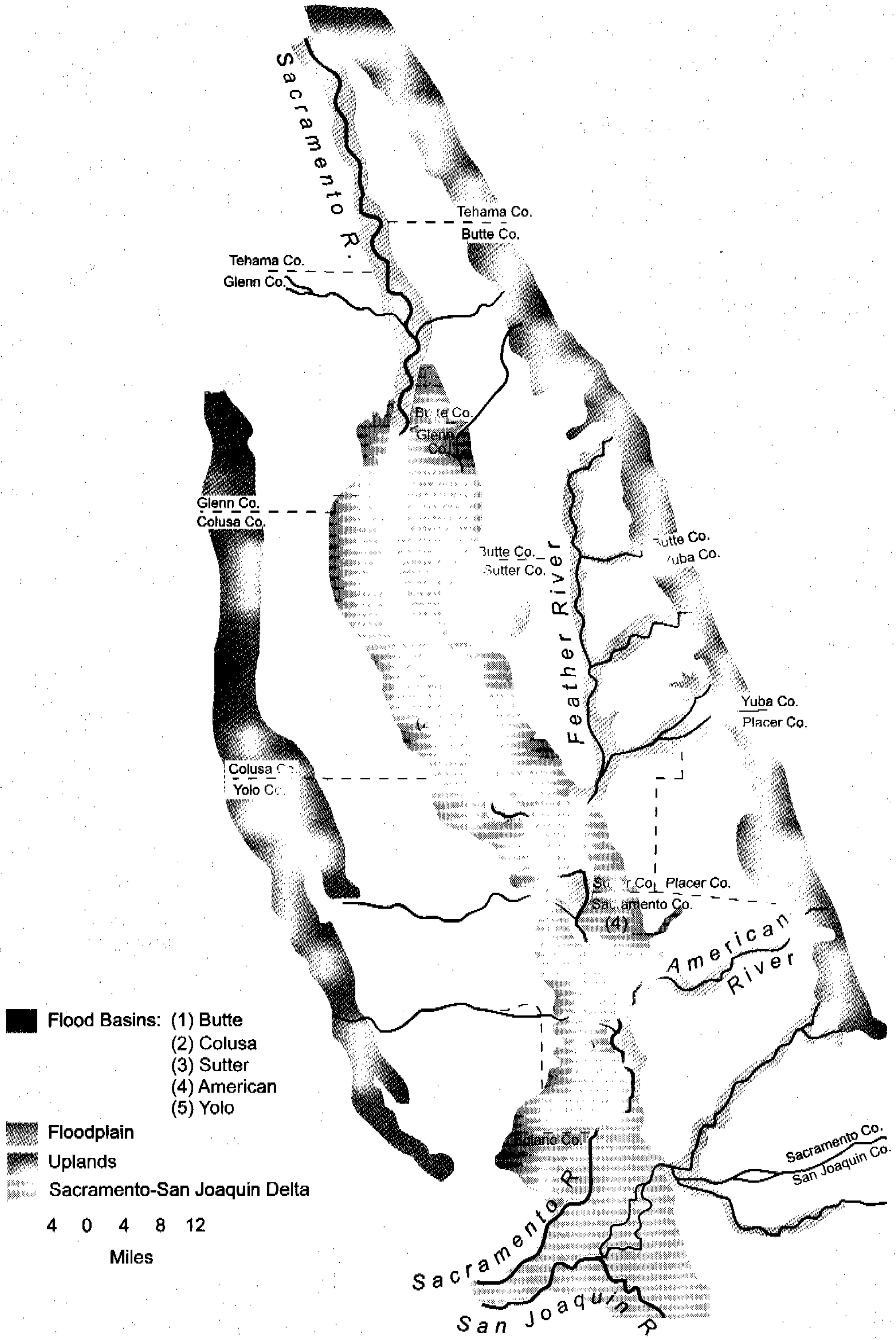
[1] Marshes filled with bulrushes, primarily *Scirpus acutus*.

Figure 18-3

Physiographic Regions of the Sacramento Valley



Source: Adapted from Thompson 1961

habitat for the millions of waterfowl and shorebirds migrating through the area during winter and early spring, and for resident species throughout the year.

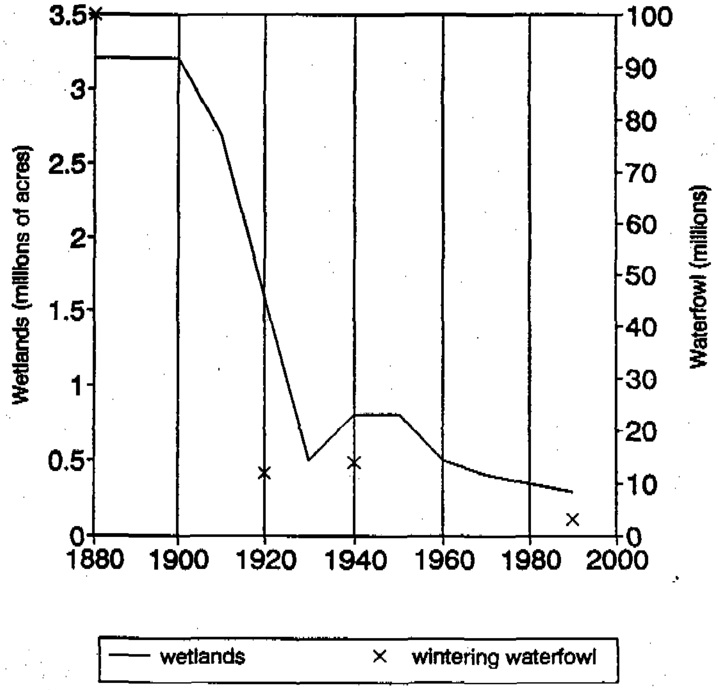
In the early 1900s, however, approximately 94 percent of the Sacramento Valley's wetlands were filled or drained for agriculture, flood control projects, highways, and railroad levees. The destruction of these wetlands (along with overhunting) devastated the populations of ducks, geese, swans, and shorebirds that used the Pacific Flyway (see Figure 18-4) as a migration route from their northern breeding grounds to their wintering grounds in Central America (Prillwitz 1995). Although these populations once numbered between 50 and 60 million, birds using the flyway today total only between 3 and 5 million. The remaining "natural" wetlands alone (wildlife refuges and privately-owned marshlands managed for duck clubs)[2] are insufficient to support even these birds, especially since an estimated 60 percent of the birds using the Flyway over-winter in the Central Valley, primarily in the Sacramento Valley (Andrews et al. 1992; Prillwitz 1995; Shuford 1997).

Air Quality and Rice Disposal

The Sacramento Valley experiences serious air pollution problems, particularly in the fall, when stable air patterns reduce circulation. After rice is harvested, as much as three to four tons of rice straw per acre can be left on the fields. Rice straw is high in silica, which means that it decomposes slowly, unlike the straw of wheat or other small grains. This straw must be disposed of before the next planting season so new rice seedlings can become established, and to prevent diseases from infecting the new crop. Open-field burning has traditionally been the preferred method of straw disposal, both because it is cheap (burn permits cost between $25 and $50 per year, with a charge of $0.25–1.75 per acre burned) and because it helps control diseases like stem rot (caused by the fungus *Sclerotium oryzae*) and aggregate sheath spot (caused by the fungus *Rhizoctonia oryzae*). However, burning also contributes to air pollution, particularly in the fall when less atmospheric mixing takes place in the Sacramento Valley. On "heavy burn days" in the fall of 1996 (during which up to 10,000 acres were burned), rice straw burning accounted for 27 percent of PM_{10} emissions[3] in the Sacramento Valley Air Basin (CARB/CDFA 1997). On a "typical" 1996 burn day (when 3,000 acres were burned), rice straw burning accounted for 10 percent of the Sacramento Valley's total PM_{10} emissions. In some northern rural portions of the Valley, rice burning is by far the major source of air pollution.

Burning rice straw also generates carbon monoxide, carbon dioxide, nitrogen dioxide,

Figure 18-4
Central Valley Wetlands and Estimated Numbers of Winter Waterfowl



Source: Philip Williams & Associates, Ltd. 1992

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[2] Although some of these wetlands are not necessarily original wetlands, they have been created and are managed to closely emulate natural wetlands through the planting of diverse species of native plants that offer habitat (see later discussion in Management Issues section).

[3] Particulate matter less than 10 microns in diameter, the primary pollutant of concern in rice burning.

sulfur dioxide, and numerous organic vapors that may serve as precursors to ozone. But particulate matter less than 15 microns in diameter is the pollutant of greatest concern in relation to human health and is associated with adverse health effects on people with respiratory illnesses as well as very young and elderly people (CARB/CDFA 1997).[4] On heavy burn days, Sacramento area physicians report increased complaints from patients with asthma, bronchitis, and allergies (CARB/CDFA 1997).

In 1991, in response to numerous complaints about air quality and petitions to eliminate rice burning, the California State Legislature passed the Rice Straw Burning Reduction Act (AB 1378). That act limited the total amount of straw burned each year to 125,000 acres (or 25 percent of each farmer's acres, whichever was smaller), with a complete ban scheduled for the year 2000. However, Senate Bill 318 (passed in late 1997) changed the 1998 through 2002 phase-down schedule. SB 318 permits the burning of 240,000 acres during each of those five years, although it phases *fall* burning down from 90,000 acres in 1998 to 60,000 acres in 2002. After 2002, farmers will be allowed to burn up to 25 percent of their total acreage if crops are being lost from disease. As of early 1998, farmers were permitted to burn up to 38 percent of their acreage (Engstrom 1997), although each year since the Rice Straw Burning Reduction Act began, they have consistently burned fewer acres than the maximum allowed (CARB/CDFA 1997). (See Table 18-1.)

The Ricelands Habitat Partnership

In the 1980s, environmentalists began to criticize the rice industry, not only for the pollution caused by rice straw burning, but also for the amount of water needed to grow rice. In response, the rice industry decided to show its critics that rice had other, positive environmental values, and to encourage more growers to engage in environmentally-beneficial practices such as winter-flooding. In 1991, members of the California Rice Industry Association invited water expert Marc Reisner, an outspoken critic of the rice industry and its water use, to visit the Sacramento Valley to see the large numbers of birds using flooded rice fields. Without rice fields, the growers argued, migratory waterfowl and shorebirds would have few areas in which to stop and refuel in the Sacramento Valley. Reisner became convinced that, under certain conditions, rice fields could offer refuge for wildlife, and agreed to help the industry association create a partnership between growers, The Nature Conservancy, Ducks Unlimited, and the California Waterfowl Association: the

Table 18-1

Sacramento Valley Rice Straw Burning Phase Down
Maximum Allowable and Actual Burned Acreage

Burn Year	1992	1993	1994	1995	1996
Phase-down act: percent allowable burn	90	80	70	60	50
Compliance (percent actually burned)	76	70	59	55	42
Acres planted	402,000	450,000	514,000	501,000	515,000
Acres burned	303,000	306,000	293,000	268,000	211,000

Source: California Air Resources Board/California Department of Food and Agriculture 1997 Report to the Legislature

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[4] Reports documenting those effects form the basis of state and federal ambient air quality standards.

"Ricelands Habitat Partnership." Later, particularly as the Central Valley Habitat Joint Venture got underway, fish and wildlife managers and resource conservation districts also became interested in winter flooding and joined the partnership.

In 1991, legislation phasing out rice straw burning was passed, and the partnership began looking for alternative disposal methods. Farmers had always known that rice fields offered habitat for wildlife, particularly in the spring when resident species like mallard, cinnamon teal, and gadwall are nesting. They had also noticed that birds migrating through the area used the fields in the winter, and some growers had been experimenting with flooding their fields both to decompose rice stubble and to provide habitat for the birds. The Lundberg family, organic growers, were leaders in this effort, having flooded their fields for over 30 years. The partnership's board contacted the Lundbergs and created an instructional video about their practices, which was (and is) shared with growers to encourage them to try flooding as an alternative to burning. Other growers had begun experimenting with flooding as well. Al Montna, for example, says he began flooding his fields in the 1980s after he saw habitat for migratory birds in the Central Valley increasingly being converted to housing and industrial uses.

Growth of the Ricelands Habitat Partnership

The Ricelands Habitat Partnership has grown from a 20,000-acre pilot project in the winter of 1992–93 with 41 growers, to an effort involving at least 184 growers flooding 140,000 to 150,000 acres of rice straw (as of winter 1997–1998). The partnership tries to base its goals on sound management and ecological principles and meets periodically to discuss monitoring and management issues. While Ducks Unlimited works with many of the partnership's farmers, encouraging them to flood their fields and establish duck clubs, other farmers besides those officially counted in the project also flood their fields. Farmers who cannot afford to divert or pump water to flood sometimes "button up" their farms with boards or temporary levees and allow whatever rainfall is received during the winter to flood their fields and provide habitat. Based on satellite imagery, Ducks Unlimited biologist Mike Bias estimates that the current amount of winter wetlands—including rice fields, private duck clubs, and wildlife refuges—exceeds 200,000 acres.

Flooding To Decompose Rice Straw

Flooding is generally believed to accelerate decomposition although different depths and soil types will influence the rate (Scarduci 1997). Flooding in the warmer weather of mid-October to early November is thought to encourage better decomposition than flooding later in the fall or winter. Continuous and long-term flooding is not required to achieve adequate decomposition: decay actually proceeds more quickly with some oxygen present (*Valley Habitats* 1995 and 1997). Some rice farmers believe that the efficiency of rice decomposition increases with successive years of flooding, and a five-year study is underway at UC Davis to determine optimal conditions for straw decomposition.

Some farmers use flooding in conjunction with dry-disposal methods (incorporating straw into the soil without flooding), applying between two and twelve inches of water once dry methods have been completed. Others simply flood their fields immediately after harvest and then let the birds "chop" and break down the straw. Most farmers seem to feel a combination of wet and dry methods works best (Brewster 1997).

Evaluation of Success

Various reasons explain why more rice farmers don't flood their fields. Some farmers who have burned their straw for years simply don't want to change—they see burning as their "right," even though legislation is slowly eating away at that "right" (Roberts 1997). Others don't flood because their soils are too porous and don't retain water; however, most of the soils in the Sacramento Valley are alluvial clay, which holds water well (Andrews et al. 1992). Most farmers who are not flooding their fields, however, are still burning close to the maximum acreage permitted and using either dry incorporation or physical removal for the remaining acreage (see the "Disposal Options" section). These farmers want to continue burning because it is both cheap and provides good disease control. Some farmers think flooding contributes to crop disease, but preliminary results from a five-year study underway at the UC Davis Agronomy and Range Science Department indicate that flooding—like burning—actually reduces disease, particularly with successive years of flooding (Cintas et al. 1997). In 1996, a new disease, "rice blast," occurred for the first time in the Sacramento Valley. This fungus (*Pyricularia grisea*) is considered the most destructive of all rice diseases (CARB/CDFA 1997). Flooding and burning are both thought to help control its spread; however, no studies have yet been conducted comparing occurrence of blast on flooded versus burned fields. Blast is more of a problem in humid regions, so California, with its typically dry summers, has not (until just recently) been affected by this disease (Roberts 1998).

Habitat

Between three and four million water birds and close to 300,000 shorebirds now use the winter-flooded rice fields (Bias 1997; Shuford 1997). Species of waterfowl include geese, swans, and diving and dabbling ducks. (Dabbling ducks include pintails, American wigeons, mallards, green-winged teals, shovelers, gadwalls, and wood ducks; diving ducks include canvasbacks and ruddy ducks.) As the birds forage for waste grain and invertebrates, they trample the rice straw, further mixing it into the soil and aiding decomposition. At the same time, they fertilize the fields with their droppings, which contain high amounts of nitrogen. The nitrogen helps break down the cellulose in rice straw (Roberts 1998).

Flooded rice fields also provide habitat for about 70 percent of the hundreds of thousands of shorebirds that migrate through the Valley in the winter: curlews, ibis, killdeer, sandpipers, godwits, yellowlegs, and dowitchers, among others. Wading birds like egrets, herons, and cranes, and even gulls use this winter habitat (Rollins 1997).[5]

Air Quality Benefits

By flooding more fields, rice farmers have decreased their contribution to Sacramento Valley air pollution. Total acres burned decreased from 303,000 (of 402,000 acres planted in 1992) to 211,000 (of 515,000 acres planted in 1996) (CARB/CDFA 1997), and particulate matter emissions decreased by about 30 percent between 1992 and 1996 (see Table 18-2).

However, overall air quality improvements are not expected to be measurable until total acreage burned is phased down to only 25 percent of the total acres planted. Also, while the number of acres of rice being burned per year has greatly decreased (see Table 18-1), other sources of particulate matter have increased. In 1996, rice straw burning contributed only four percent of the total 83,000 tons of PM_{10} emitted in the Sacramento Valley, with residential fuel combustion accounting for 8 percent, "unpaved road dust" 32 percent, and other farm operations 16 percent of the total (CARB/CDFA 1997) (Figure 18-5).

Flooding and Water Use

No numbers are available for the exact amount of water diverted by farmers to flood their fields to decompose rice straw. The amount of water needed for this process is highly variable: it depends on the type of soil on a given farm, the depth of flooding, the length of time a farmer needs or wants to flood, and the amount of precipitation received. On tight, clay pan soils where water doesn't infiltrate quickly, farmers can flood their fields with six inches of water or less (Roberts 1997; Brewster 1997). Some farmers divert just enough water to dampen the soil, but fields managed specifically to attract ducks are usually flooded to depths of 10 inches or more (Rollins 1997). At the upper end of the spectrum, some farmers apply as much as two acre-feet of water per acre (Butler 1997). John Roberts, President of the California Rice Indus-

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[5] Winter is not the only season in which rice offers habitat, nor are birds the only wildlife to benefit from rice fields. In the spring, fields flooded to grow rice provide habitat for various amphibians and reptiles, including the endangered Giant Garter Snake, which, like migratory birds, has suffered from disappearing habitat and would even be at risk of extinction without flooded rice fields (G. Hansen 1994).

try Association, believes average application of water is closer to a depth of three inches. Since different farmers flood to different depths, and some re-flood while others do not, the exact amount of water diverted is impossible to ascertain. A broad estimate of water diverted for flooding would be 150,000 acre-feet per year. To flood 150,000 acres to a depth of 6 to 12 inches would require 75,000 to 150,000 acre-feet per year. Much of that water eventually becomes available for other uses since it infiltrates the water table or flows into rivers in the spring; however, if fields are flooded early in the fall when temperatures can still be quite high in the Sacramento Valley, some of that water will be lost to evaporation. Although no exact figures are available, Dave Paullin with the U.S. Fish and Wildlife Service's Central Valley Habitat Joint Venture says a rough estimate of the amount of water released from the fields in the spring into the rivers is close to 70,000 acre-feet.

Cost of Flooding

Farmers who want to flood (but aren't willing to pay for delivered or pumped water) "button up" their fields with boards and flood them using whatever amount of rain falls—with this method, the cost is simply the time and labor needed to board up the fields. However, many farmers want to begin flooding as early as October, both for optimal decomposition and to provide habitat for the large numbers of migratory birds arriving in November (Roberts 1997). If rain hasn't fallen by then, farmers must pay to divert water or pump groundwater. Less than 10 percent of Sacramento Valley farmers pump groundwater due to the cost ($20–50 per acre-foot) and the variable quality of the Sacramento Valley groundwater (Andrews et al. 1992; Roberts 1997). Surface water prices can range from as low as $2.85 per acre-foot to as high as $125 per acre-foot, depending on the supplier (Roberts 1997). Sources of surface water include the Sacramento, Bear, Feather, and Yuba Rivers, as well as Cache Creek and Butte Creek; the water is conveyed to farmers primarily through the Tehama-Colusa, Glenn-Colusa, and Western Canal Water Districts (Anderson 1992).

Table 18-2

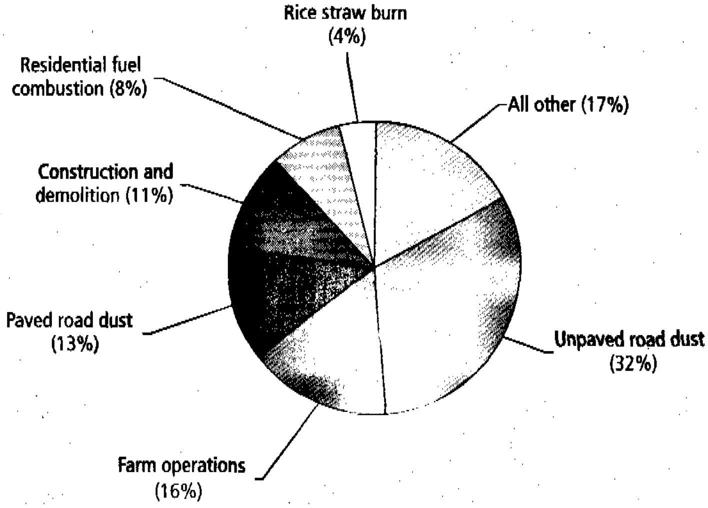
PM_{10} Emissions from Rice Straw Burning in the Sacramento Valley Air Basin by Burn Year (In Tons)

1992	1993	1994	1995	1996
3,150	3,180	3,050	2,790	2,200

Source: California Air Resources Board/California Department of Food and Agriculture 1997 Report to the Legislature

Figure 18-5

Relative Contributions to 83,000 tons PM_{10} in 1996



Note: Chart totals 101 percent due to rounding.
Source: CARB 1997

Some help with the cost of water is available to farmers through Section 3406 B22 of the Central Valley Project Improvement Act. Ducks Unlimited also helps some farmers pay for water and capital improvements to their conveyance systems (Bias 1997) (and see the sidebar on Wildlife-Friendly Farming).

Disposal Options Other than Flooding or Burning

Farmers who either can't afford or don't wish to flood have a number of other options for disposing of their rice straw. Some farmers bale their straw into large (900–1,200-lb) or small (80–90-lb) bales and transport it offsite. However, the market for baled straw is limited at present, and the cost of transporting it is high. Purchase, removal, and transport of straw bales from the fields can range from $4 to $6 per bale, depending on the transporter and the destination. Although straw can be used in alternative energy production, bio-energy production plants often have a source-straw limit of 15 to 20 miles, making this alternative less feasible for many rice growers. Currently, there are plans to build two ethanol plants in the Sacramento Valley, which could dispose of 20 percent of the rice straw (Engstrom 1997). Some straw is used for erosion control on highway projects and burned areas, and the Rice Straw Burning Alternatives Advisory Committee is cataloguing existing and potential alternative uses for straw. The Rice Straw Demonstration Project Fund created by SB 318 in 1997 provides grants for up to 50 percent of the cost of demonstration projects using rice straw (Hrynchunk 1997). Currently, however, less than two percent of the straw goes to alternative uses (Herkert 1997).

Another method of straw decomposition involves chopping the straw into smaller pieces (thereby increasing the straw's surface area so that bacterial and fungal decomposition can take place) and incorporating it into the soil. Some farmers incorporate the straw without chopping it into smaller pieces since chopping rice straw can wear down harvester blades. However, newly-designed straw rollers (pulled by tractors) that push the stubble into the soil without actually turning it under have been found to be very effective. This action brings the crop residue into contact with the soil microorganisms that begin the decomposition process (*Valley Habitats* 1995). Not all soils are suitable for incorporation alone, however, and many farmers feel that a combination of incorporation and flooding works best. Although critics of incorporation cite the increased amount of diesel fuel this practice requires—600,000 gallons of additional fuel in the 1996 burn year—particulate emissions from diesel-fueled soil incorporation are much lower than those from burning rice straw and accounted for only three percent of the total diesel fuel burned in agricultural operations and by on-road motor vehicles in California in 1996 (CARB/CDFA 1997). PM_{10} emissions from soil incorporation range from 0.62 to 1.9 $\mu g/m^3$, compared to 20.8 $\mu g/m^3$ from rice straw burning.

Although water for flooding can be costly for farmers, straw incorporation without flooding can also be expensive (Roberts 1997; Butler 1997). For many farmers the two methods are similar in cost (Brewster 1997; Butler 1997). Grower Steve Butler estimates that the cost of discing or plowing his fields ranges from $15 to $18 an acre, plus $1 to $2 per acre for disposal. He pays around $20 per acre to flood his fields, so for him, the costs are fairly equal, plus he enjoys providing habitat for waterfowl. Butler comments that when farmers share water costs with duck hunters or defray their water costs by leasing land to hunters, flooding becomes a much more appealing option. He hopes that rice flooding is not seen as a "new use" of water, especially since, (as he puts it), "we're farming a drained swamp. This whole area was once a giant patch of tules."

Management Issues

Duck Clubs

Before farmers began flooding their fields, private landowners, duck hunters, and refuges were managing wetlands to attract as many birds as possible, by planting a variety of native plants that go to seed at different times and have high nutritional value for birds, and by offering the variety of water depths that different species require (see Figure 18-6).

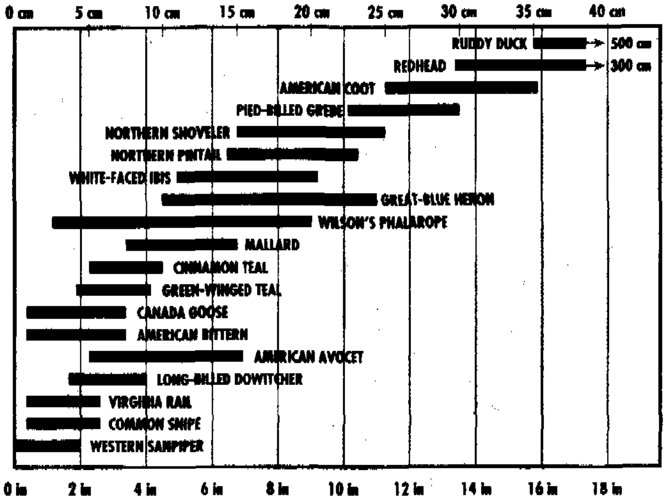
These managed wetlands are considered higher quality habitat than flooded rice fields because they more closely resemble natural habitat. With flooded rice fields now doubling the overall acreage of wetlands, some hunters claim they are seeing fewer birds at the managed wetlands. Duck hunter satisfaction is a concern because license and blind fees help pay for 70 percent of the state's wetlands. Plus, some resource managers caution that hunter-owned habitat could become more crucial for birds if profitable markets for rice straw are found and farmers stop flooding their fields.

On the other hand, many duck clubs drain their fields at the end of the hunting season in

January, just when birds numbers are highest. Although some hunters are beginning to change this practice and leave water on the fields longer, flooded rice fields offer one way to ensure that habitat is still available during January, February, and March, if hunters decide to "pull their boards" and drain their fields.

While some hunters were happier when more ducks were crowded into less space, others feel such a situation is unethical, particularly since crowding can contribute to outbreaks of avian cholera and botulism (Miller 1997). In the long run, more winter habitat should help increase duck numbers by improving the overall health and survival of ducks, although other factors—such as the amount and quality of breeding grounds in the north—are critical too (Miller 1997). The way water is managed in the spring is important too, particularly for resident species, whose breeding success can be negatively impacted by the one-month "lag" between draining the winter-flooded rice fields and re-flooding them in the spring for planting.

Figure 18-6
Preferred Foraging Depths for Waterbirds



Source: Ducks Unlimited 1994

Potential Impacts on Fish

Late October to mid-November, when farmers are beginning to divert water from the Sacramento River to flood their fields, anadromous fish are beginning to migrate. Although the actual reduction in flows is very small,[6] juvenile salmon attempting to migrate may become confused and swim or be sucked into diversions if river flows are low. If no rain falls and farmers must divert water again later in the season to keep their fields flooded to a certain depth, low flows could impede spring and fall salmon runs (December–February) and the winter run (October–February). In drought years, water diversions could become even more controversial. One solution has been to transfer water from the State Water Project, by sending water from Lake Oroville through Butte Creek and the Western Canal System to farmers who would ordinarily divert from the Sacramento River. Until recently, however, juvenile salmon were becoming trapped in diversions above the Western Canal dams in Butte Creek, and in the fall of 1993, fish were sucked out of the creek and diverted onto rice fields where they were stranded (Reisner 1994). The recent construction of a giant underground siphon eliminated the need for five dams, which have been removed, and one of the most problematic unscreened diversions. The siphon, plus some fish ladders and screens being installed upstream, should prevent further problems with fish entrapment (see *Improving Passage for Spring-Run Salmon,* Chapter 21).

Another potential problem for adult winter- and spring-run salmon can occur when water from rice fields is released in the spring into the Colusa Basin Drain, Cherokee Canal, or Butte Slough. If drain outlets are not properly screened, fish can become misdirected and swim into inappropriate ditches (Andrews et al. 1992).

One potential benefit for fish could be increased flows from the water released from the flooded fields into the Sacramento River mid-March, as increased freshwater inflows into the San Francisco Bay Estuary could have beneficial effects on salmon smolt migration and the estuarine ecosystem.

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[6] The studies performed in 1992 by Elizabeth Andrews, Philip Williams, and Tamara Rose assumed diversions sufficient to flood 250,000 acres.

Water Quality

Although concerns have been raised about the quality of the water released into the rivers in the spring, studies by both Philip Williams and Associates and the National Biological Survey found pesticides and herbicides to be present in insignificant quantities in flooded rice fields during the winter, and that those detected were further broken down by the time the water was released in the spring (see *Improving Water Quality Through Reducing the Use of Herbicides on Rice,* Chapter 17). Another potential water quality concern is the level of organic matter in the released water. When water high in organics is disinfected for drinking, byproducts such as trihalomethanes, which are carcinogenic, can be formed. While Andrews, et al. (1992) found total organic matter levels to be low (especially since rice detritus is released during times of higher flows), some municipalities are now demanding that the level of organic matter in water that flows into the Delta, some of which supplies domestic needs, be reduced (Roberts 1997). Meanwhile, fisheries biologists point to the importance of organic detritus in maintaining healthy aquatic life in the Delta and its tributaries (Roberts 1997).

Conclusions/Lessons Learned

Because California is usually still dry in late October/early November when farmers need to begin flooding, some water diversions will probably always be necessary. On-farm water storage offers one partial solution to the problems associated with diversions and spring releases into the rivers, and to the cost and scarcity of water, especially in drought years. In on-farm storage, water is drained from the winter-flooded fields, placed in a holding basin, and then re-used for the next year's planting. Glenn County rice farmer Allen Garcia claims that his on-farm tailwater pond system helps him maintain approximately half of his acreage on recycled water. Garcia installed tailwater ponds next to naturally-occurring ephemeral streams on his property. When the water in these streams rises, Garcia allows it to overflow into his ponds, from which it then flows by gravity onto the rice fields. When the water reaches the lowest pond, it is pumped back to the highest pond and used again. Garcia used grant monies to construct the ponds, which saved him much of the expense of delivered water (he still must divert some water). Garcia explains that his reduced cost for water depends on the particular field: those with an underlying hard-pan clay layer do not need as much water to flood (the clay layer helps hold the water on the fields by slowing down deeper infiltration).

John Roberts says that to implement on-farm water storage, many farmers would need to improve their levees and conveyance systems, at costs that would deter them from implementing water-recycling systems. Garcia, however, says that while an on-farm recycling/storage system can cost between $10,000 and $20,000, enough cost-sharing programs exist to offset approximately 75 percent of those costs. Garcia also points out that many farmers have access to what he calls "free water"—the ephemeral streams that run off the Coast Ranges into valley foothills (see *Improving Water Quality Through Reducing the Use of Herbicides on Rice,* Chapter 17 for more information about on-farm water recirculating systems.)

Garcia, and the Lundberg family, are models for other rice farmers. Garcia believes that the key to the success of the winter-flooding program is "fully integrating wildlife habitat into farming opportunities" (Garcia 1997). He sees wildlife-friendly farming as part of an integrated resource management program. Garcia deals with the problem of fall rice straw disposal using a variety of methods. In addition to flooding about one-third of his acreage, Garcia also donates some of his rice straw to erosion control projects and uses the remaining straw as a form of dry "compost" on his remaining acres, where its slow rate of decomposition is actually beneficial. During the months the straw protects Garcia's fallowed fields by covering the soil and preventing erosion, it also offers nesting habitat for pheasants and other birds. Garcia says that by leaving straw on the fields (and later incorporating it into the soil) and flooding his fields, he saves on the costs of fertilizer and other chemical inputs and will have healthier

Detailed Information About Wildlife-Friendly Farming Practices and Cost-Sharing Programs is available in a booklet entitled "Farming for Wildlife/Voluntary Practices For Attracting Wildlife To Your Farm," published by 25 organizations, including the California Rice Industry Association, Ducks Unlimited, the University of California Cooperative Extension, the California Farm Bureau, the Community Alliance with Family Farmers, the Department of Pesticide Regulation, California Department of Fish and Game, the U.S. Fish and Wildlife Service, various resource conservation districts, and many others.

The booklet offers detailed instructions on practices like flooding fields, creating tailwater ponds, fallowing fields, using integrated pest management, planting shelterbelts, etc. and contains the names and phone numbers of individuals and agencies who can be contacted for advice on specific practices or funding sources. It can be ordered through Glenn Rollins, California Department of Fish and Game, Sacramento (916/653-1768).

crops in the long run. He sees winter-flooding as part of a big habitat "quilt," a patchwork of different types of habitat. A combination of several decomposition methods—flooding, baling, and dry incorporation—could address concerns, for instance, that flooding all fields will harm raptors who need rodents for prey (with less grain in dry fields, rodent populations have dropped) or the geese and cranes that prefer dry fields.

By flooding their fields to depths of 6 to 8 inches or less (rather than 10 to 12 inches), farmers can attract the greatest number of species *and* lower their water costs (Elphick and Oring 1998). By varying the timing of flooding and de-watering their fields, farmers can also offer habitat for the many shorebirds wintering in the Sacramento Valley (in addition to waterfowl), which need even shallower depths (Rollins 1997; Anderson, et al. 1992). And a few fields could be kept flooded until the breeding season is over, to help resident species.

Winter-flooding has shown itself to be a viable way to keep agricultural land in production while avoiding the pollution caused by burning and providing much-needed wildlife habitat. Unless more flood levees along the Sacramento River are eliminated, which would permit natural seasonal flooding to take place once again, (see *Restoring Riparian Forests and Natural Flood Regimes,* Chapter 20), winter-flooding of rice and other fields offers a way to begin to recreate some of the wetlands that once covered the Sacramento Valley.

Initiated in part by regulatory action (to limit rice straw burning), winter-flooding in the Sacramento Valley has taken on a life of its own, and some farmers are so thrilled with the results they plan to continue the practice, even if alternative markets for straw are developed. Perhaps some of the most important benefits to come from winter-flooding are the new alliances that have been created between environmentalists and farmers—and the realization that their interests need not be at odds. Allen Garcia points out that prior to the winter-flooding program, "the environmental community was ready to take away 50 to 75 percent of our water." Instead, environmentalists are forming partnerships with farmers, in the realization that farming practices can actually benefit wildlife by offering habitat. The practice of winter-flooding has also brought attention to other species besides birds. Irrigation districts—primarily rice farmers—are now spending money on fish screens and ladders, and even taking down dams, actions that will ultimately benefit entire ecosystems (see *Improving Passage for Spring-Run Salmon,* Chapter 21). Farmers have begun to realize the critical role they play in providing habitat in the Central Valley and the Delta, and are continuing to use and improve farming practices that benefit soil, water, air quality, and wildlife.

Contacts

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References

Andrews, E., P. Williams, and T. Rose. 1992. "An Assessment of the Feasibility of Integrating Wetland Management, Water Storage, and Rice Farming in the Sacramento Valley" for The Nature Conservancy.

Bias, M. 1997–1998. Ducks Unlimited. Rancho Cordova, CA. Personal communications.

Brewster, G. 1997. Lundberg Family Farms. Personal communications.

California Air Resources Board; California Department of Food and Agriculture. 1997. *October 1997 Report To The Legislature: Progress Report On The Phase Down Of Rice Straw Burning In The Sacramento Valley Air Basin 1995-1996*. Sacramento, CA.

Cintas, N.A., R.K. Webster, and S.C. Scardaci. 1997. "Effects of Different Rice Residue Treatments on *Sclerotium Oryzae*." Department of Plant Pathology, University of California, and University of California Cooperative Extension. Davis, CA.

Clark, J. and G. Rollins. 1996. California Department of Fish and Game, et al. "Farming for Wildlife/Voluntary Practices for Attracting Wildlife to Your Farm." Sacramento, CA.

Dillinger, W. 1993. "Meshing Birds With Business," *Audubon*, July–August.

Elphick, C. 1998. "Winter Management of California Rice Fields for Waterbirds." *Journal of Applied Ecology* 35:95–108.

Engstrom, S. 1997. Sacramento Metropolitan Air Quality Management District. Sacramento, CA. Personal communications.

Hansen, G. 1994. In *Special Status Wildlife Species Use of Rice Cultivation Lands in California's Central Valley*, a report prepared by Western Ecological Services Company, Inc. for the California Rice Industry Association, and *Life on the Edge/A Guide to California's Endangered Natural Resources: Wildlife*, Santa Cruz, CA: Biosystems Books.

Herkert, B. 1997. California Rice Industry Association. Sacramento, CA. Personal communications.

Hill, J.E. 1992. "Rice production in California." Cooperative Extension. University of California Publication 21498.

Hrynchuk, L. 1997. California Air Resources Board. Sacramento, CA. Personal communications.

Phillips, J. and C.W. Hale. 1994. "Splendors of the Rice Fields." *Sunset* (Oct.):86-91.

Prillwitz, M. 1995. "The Water Connection: The Relation of Water to Sustainable Agriculture." Unpublished paper. California Department of Water Resources. Sacramento, CA.

Reisner, M. 1994. "Rethinking Rice and Water." As reprinted in the *Chico News and Review*. December 8.

Roberts, J. 1997–1998. California Rice Industry Association. Sacramento, CA. Personal communications.

Scardaci, S., A U. Eke, and J. E. Hill. 1996. "Agronomic Effects of Alternative Rice Straw Management Practices Progress Report: Maxwell Site." Cooperative Extension, University of California. Colusa, CA.

Scott, L.B. and S.K. Marquiss. 1984. "A historical overview of the Sacramento River." In California Riparian Systems. R.E. Warner and K.M. Hendrix, Eds. Pages 51-57. Berkeley, CA: University of California Press.

Shanks, S. 1998. M & T Staten Ranch. Walnut Grove, CA. Personal communications.

Shuford, D. 1997. Point Reyes Bird Observatory. Point Reyes, CA. Personal communications.

Thompson, K. 1961. "Riparian Forests of the Sacramento Valley." *Annals of the Association of American Geographers* 51:294-315.

Western Ecological Services Company, Inc. 1991. "Environmental Attributes of Rice Cultivation in California." California Rice Promotion Board Report No. 90001. Sacramento, CA. December 10.

Valley Habitats, various issues. Ducks Unlimited. Rancho Cordova, CA.

Zerkle, O. 1998. The Nature Conservancy. Sacramento, CA. Personal communications.

Chapter 19

Reviving Central Valley Wetlands: Upper Beach Lake Wildlife Enhancement and the Beach Lake Mitigation Bank

Anna Steding

Introduction

In 1850, wetlands covered nearly a third of the Central Valley. Today, only nine percent of the original wetlands remain, due to the conversion of land to agriculture, the construction of flood control channels, and urbanization. In recognition of the importance of the Central Valley wetlands for migratory birds along the Pacific Flyway, as well as other forms of wildlife, a number of public and private efforts are underway to restore wetland habitats. Two successful wetland restoration projects that provide useful lessons for future restoration are the Upper Beach Lake Wildlife Enhancement Project and the Beach Lake Mitigation Bank in the Beach/Stone Lakes area of southern Sacramento County, California.

The Upper Beach Lake Wildlife Enhancement Project, directed by the Sacramento Regional County Sanitation District in collaboration with the Western Sanctuaries Office of the National Audubon Society and the Sacramento Job Corps Training Center, contains 185 acres of restored wetlands and 365 acres of restored riparian forests and grasslands. An integral component of the project was the restoration of the natural stream channels and other hydrologic components of the wetland area and adjacent Morrison Creek. Vegetation and bird monitoring since the completion of construction in 1994 have shown an increase in the cover of desirable vegetation and in bird species density.

In 1995, the California Department of Transportation completed construction of the Beach Lake Mitigation Bank under the guidance of numerous state and federal agencies. The mitigation bank provides off-site mitigation for small adverse impacts to wetland and riparian habitat from other California Department of Transportation projects in the region. A total of 98 acres were restored, including 65 acres of wetlands, 25 acres of riparian habitat, and 8 acres of uplands. Monitoring results show there is now 70 to 90 percent vegetation coverage in all parts of the mitigation bank, and that the seasonal wetlands have reached maturity. The Department of Transportation has already "debited" three projects against the Bank.

Both projects demonstrate that a combination of agency initiative, creative funding, and reliance on sound restoration principles can yield good wetland restoration results. Both illustrate the linkage between good water management and wetland restoration and both will have multiple benefits beyond habitat restoration, including recreation possibilities for birdwatchers and hikers, and some flood control and water quality improvement capacity. Finally, both will contribute to the creation of an 18,000-acre regional wetlands, as part of the larger Stone Lakes National Wildlife Refuge.

Background

What Are Wetlands?

A number of terms have been used to refer to wetlands, including "swamp," "marsh," "bog," and "bottomland." Regardless of its name, a wetland is a transitional area between a terrestrial and an aquatic habitat "where the water table is at or near the surface or the land is covered by shallow water" (Cowardin et al. 1979). Further, a wetland is characterized by the presence of vegetation that requires permanently or periodically saturated soil for survival. To implement dredge and fill permits under Section 404 of the 1977 Clean Water Act Amendments, for example, the U.S. Army Corps of Engineers requires that a wetland support under normal circumstances "a prevalence of vegetation typically adapted for life in saturated soil conditions" (33 CFR 323.2(c)1984). Any discharge of dredged or fill material into a wetland or other water body done by, or on behalf of, a federal agency, must be done with a "Section 404" permit issued by the U. S. Army Corps of Engineers.

In addition to providing well-known habitat benefits for waterfowl, wetlands also offer fish habitat, flood protection, groundwater recharge, shoreline and streambank protection, water quality amelioration, and aesthetic, scientific, and educational values. Wetlands can exist in salt water, mixed salt water and freshwater, or purely freshwater environments. Freshwater wetlands may appear in the form of small inland open water bodies or water bodies contained within river channels and may contain a variety of vegetation, including both woody and non-woody species.

Wetlands in the Central Valley

When California entered the Union in 1850, there were approximately four million acres of wetlands in the Central Valley (Dennis et al. 1984; Mitsch and Gosselink 1986). By 1939, 85 percent of the original wetlands in the Central Valley had been lost. By the mid-1980s, only nine percent of the original acreage, or 360,000 acres, remained. Most of the wetland loss was a result of the conversion of land to intensive agriculture, and construction and maintenance of flood control channels. Indeed, one reason why the Central Valley is such a rich agricultural area is that its crops are planted on former wetlands that have been drained, leveled, and filled.

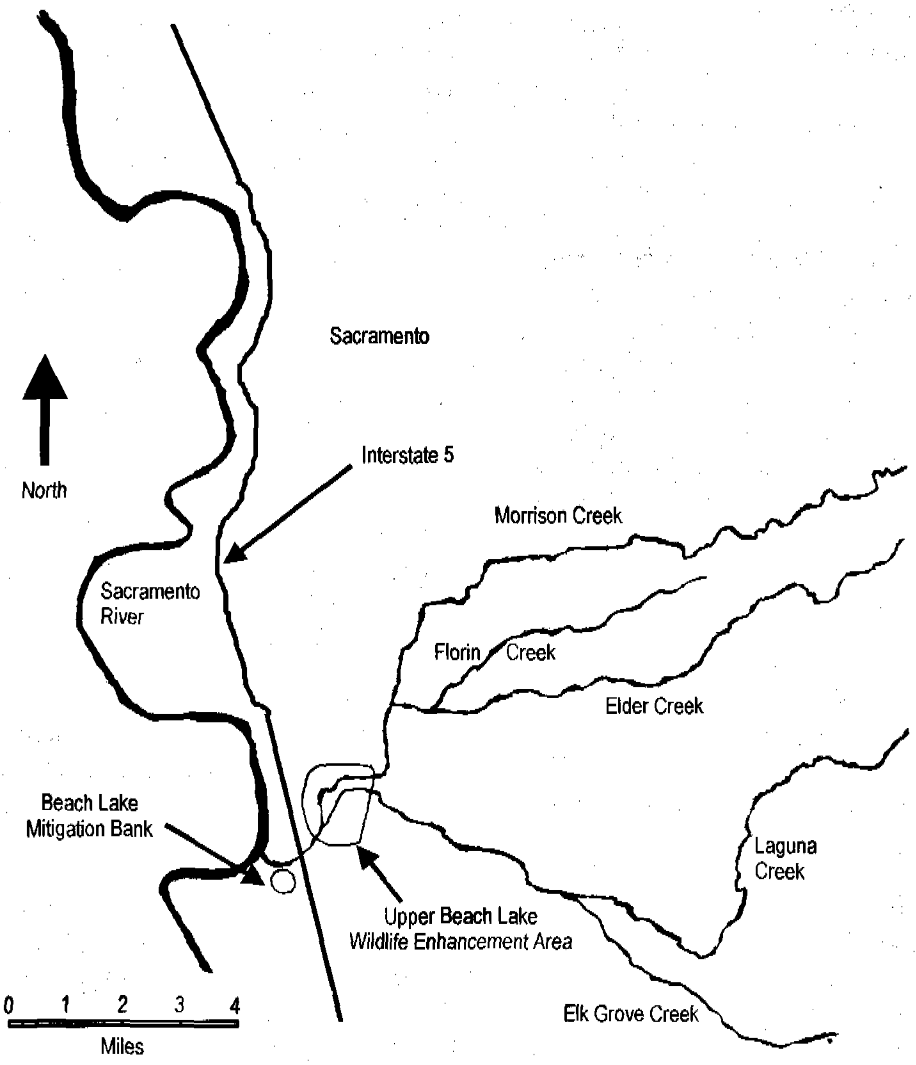
The wetlands in the Central Valley—primarily of the freshwater type—remain important wintering grounds for Pacific Flyway waterfowl, with approximately 60 percent of the ducks, geese, and swans of the Flyway using the Valley wetlands during the winter. The U.S. Fish and Wildlife Service (USFWS) and other government agencies have recognized the need to enhance existing habitat for these and other waterfowl. In its 1976 Concept Plan for Waterfowl Wintering Habitat Preservation, the USFWS established guidelines for implementing the federal Migratory Bird Land Acquisition Program. This concept plan, in combination with the 1987 Presidential Executive Order 11990 that established the policy of avoiding or minimizing adverse impacts to wetlands, led to the generation of the Central Valley Habitat Joint Venture Management Plan in 1988. In this management plan, a number of public and private entities established a goal of increasing the population of Central Valley wintering waterfowl to 1970 levels of 4.7 million ducks and 865,000 geese and swans, through habitat enhancement and restoration on more than 930,000 acres. As part of that effort, the Beach/Stone Lakes area was targeted for significant wetland restoration (USFWS 1992).

Beach/Stone Lakes Basin

Both the Upper Beach Lake Wildlife Enhancement Project and the Beach Lake Mitigation Bank are located in unincorporated Sacramento County in the Beach/Stone Lakes basin (Figure 19-1). This basin was historically flooded for long periods of time in the winter and spring as a result of overbank flooding from the Sacramento River, backwater flooding from the Cosumnes and Mokelumne Rivers, and some flooding from Morrison and Laguna Creeks (Caltrans 1998). Water is currently stored in North and South Stone Lakes, Upper and Lower Beach—which are divided by the Beach Lake dike and, together, make up historic Beach Lake—and, during high water periods, Stone Lake and Snodgrass Sloughs (Caltrans 1998). Morrison and Laguna Creeks were intermittent under natural conditions but, with return flows from lawn irrigation and the discharge of urban wastewater into the creeks from upstream users, there is now a low summer flow.

The major land uses in the project area are agricultural, with a variety of orchards, vineyards, croplands, livestock grazing, dairies, and feedlots in operation (USFWS 1992). The area contains a number of urban developments that amount to less than one percent of Sacramento County's population.

Figure 19-1
Beach/Stone Lakes Basin in Southern Sacramento County



Source: Adapted from Caltrans 1994

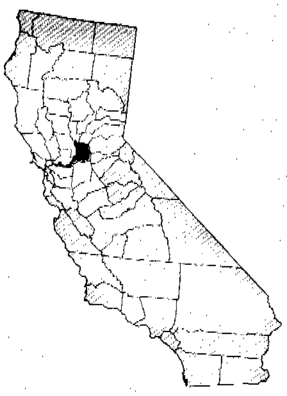
The Projects

Upper Beach Lake Wildlife Enhancement

History and Approaches

In 1978, the Sacramento Regional County Sanitation District (SRCSD) began construction of its Regional Wastewater Treatment Plant in southern Sacramento County. In the mid-1970s, SRCSD planned a 2,500-acre undeveloped "buffer" area between its treatment plant and the surrounding neighborhoods to guard against urban encroachment and minimize potential odor nuisances. They passively managed this area, known as the Bufferlands, for nearly two decades. During that time urbanization continued around the Bufferlands, and today developed communities extend to the Bufferlands boundaries (Jones 1998).

In 1989, the SRCSD board of directors, after considering various uses for the Bufferlands property (including an amusement park),



decided to pursue habitat restoration. They hoped that restored wetland and riparian habitat would not only benefit waterfowl and mammalian species, but also the residents of the surrounding communities. Thus, they joined with the Western Sanctuaries Office of the National Audubon Society and the Sacramento Job Corps Training Center to develop the Upper Beach Lake Wildlife Enhancement Area. An important part of the restoration was the revitalization of the 145-acre Upper Beach Lake wetland complex, which had been severely degraded after the urbanization, channelization, and diking of its lifeblood, Morrison Creek (SRCSD 1998).

Wetland restoration in the Upper Beach Lake complex involved the creation of potholes, islands, and low, constructed levees for water flow management. The SRCSD and its collaborators realigned a section of Morrison Creek into its natural meander so it would follow its historic path through the Upper Beach Lake wetland complex. The wetlands complex itself consists of two "cells:" the east wetland and the west wetland, separated by a berm and a water control structure (Figure 19-2). Nearby Meadowlark Lake, created as a borrow pit during the construction of Interstate 5, was enhanced by forming islands and submerged shelves suitable for tules, cattails, and other aquatic vegetation. Construction was completed in 1994 (SRCSD 1998).

Since 1994, Bufferlands staff members have been actively managing the vegetation in the complex through plantings, weed control, and water management. They are aiming for a high percentage of valuable seed producers to make the area attractive to waterfowl. They have been successful to date in increasing the percentage of vegetation cover in annual smartweed (*Polygonum spp.*) and watergrass (*Echinochloa crus-galli*), both good seed-producing wetland species, while decreasing the cover of the less desirable perennial smartweed (*Polygonum amphibium*) and cocklebur (*Xanthium strumarium*) (SRCSD 1998).

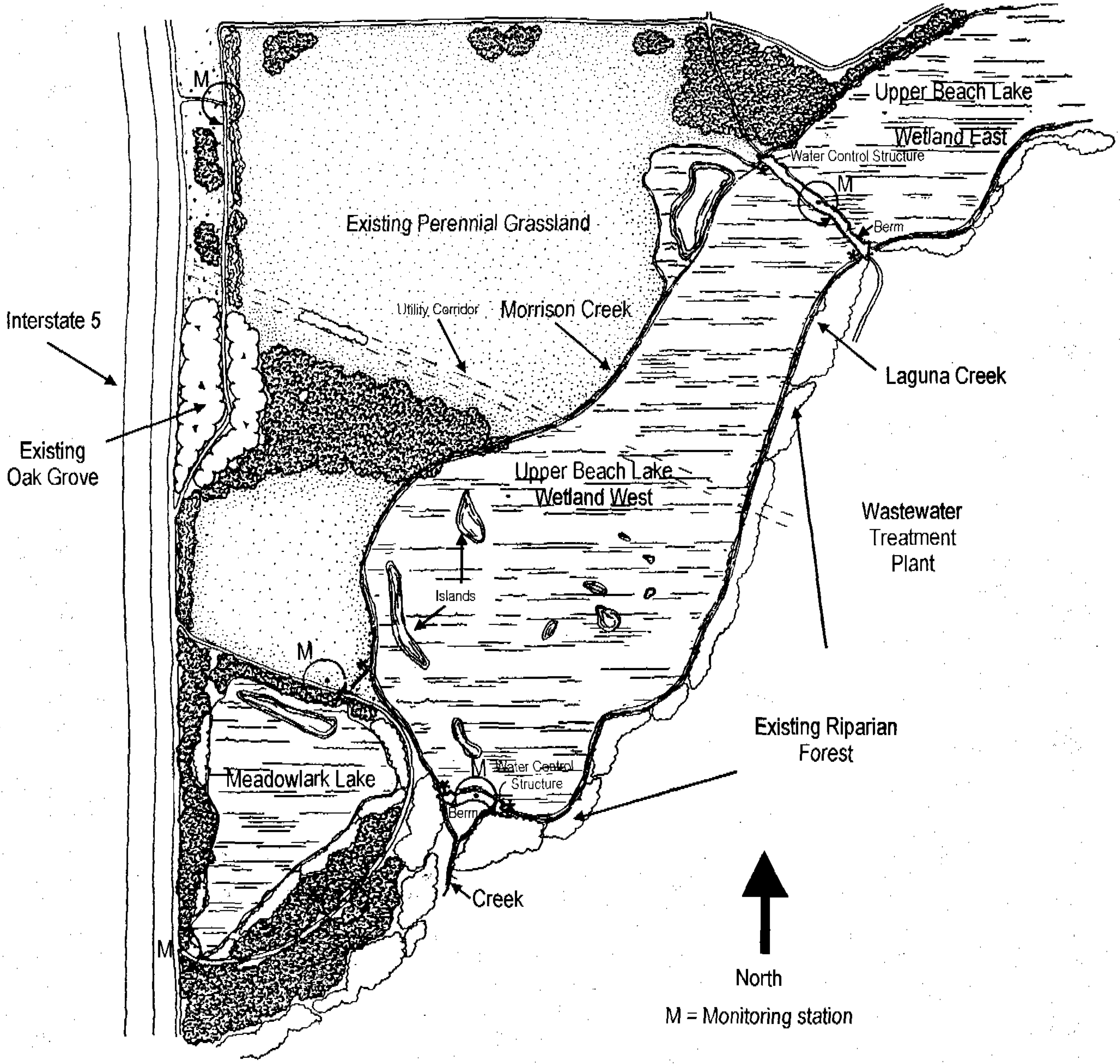
The Bufferlands managers have also been actively managing the water in the Upper Beach Lake complex to simulate the original hydrology of the system. Winter storm flows are impounded in the wetland complex and provide a suitable environment for waterfowl and other birds. During summer, water diverted from Morrison and Laguna Creeks complements low flows in Upper Beach Lake. Bufferlands staff "conserve" water by using a system that allows for gravitational movement of water from one wetlands cell to the next (Jones 1998). The water flows from the east wetland into the west wetland and drains into Morrison Creek just below its confluence with Laguna Creek (see Figure 19-2). Thus, water is used by each wetland in turn, as opposed to remaining stagnant and being lost to evaporation and groundwater seepage.

This movement of water also facilitates mosquito control, since standing water is conducive to mosquito breeding (Jones 1998). Mosquito problems are further minimized in the wetlands by stocking mosquito fish (*Gambusia affinis*), *maintaining minimum water depths, and* occasionally applying *Bacillus thuringiensis* var. *israelensis*, a biodegradable pesticide, as per the Sacramento–Yolo Mosquito and Vector Control District's guidelines.

In addition to the 145 acres of managed wetlands, there are 40 acres of unmanaged wetlands, 50 acres of perennial grasslands, 40 acres of existing riparian forest, 45 acres of restored riparian forest, and 230 acres of annual grasslands within the Upper Beach Lake Wildlife Area (Jones 1998). The perennial grasslands were planted with native California grasses, such as purple needlegrass *(Nasella pulchra)*, California meadow barley (*Hordeum brachyantherum)*, blue wildrye *(Elymus glaucus)*, slender wheatgrass *(Elymus trachycaulus)*, and creeping wildrye *(Elymus triticoides)*. Bufferlands staff members are currently evaluating these and other native species to determine cost-efficient ways to restore large parcels of grasslands elsewhere.

Riparian forests were restored after an inventory in 1992 revealed that less than 40 acres of mature riparian forest remained intact on the Bufferlands. More than 10,000 young trees—including valley oak, elderberry, box elder, Fremont cottonwood, and several species of native willows—have since been planted on the property and are now thriving. In some

Figure 19-2
Upper Beach Wildlife Enhancement Project Site



Source: SRCSD 1998

areas, the simulated natural flow of the creek has provided the conditions necessary to make the trees naturally sprout and grow.

An important part of the Upper Beach Lake Wildlife Enhancement Project was the involvement of the Sacramento Job Corps Training Center. The Job Corps, a vocational training program for inner city youth, recruited 150 people to work on Upper Beach Lake. As a result of their work on the project, Job Corps participants learned skills related to surveying, carpentry, and heavy equipment operation, as well as the fundamentals of biology, ecology, and stream and wetlands restoration (National Audubon Society 1998).

Restoration Results

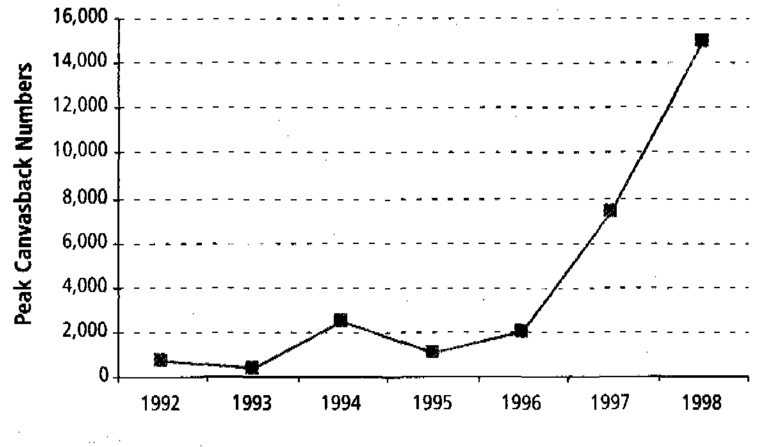
As mentioned above, the Upper Beach Lake Wildlife Area has successfully increased coverage of valuable seed-producing vegetation. Restoration improvements have also been noted for wildlife, in particular the main beneficiaries of wetland restoration: waterfowl. Since the completion of construction in 1994 there have been increases in canvasback, wood duck, great blue heron, and great egret use of the complex (Figures 19-3–5). Other species, although not measured, have surely benefited from the wetland management.

Costs

The construction and implementation costs for the Upper Beach Lake project total approximately $130,000 and were funded by the Packard Foundation, the Whitecap Foundation, and grants from the California Environmental Protection Agency (Gilbert 1998). The National Audubon Society coordinated the funding for the project. Ongoing maintenance of the wildlife area is part of the overall property management of the Bufferlands and is funded by appropriations in the SRCSD budget (Jones 1998).

Figure 19-3

Peak Canvasback Numbers at Upper Beach Lake Wetlands Complex, 1992 to 1998



Source: SRSCD 1998

Other Bufferlands Projects

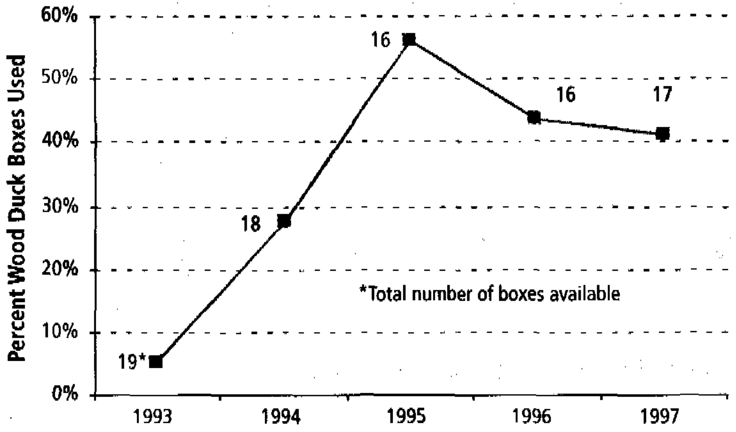
Beyond the Upper Beach Lake Wildlife Area, Bufferlands staff members have begun the expansion of riparian forest along two nearby creeks and developed a pilot constructed wetlands demonstration project as well. The constructed wetlands project, on-line since 1993, consists of 10 treatment cells that treat one million gallons per day of secondary-treated and UV-disinfected wastewater from the SRCSD plant (Perry 1998). The project has been successful in removing metals and nitrates from the wastewater, developing a fate and transport model for metals, and developing an understanding of mosquito control. Also, research at the facility has shown that the 22-acre project produces high quality bird habitat, with several species being observed there for the first time in Sacramento County. The facility is currently operating in its final pilot year; options for continued operation include maintaining the constructed wetlands as an educational and research site, or using the facility to produce high-quality reclaimed water for use in the Stone Lakes National Wildlife Refuge (Perry 1998).

Beach Lake Mitigation Bank

History and Approaches

In the mid-1970s the California Department of Transportation (Caltrans) purchased 142 acres adjacent to SRCSD's Bufferlands to provide a right-of-way for Interstate 5. Nearly two decades and much wetland litigation and policy-making later, Caltrans began negotiating with state and federal agencies to develop guidelines to use the property as a wetland mitigation bank. They aimed to fully restore the habitat on the property and then, as mitigation for small adverse wetland impacts became necessary for other Caltrans projects in the future, dedicate an appropriate portion of the mitigation bank to off-site habitat mitigation (Caltrans 1993).

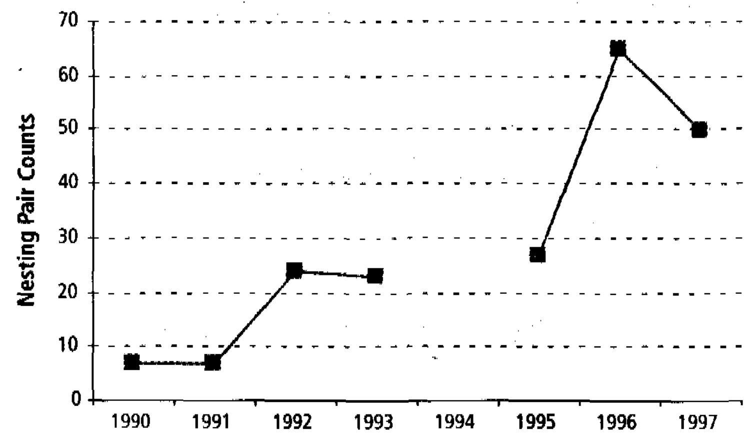
Figure 19-4
Percentage of Wood Duck Nest Boxes Used at Upper Beach Lake, 1993 to 1997



Source: SRSCD 1998

Such a bank would give Caltrans a cost-effective means to fulfill its obligations under Section 404 of the Clean Water Act and would also reduce the uncertainty of successful replacement of lost habitat values, since the bank would have to be successfully restored before "debiting" could occur. In addition, the wetland mitigation bank would make more ecological sense than a collection of smaller, scattered mitigation sites since it would generate a contiguous patch of restored wetland habitat (Caltrans 1993).

Figure 19-5
Great Blue Heron and Great Egret Nesting Pair Counts at Upper Beach Lake



Source: SRSCD 1998

A farmer had been leasing the Caltrans property from year to year since the 1970s. In 1991 and 1992 the farmer left the land fallow, intending to leave it fallow indefinitely, and Caltrans terminated the lease in 1992 (Wyatt 1998). Before construction for the mitigation bank proceeded, the Natural Resource Conservation Service determined that the conversion of the 142 acres of farmland—130 of which were "prime" or "unique" farmland[1]—into wetland and riparian areas was not significant. Of the 142 acres total, the U.S. Army Corps of Engineers determined that 39 were wetlands according to the Section 404 definition—or "regulatory" wetlands—that could not be farmed anyway. Archeological studies showed an additional 4.5 acres to be of historic importance that would have to be excluded from future farming as

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[1] Prime farmland is the highest quality farmland and has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Unique farmland is farmland with lesser quality soils, but it is nonetheless used for producing California's leading agricultural crops. The California Department of Conservation uses these designations in their Farmland Mapping and Monitoring Program to monitor land use changes affecting California's agricultural land. They also produce maps and statistical data used for assessing and planning California's agricultural resources (see *http://consrv.ca.gov*).

well. The Natural Resource Conservation Service deemed acceptable the conversion of the remaining 98.5 acres from farmland to a habitat mitigation bank (Caltrans 1993).

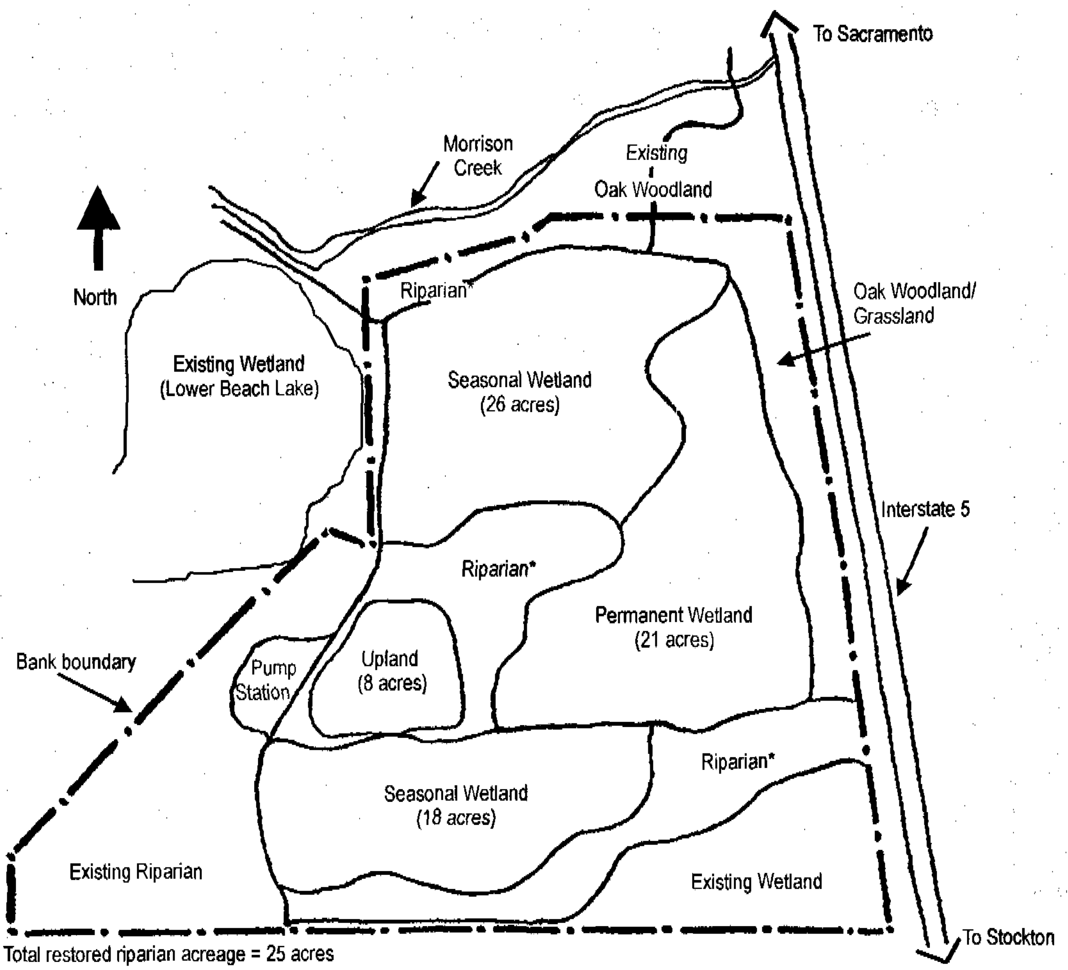
Before beginning construction, Caltrans worked with the U.S. Federal Highway Administration, the U.S. Environmental Protection Agency, USFWS, the U.S. Army Corps of Engineers, and the California Department of Fish and Game to develop guidelines for operation of the Beach Lake Mitigation Bank (Caltrans 1994). The agreement stated that debits from the bank for Caltrans projects could take place only if certain conditions were met. First, only impacts from Caltrans transportation projects in the lower Sacramento Valley and the upper San Joaquin Valley could be debited against the bank. Second, the bank could be used to replace habitat losses for "regulatory" wetlands in these regions, including both seasonal and permanent freshwater wetlands, as well as woody riparian habitat (scrub-shrub and/or forested). Habitat loss in vernal pools could not be debited in the mitigation bank. Third, the mitigation bank could not be used unless "all practicable measures to avoid and minimize resource loss [had] been incorporated into the project design" and on-site mitigation had been shown to be impractical or inappropriate (Caltrans 1994). Fourth, the bank would best be suited to mitigate impacts to less than one acre of wetland or riparian habitat, but mitigation of up to 10 acres might be considered.

Final design and construction was begun in 1994 by Ducks Unlimited, Inc. under contract to the Stone Lakes National Wildlife Refuge. They excavated soil from portions of the site (to an elevation of four feet above sea level) to bring the soil closer to groundwater tables. Some of the excavated soil was used to construct small levees within the mitigation bank and berms along the highway. The majority of soil was removed off-site for use at a city of Sacramento project site (Wyatt 1998). A pump was installed to draw water from Beach Lake. Caltrans obtained a permit from the California State Water Resources Control Board to divert water from Lower Beach Lake to the wetlands in the mitigation bank, subject to the prior rights of downstream users. Finally, Caltrans planted riparian species on 25 acres of riparian habitat. The work was completed in September 1995, with 21 acres of permanent wetlands, 44 acres of seasonal wetlands, 25 acres of riparian habitat, and 8 acres of uplands restored. The restored acreage will be managed in conjunction with 39 acres of existing riparian forest and wetlands for a total of 137 acres in the mitigation bank (Figure 19-6).

Water control is an important part of maintenance on Beach Lake Mitigation Bank. Although the area naturally floods every year, which causes groundwater levels to rise, water in the wetlands must be supplemented starting in September by pumping water from Lower Beach Lake. Approximately 260 acre-feet or less are annually pumped into the wetland units in the mitigation bank and then circulated back into Upper Beach Lake. The small levees, along with alfalfa valves and flashboard structures, facilitate water control. Maintenance of vegetation is also important, and involves infrequent mowing and shallow disking in seasonal wetlands to induce disturbance and the initiation of successional processes (Wyatt 1998).

Since construction was completed in 1995, Caltrans has debited impacts from two nearby projects against the Beach Lake Mitigation Bank. The first project involved the construction of a highway interchange. Since some, but not all, of the project mitigation could take place on site, Caltrans mitigated the remaining one-half acre of project impact by debiting one acre against the Beach Lake Mitigation Bank. For the second project—construction of a median—there was no space for on-site mitigation, so Caltrans mitigated 0.33 acres of shade impact with one acre in the Bank. A third project involving road widening is in process and will require 0.34 acres of impact to be mitigated with 0.68 acres in the mitigation bank. No on-site mitigation will be possible because the project area—located in the Alder Creek drainage near Lake Natoma—is already being restored by the U.S. Bureau of Reclamation (Wyatt 1998). At this rate of project impact mitigation banking, Caltrans estimates that the Beach Lake Mitigation Bank will serve to mitigate the impacts of 20 years worth of projects. Wetland mitigation for projects in other regions of California will

Figure 19-6
Beach Lake Mitigation Bank Project Area



* Total restored riparian acreage = 25 acres

Source: Caltrans 1993 and Wyatt 1998

take place in four future Caltrans mitigation banks. These other mitigation banks, currently in the planning phases, will be based on the Beach Lake Mitigation Bank model.

Restoration Results

The ratio of debited mitigation acreage to impact acreage at the project site (i.e. 2 to 1 in project one, 3 to 1 in project two, and 2 to 1 in project three) depends on the habitat type impacted and the "performance" of the habitat in the Beach Lake Mitigation Bank. Currently, one acre of riparian impact requires three acres of riparian mitigation, and one acre of freshwater wetland impact requires two acres of mitigation (Caltrans 1994). Caltrans can adjust this ratio in the future—with concurrence from the regulatory agencies—based on habitat evaluations completed annually through the first five years of the bank (1996 to 2001) and every other year thereafter.

For freshwater wetland vegetation, Caltrans measures performance using species composition, relative cover, vegetation/open water distribution, vegetation vitality, and hydrologic monitoring parameters. For the woody riparian habitat, Caltrans uses species composition, stem density, absolute cover, vegetation height, and vegetation vitality parameters. For each habitat type, Caltrans has identified "target" species; it is aiming for half of the dominant vegetation species in the mitigation bank—i.e. the species that occur most frequently during monitoring—to be target species (Table 19-1).

The vegetative cover throughout the bank has increased from sparse coverage at the time of construction to 70 to 90 percent coverage throughout the bank in 1998 (Wyatt 1998 and Caltrans 1996). Monitoring results in 1996 showed that the target species did not yet account for half of the dominant species in the bank. Since 1996 there has been an increase in the relative coverage of target species in all units of the bank; specific results are forthcoming. The seasonal wetlands satisfied the vegetative coverage criteria for mature wetlands by 1998.

Caltrans is also monitoring wildlife, including insects, birds, and mammals. Bird surveys in 1996 and 1997 consistently showed 30 to 40 species of birds present in the mitigation bank, including the threatened Swainson's hawk and the candidate tricolored blackbird.

Costs

The total project cost has been $1,823,679. Of this total, approximately $1,200,000 was used for construction, including pumps, piping, gates, and roadway improvement, and $65,000 was used for riparian plantings. In addition, $400,000 of the total was placed in an endowment to finance long-term operations, maintenance, and equipment (Wyatt 1998). Caltrans estimates that to restore one acre of wetlands in the Sacramento area outside the mitigation bank can cost $130,000, including $80,000 for site acquisition and $50,000 for restoration (Caltrans 1993). Thus, to restore 65 acres of wetlands in separate one-acre parcels outside the mitigation bank would cost a total of $8,450,000, or more than four times the cost of the entire mitigation bank.

Stone Lakes National Wildlife Refuge

A portion of the Upper Beach Lake Wildlife Area and the entire Beach Lake Mitigation Bank are located within the bounds of the recently created Stone Lakes National Wildlife Refuge.

Table 19-1
Target Species for Beach Lake Mitigation Bank Vegetation

Common Name	Scientific Name
Freshwater wetland (permanent)	
Narrow-leaf cattail	*Typha angustifolia*
Broad-leaf cattail	*Typha latifolia*
Hardstem bulrush	*Scirpus acutus*
Freshwater wetland (seasonal)	
Barnyard grass	*Echinochloa crusgalli*
Bearded sprangletop	*Leptochloa fasicularis*
Swamp timothy	*Crypsis schoenoides*
Creeping spike-rush	*Eleocharis macrostachya*
Annual smartweed	*Polygonum spp.*
Riparian woodland	
Fremont cottonwood	*Populus fremontii*
Gooding's willow	*Salix gooddingii*
Arroyo willow	*Salix lasiolepis*
California wild grape	*Vitis californica*
California blackberry	*Rubus vitifolius*
Valley oak	*Quercus lobata*

Source: Caltrans 1995

USFWS will ultimately manage the Beach Lake Mitigation Bank as part of the core area of the refuge, while SRCSD will manage the Upper Beach Lake Wildlife Area. SRCSD is currently negotiating a memorandum of understanding with the USFWS for cooperative management of the area. The Stone Lakes National Wildlife Refuge has its roots in a 1976 U.S. Army Corps of Engineers flood control study of Morrison Creek in which the Corps recommended that a National Wildlife Refuge be created in the Beach/Stone Lakes Basin of Sacramento County. While the Corps' flood control plan was never implemented, the USFWS released a draft environmental impact statement in 1990 suggesting the creation of a refuge in southern Sacramento County (USFWS 1998).

In the final environmental impact statement, released in 1992, USFWS called for an 18,000-acre area consisting of a 9,000-acre refuge under USFWS management and a 9,000-acre area under cooperative management between USFWS and other agencies. Stone Lakes National Wildlife Refuge was subsequently established in 1994 as the 505th National Wildlife Refuge. At that time, the refuge was a boundary—drawn roughly between the town of Freeport, Interstate 5, the town of Walnut Grove, and the Sacramento River—surrounding a conglomeration of public and private lands.

The goals of the Stone Lakes National Wildlife Refuge are to preserve, enhance, and restore the diverse and unique native Central Valley habitats and their associated aquatic, wildlife, and plant species; create linkages between fragmented habitats for the benefits of wildlife and plant species; and provide environmental education and recreation opportunities to the public, among others (USFWS 1998). Of major concern to local growers is the reduction in the acreage of prime agricultural land and therefore local employment and economic viability. USFWS notes that the National Wildlife Refuge will ultimately result in less than a five percent decrease in agricultural employment within the Refuge boundaries, and may result in an increase in tourism, and that the amount of farmland converted to refuge uses will be sufficiently low to be in compliance with the Farmland Protection Policy Act.[2]

Much of the work needed to build the refuge lies ahead. USFWS has only acquired fee title interest in 970 acres, including the Lewis Property (405 acres), the Lodi Gun Club (300 acres), the Galagher Property (45 acres), and the Agri-Versified property (220 acres). Discussions are underway between USFWS and private landowners regarding the donation of two properties, totaling 1,440 acres, as part of U.S. Army Corps of Engineers Section 404 permit requirements. Land acquisition is voluntary; USFWS will not use its power of eminent domain to obtain lands for the refuge from private landowners, unless the land is not actively being farmed and is not in compliance with Sacramento County's general plan (USFWS 1992).

USFWS is also working to form cooperative agreements with partner agencies responsible for managing a total of 5,239 acres within the refuge boundary. A number of these agencies are already undertaking habitat improvement efforts on these lands. In addition to the efforts of SRCSD and Caltrans, Ducks Unlimited, Inc. is working with USFWS to restore and enhance 762 acres of wetlands.

What Makes the Beach Lake Projects Successful?

Adherence to sound restoration principles formed the basis for success at both the Upper Beach Lake Wildlife Enhancement Area and the Beach Lake Mitigation Bank. Caltrans and SRCSD have restored a variety of complementary habitats, including seasonal and permanent wetlands, riparian habitat, uplands, and grasslands. Both managing agencies have emphasized the importance of "getting the hydrology right" in the project areas to facilitate vegetation and wildlife restoration. Both take an active role in the management of vegetative and hydrologic regimes through planting, mowing, disking, vegetation monitoring, and opera-

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[2] The Farmland Protection Policy Act (Public Law 97-98) was enacted to minimize the extent to which federal programs contribute to the unnecessary and irreversible conversion of prime or unique farmland to nonagricultural uses (USFWS 1992). The National Resources Conservation Service evaluates the conversion of farmlands under federal programs.

tion of water control structures.

Further, collaboration with a number of federal, state, and non-profit agencies has been critical for success. Caltrans, although the lead agency in the project, needed support and expertise from the U.S. Federal Highway Administration, the U.S. Environmental Protection Agency, the USFWS, the U.S. Army Corps of Engineers, and the California Department of Fish and Game. SRCSD, although the owners of the Bufferlands property, worked closely with both the Western Sanctuaries Office of the National Audubon Society and the Sacramento Job Corps Training Center, in addition to government agencies, such as the Sacramento-Yolo Mosquito and Vector Control District and the California Department of Fish and Game.

Caltrans and SRCSD have also employed innovative finance mechanisms. Caltrans, as part of the initial outlay, set aside a $400,000 endowment to fund future operation and maintenance needs. SRCSD, working closely with the National Audubon Society, benefited from a labor source available from and paid for by the Sacramento Job Corps, as well as funds raised from foundation sources.

The successes of the Beach Lake projects are amplified by their proximity to a regional wetlands system: the Stone Lakes National Wildlife Refuge. The fact that the Beach Lake Mitigation Bank will be managed as part of the larger refuge is, in part, what makes this mitigation bank more successful than others. The refuge, in turn, will be part of a larger corridor of wetlands (including the Cosumnes River Preserve described in *Restoring Riparian Forests,* Chapter 20) that, once fully restored, will be 13 miles long. This stretch of contiguous habitat will be more successful in the long run for maintaining waterfowl populations than a series of discontinuous patches. In addition to the habitat benefits, there will be recreational and educational opportunities within the refuge, as well as some employment opportunities and some regional flood control benefits from the detention capacity of the individual wetland basins.

Conclusions/Lesson Learned

The restoration of wetlands in the Central Valley will remain a focus of public and private agencies alike in the near future. Both cases described here illustrate positive ways in which restoration can proceed. Several useful lessons can be learned from these cases:

- Letting habitat be "natural" doesn't mean leaving it unmanaged—management of vegetation and hydrology are important for restoring damaged ecosystems.
- Wetland restoration projects, much needed because of the destruction to wetlands caused by urbanization and agriculture, can also help solve environmental problems caused by human land uses.
- The success of a single restoration project can be magnified by coordinating it with other regional restoration efforts, which requires coordination between managing agencies.
- Partnerships with the Sacramento Job Corps and other training programs can provide much needed labor for restoration projects, while supplying participants with useful construction and restoration skills.

In the Upper Beach and Beach Lake projects, completion of construction did not signify the end of restoration. SRCSD and Caltrans continue to operate their water control structures to maintain the hydrologic conditions needed by wetland vegetation, as well as to actively manage the vegetation itself. Water control structures are also important in managing the project areas for mosquito control. Understanding how to use the control structures and how to manage the vegetation requires constant surveillance and intervention. It would not be possible to achieve the same restoration results by merely diverting a creek into its old stream channel or excavating dirt and leaving the system alone since the ecosystems have been extensively altered by urban land uses.

These urban uses of land continue to influence local hydrology and ecology today. These cases demonstrate that created wetlands can help solve current problems related to urbanization, as well as head off future problems, and also help repair the historic damage caused by urban uses. The Upper Beach Lake Wildlife Enhancement Project has been important for preventing urban encroachment into the SRCSD treatment plant area, and has provided permanent, high-value habitat in the midst of a growing region. The Beach Lake Mitigation Bank will help solve problems caused by dredging and filling of wetlands during the course of highway construction—yet another consequence of urbanization. The existence of these restored wetlands in close proximity to developed areas has presented few problems with odor or safety, while at the same time has provided recreational and educational values that will further local understanding of the intricacies of wetland ecology.

The multiple benefits and restoration success of the projects would not have been possible without coordination among multiple government and private agencies. Such coordination has served to tie together separate projects from three very different agencies: a highway construction agency, a sanitation district, and a fish and wildlife conservator. Indeed, one of the most successful characteristics of the two Beach Lake projects is that they will play a part in a larger regional wetland resource that will have more ecosystem value than a series of disconnected wetlands.

Interagency coordination has also made it possible for project managers to tap into local institutional resources, such as the labor resources supplied by the Sacramento Job Corps Training Center for the Upper Beach Lake Wildlife Enhancement Project. As the Western Sanctuaries Office of the National Audubon Society notes: "With a backlog of over $1 billion in construction actions needed, national wildlife refuges may be able to take advantage of the partnership approach exemplified by Audubon and the Sacramento Job Corps" (National Audubon Society 1998). Perhaps some jobs lost from the reduction in agricultural production might be taken up by job training programs of this type.

Contacts

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Mark Perry, Wetlands Engineer, Sacramento Regional County Sanitation District

Dave Wyatt, District Biologist, California Department of Transportation

References

Caltrans (California Department of Transportation). 1993. *Initial Study and Environmental Assessment for Beach Lake Mitigation Bank.* Sacramento, CA.

Caltrans. 1994. *Agreement on Mitigation Strategy Pertaining to Implementation and Operation of the Beach Lake Mitigation Bank.* Sacramento, CA: California Department of Transportation, U.S. Federal Highway Administration, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and California Department of Fish and Game.

Caltrans. 1996. *Beach Lake Mitigation Bank: Vegetation Monitoring Results*, First Year–1996. Sacramento, CA.

Caltrans. 1998. *Revised Beach Lake Mitigation Bank Restoration Plan.* Sacramento, CA.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States.* Washington DC: U.S. Fish and Wildlife Service FWS/OBS-79/31.

Dennis, N.B., M.L. Marcus, and H. Hill. 1984. *Status and Trends of California Wetlands: A Report to the California Assembly Resources Subcommittee.* Sacramento, CA.

Frayer, W.E., D.P. Peters, and H. Ross Pywell. 1989. *Wetlands of the California Central Valley, Status and Trends: 1939 to mid-1980s.* Portland, Oregon: U.S. Fish and Wildlife Service, Region 1.

Gilbert, K. 1998. Western Sanctuaries Office of the National Audubon Society. Sacramento, CA. Personal communications.

Jones, R. 1998. Sacramento Regional County Sanitation District. Sacramento, CA. Personal communications.

Mitsch, W.J. and J.G. Gosselink. 1986. *Wetlands.* New York, NY: Van Nostrand Reinhold.

National Audubon Society. 1998. Unpublished information on Upper Beach Lake. Sacramento, CA.

Perry, M. 1998. Sacramento Regional County Sanitation District. Sacramento, CA. Personal communications.

SRCSD (Sacramento Regional County Sanitation District). 1998. Various pamphlets and unpublished materials. Sacramento, CA.

U.S. Army Corps of Engineers. 1974. *Final Environmental Impact Statement: Morrison Creek Stream Group, California.* Washington DC.

USFWS (U.S. Fish and Wildlife Service). 1992. *Final Environmental Impact Statement: Stone Lakes National Wildlife Refuge, Sacramento County, California.* Prepared by Jones and Stokes and Associates. Sacramento, CA.

—. 1998. Unpublished update on Stone Lakes National Wildlife Refuge. Sacramento, CA.

Wyatt, D. 1998. Caltrans. Sacramento, CA. Personal communications.

Restoring Riparian Forests and Natural Flood Regimes: The Cosumnes River Preserve

Anna Steding

Introduction

What do riparian forests and floods have in common? The connection may seem, at first glance, to be a tenuous one. Riparian forests don't generally make the news, while floods do. (What Californian will be able to forget the recent 1998 winter flooding, or the 1997 New Year's floods that destroyed or damaged 16,000 homes, killed eight people, and caused an estimated $1.6 billion in damage?) Riparian forests provide good habitat for wildlife and are generally viewed by humans as desirable. Floods are neither welcome as "habitat" nor welcome in human lives. There *is* a connection, however, and The Nature Conservancy (TNC), working with a number of other organizations, has figured it out on the Cosumnes River Preserve (CRP).

The original purpose of the CRP was restoration of riparian valley oak communities, but TNC expanded its initial aim to target many types of riparian plant communities. Because TNC staff recognized that habitat restoration efforts could be facilitated by restoration of natural processes, including flood regimes, floodplain management has become an important part of their work. In their effort to integrate habitat restoration with flood management, TNC has intentionally breached two levees on their property, while many others breached by floodwaters during the 1997 floods have been left in disrepair. Instead, the CRP has taken steps to "floodproof" its farming operation, reducing reliance on levees while expanding the riparian corridor, with an eye toward setting the levees back or removing them altogether. At 14,000 acres, the CRP is a conglomeration of seasonal and permanent wetlands and grazing and agricultural lands that are managed in floodplain-compatible ways. The CRP experience has helped to reinforce the notion that human uses in floodplains can be compatible with periodic inundation and that riparian forests and floods are good for each other.

Background

Floodplains and Forests

Technically, a floodplain is "the flat area adjoining a river channel [that is] constructed by the river in the present climate and overflowed at times of high discharge" (Dunne and Leopold 1978). When water overflows onto the floodplain, nutrient-rich sediment is dropped, forming a rich growth medium for vegetation. The plants that exist in this riparian zone are fast-growing, generally short-lived, and tolerate seasonal flooding. Riparian forests in California are composed of cottonwoods, willows, alders, valley oaks, and sycamores. When mature, these communities have ecosystem productivities that rival those of tropical rainforests (CSLC 1994).

Only 10 percent remains of the original 922,000 to 1.6 million acres of historic riparian forests in the state. This destruction is a result of more than 150 years of clearing and settling in floodplains, which are attractive to Californians because they offer flat land and access to water navigation routes. Because we have populated floodplains, we must now "manage" them to minimize the flooding risk to humans and human structures. For this we have traditionally turned to engineering approaches, notably levee construction,[1] to increase channel capacity and decrease the frequency of

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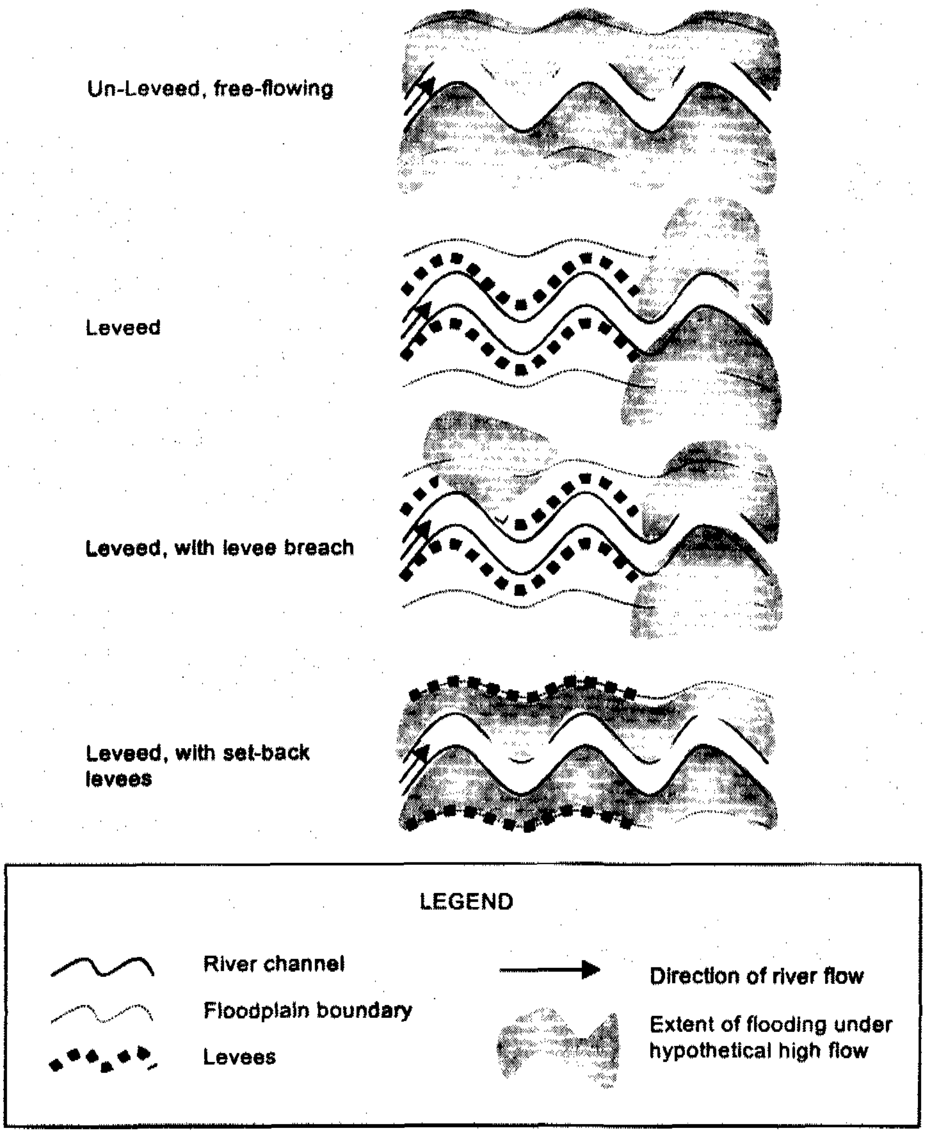
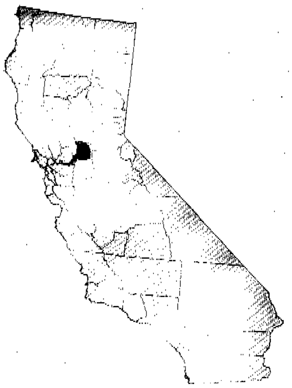
[1] Levee construction is one of many tools employed by engineers in flood control; others include channel dredging and straightening, channel diversions, and construction of dams to create either flood-detention or multipurpose storage reservoirs. We focus on levees here since they are germane to the Cosumnes River case. There are over 5,000 miles of levees in California (Mount 1995).

floodplain inundation (Mount 1995). On the one hand, levees allow agricultural or urban use of land that would otherwise be subject to periodic flooding. On the other hand, levees bring with them a false sense of security since they inevitably fail, or are overtopped by the river, inflicting damage on dwellings and human lives. The damage caused by flooding from failed or overtopped levees is generally worse than that from natural flooding alone, because levees increase the flow depth and velocity of floodwaters, and faster, deeper water is usually more destructive. Even if the levee does not fail, and flooding is controlled in the leveed section, there may be adverse impacts redirected to un-leveed sections upstream and downstream (see Figure 20-1).

Figure 20-1
Flooding Under Un-Leveed, Leveed, and "Set-Back Leveed" Conditions



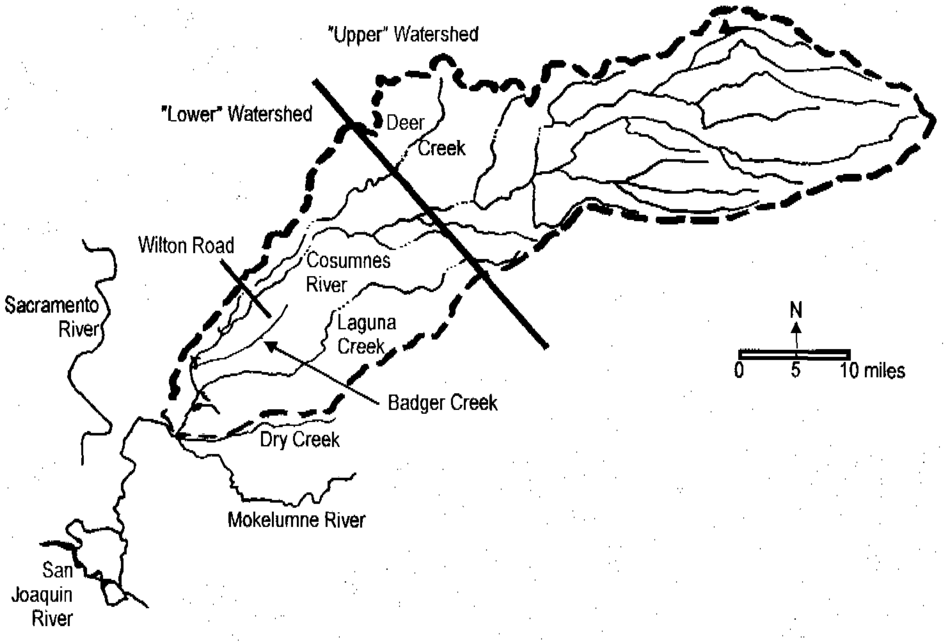
The Cosumnes River



The Cosumnes River (see Figure 20-2) is the last "unregulated," or dam-free,[2] river flowing from the Sierra Nevada to the Central Valley (Reiner 1995). It originates in Amador County at 7,000 feet and drains 1,265 square miles before it joins the Mokelumne River on its way to the San Joaquin River (PWA 1997). The major land uses in the watershed are timber harvesting, mining, agriculture, and grazing. Timber harvesting accounts for 20 percent of the existing land use within the watershed, most of which (80 percent) occurs in the El Dorado National Forest in the upper watershed (PWA 1997). Agricultural uses are dominant in the lower watershed. Only 10 percent of the watershed is urbanized, with urban and residential development concentrated in its lower portion.

An extensive levee system, built in the 1930s, has had the effect of isolating the river from nearly all of its floodplain area (PWA 1997). The upper alluvial reach of the lower Cosumnes (above Highway 99) has been particularly constrained with levees (Figure 20-3).[3] The levee system has caused significant lowering, or degradation, of the river channel in many places.[4] Channel degradation has led, in turn, to loss of riparian vegetation, aquatic

Figure 20-2
The Cosumnes River Watershed



Source: PWA 1997

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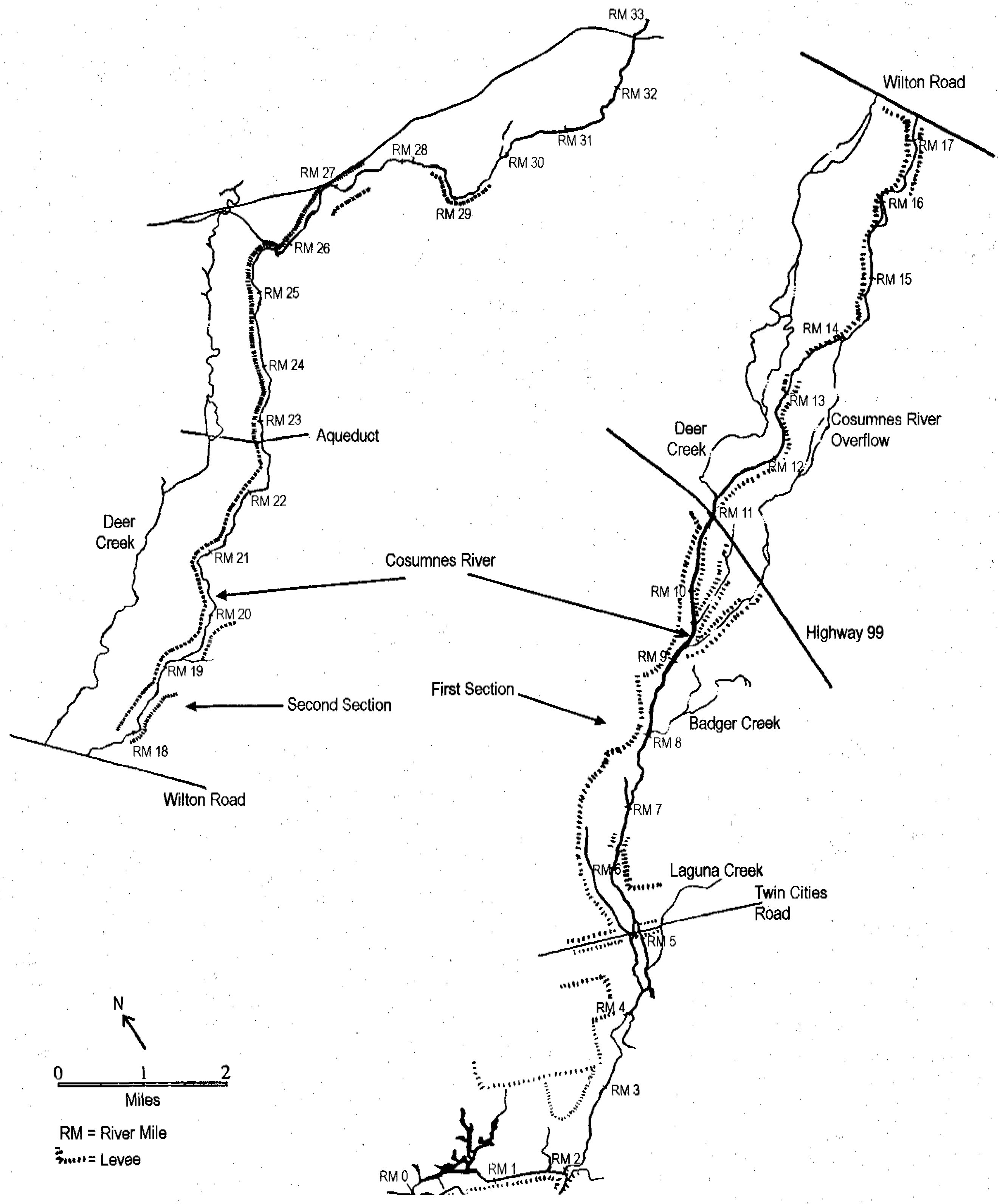
[2] The main stem of the Cosumnes is free of dams. There are two small dams and a diversion tunnel on tributaries in the watershed. In the upper watershed, the U.S. Bureau of Reclamation operates the Sly Park dam on Sly Park Creek (a tributary of the Cosumnes River) and a low diversion on Camp Creek (also a tributary of the Cosumnes River) as part of the Central Valley Project. Sly Park-Camino Conduit delivers water from the reservoir behind Sly Park dam to the El Dorado Irrigation District for agricultural and municipal uses (PWA 1997).

[3] Of the 22 miles of the lower Cosumnes between Dillard Road and Twin Cities Road, 71 percent of the right bank and 16 percent of the left bank is levied (PWA 1997). In addition, between Twin Cities and the Mokelumne River confluence, there are 2.2 miles of levees on the right bank.

[4] Levees, because they confine the river channel and restrict channel flow, cause an increase in energy slope—the total energy head of the flow as a function of elevation, depth, and velocity—and flow depth in the channel. An increase in energy slope and flow depth cause, in turn, an increase in shear stress—or tractive force—on the river bed, which augments the channel's capacity to transport sediment. Because the channel can transport more sediment, it takes that sediment from the channel bed, thereby eroding it and causing it to lower, or degrade (Dunne and Leopold 1978).

Figure 20-3
Extent of Levees on Lower Cosumnes River



Source: PWA 1997

habitat diversity, and spawning gravels. In the lower floodplain (below Highway 99), the river has been constrained by low levees that are designed to protect agricultural fields but are frequently overtopped. Many growers in this area have become accustomed to flooding, and have often adapted by planting few winter crops and leaving stubble in their fields for erosion protection (PWA 1997).

The Nature Conservancy

Founded in 1951 by a group of professional ecologists, The Nature Conservancy (TNC) is a non-profit organization that seeks to preserve "habitats and species by buying the lands and waters they need to survive" (TNC 1997). TNC works with "willing sellers and donors" to protect land through gifts, exchanges, conservation easements, management agreements, purchases from TNC's revolving Land Preservation Fund, debt-for-nature swaps, and management partnerships. To date, TNC has protected 9.5 million acres of land in the U.S. It currently runs 1,500 preserves and owns or has under conservation easement[5] 1.3 million acres.

The Cosumnes River Preserve

History and Approaches

In 1984, TNC acquired, with the intent of preserving, 86 acres of riparian oak forest on the Cosumnes River (Reiner 1995). TNC selected the land because it was one of the healthiest stands of valley oak in the entire Central Valley and would help meet its goal to "preserve some healthy remnant examples of mature valley oak [*Quercus lobata*] riparian forest" (Eaton 1997). Early restoration efforts "focused on active measures: construction and management of ponds for waterfowl and planting by hand, using volunteers and school children, of oaks and other species" (Eaton 1997). Two events since 1984 have been instrumental in changing the "active" approach originally taken by TNC.

The first event occurred in 1985, when high floodwaters caused levee failure and inundation of a 150-acre field adjacent to TNC property, covering 15 acres of farmland with sand and organic debris. The owner of the farmland repaired the levee but decided not to go to the expense of removing the sand and debris. He left this area uncultivated after inundation, which led to the germination of "fast-growing native tree and shrub species, primarily cottonwood and willows" (Christensen 1997). Within a year, an "accidental forest" of cottonwood trees, Oregon ash, and willow thickets was established, and valley oaks followed within a few years.

The second event occurred in 1990, after formal dedication of the CRP in 1987, when TNC began welcoming partnerships with other agencies (see sidebar). The creation of partnerships with these agencies has been crucial to the success of the CRP, but it has not always been easy to reconcile conflicting interests and goals (Reiner 1995). For example, after meeting with Ducks Unlimited, its first partner, TNC realized that each organization had a different philosophy. While Ducks Unlimited was primarily interested in maintaining seasonal wetlands for the purpose of maintaining healthy waterfowl populations, TNC had focused on restoring riparian oak forest. Only when the staff of each organization could see that there were "strong common threads" in both visions—namely, the restoration of riparian habitat generally—did they work together successfully (Reiner 1995). A similar learning process took place at the beginning of each partnership.

Thus, the goals for the CRP have expanded to include preservation of habitats of many types; protection of endangered species of wildlife and plants; and protection of habitat and wintering grounds for migrating waterfowl and shorebirds in the Pacific Flyway (MOA 1996). The restoration of flood regimes is also a goal for the CRP, and is viewed as a means to accelerate habitat restoration: a cost-benefit analysis showed that benefits achieved from planting trees by hand were not justified compared with the "natural" regeneration that was

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[5] A conservation easement is an interest in land owned by another that entitles its holder to use of that land for conservation purposes.

Partners in Cosumnes River Preserve Management

(in chronological order of partnership)

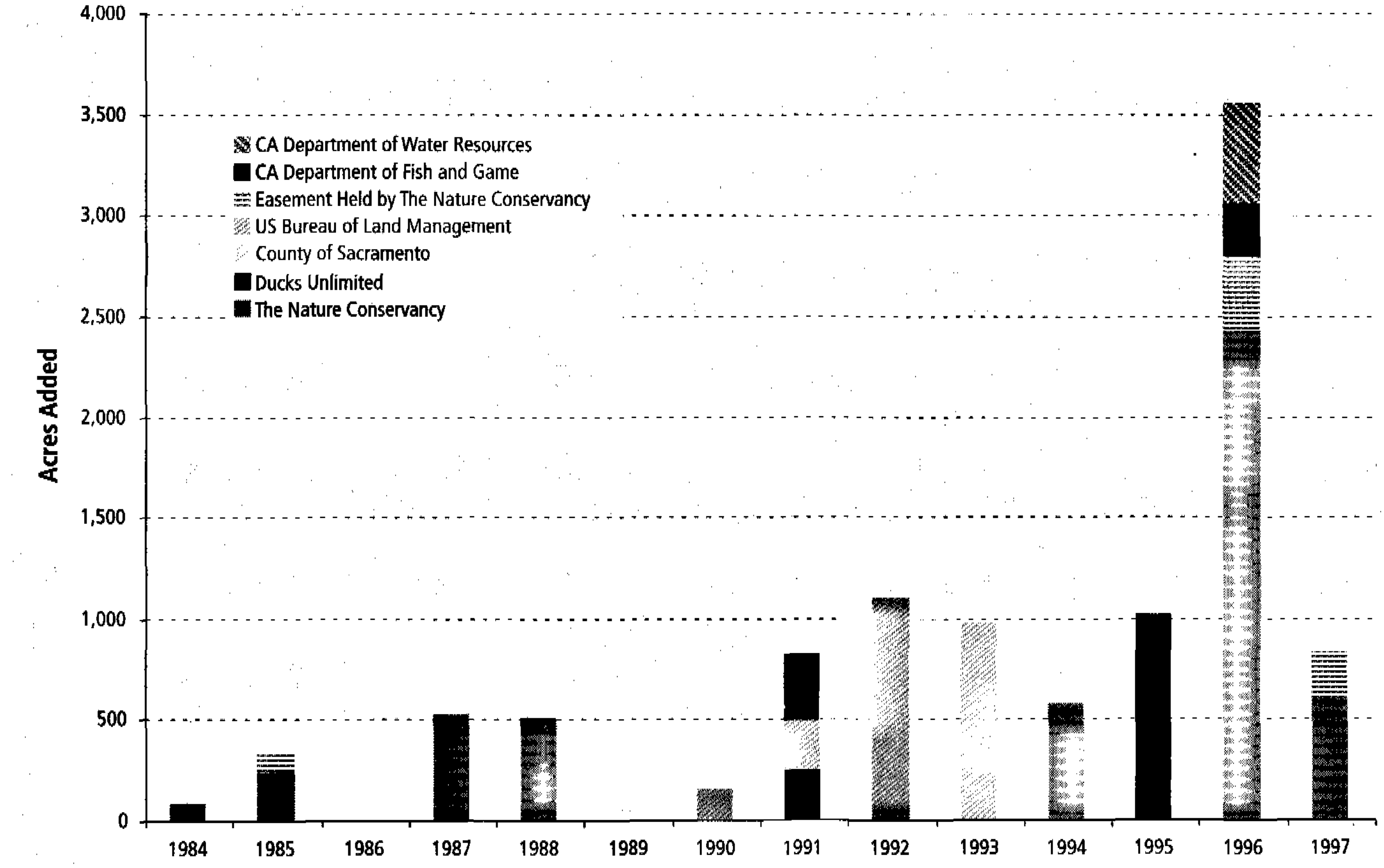
The Nature Conservancy
Ducks Unlimited
Wildlife Conservation Board
California Department of Fish and Game
Bureau of Land Management
Sacramento County
American Farmland Trust
California Department of Water Resources
Living Farms

Source: Reiner 1995

occurring in the "accidental forest" (Eaton 1997). To facilitate other "accidental" forests, TNC aims to increase the land area subjected to regular flood inundation and halt long-term degradation in the river channel (PWA 1997).

To make all of this work possible, TNC and its partners have continued to purchase, coordinate the purchase of, and secure conservation easements on tracts of land along the Cosumnes River (Figure 20-4). They envision a preserve of 30,000 acres, consisting of riparian forest, seasonal and permanent wetlands, and land for grazing, farming, and other human uses. They continue to rely on volunteer labor, particularly for monitoring activities, which are an important part of CRP operations. A variety of parameters, from waterfowl counts to wetland vegetation, butterflies, aquatic macroinvertebrate populations, and wildlife, are monitored regularly by CRP staff, volunteers, and affiliates.

Figure 20-4
Cosumnes River Preserve Property Acquisition, 1984 to 1997



Source: TNC 1997

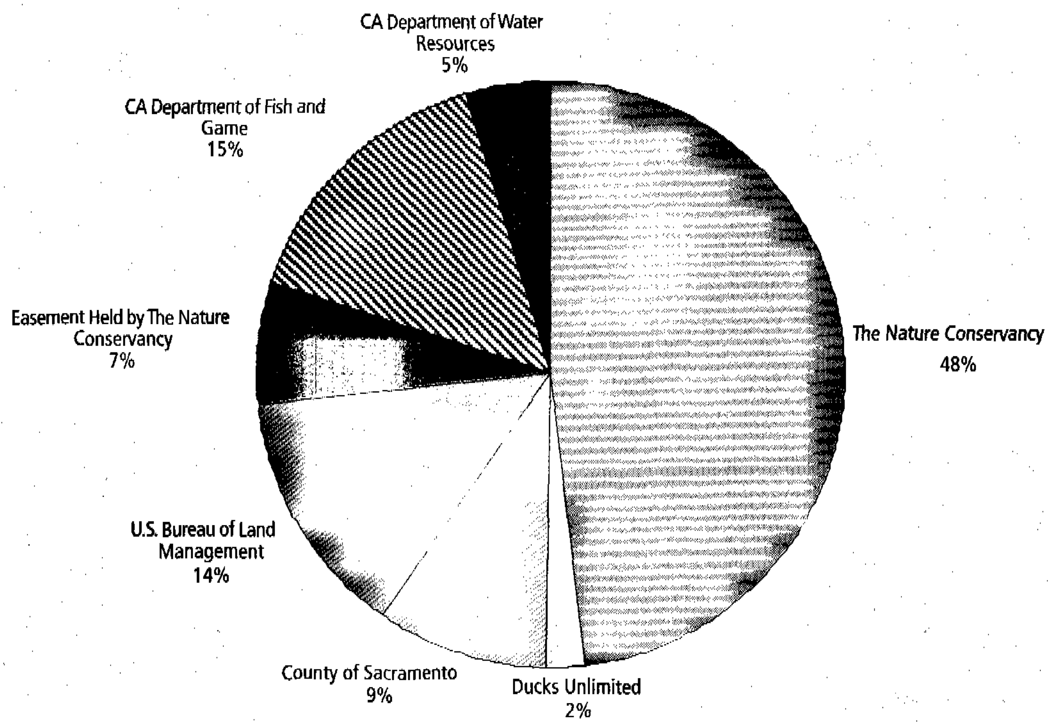
Results

As of 1998, the CRP encompasses 14,000 acres. TNC owns approximately 50 percent of this land, while the remainder is shared among the California Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Land Management, County of Sacramento, and Ducks Unlimited (see Figure 20-5). The purchase of this land has allowed the CRP to meet its complementary goals of improving the health of riparian and wetland ecosystems and moving toward the restoration of flood regimes.

As of 1994, volunteers at the CRP had helped plant 150 acres of new valley oak forest. Currently, there are 1,900 acres of riparian forests on the CRP (see Table 20-1). In addition, there are approximately 3,000 acres of managed seasonal and permanent wetlands and 4,750 acres of rangelands, for which a formal grazing management plan is being prepared. Preserve managers are hopeful that the cattle will help reduce invasive weeds and improve vernal pools on the CRP, as has been the case on other grasslands in the Cosumnes River watershed (Reiner 1995). At the same time, fences exclude cattle from sensitive riparian areas. A fence has already been erected along Badger Creek, which runs through one of the largest grazing units, to create an ungrazed riparian corridor (Cooper 1998).

Apart from 900 acres of "other" lands, the remainder of the CRP is devoted to agriculture. On a 1,000-acre farm operated since 1996 by Living Farms, organic rice fields and cattle pastures are rotated on a regular basis. The irrigated pastures are planted with nitrogen-fixing clover to become more fertile before they are planted with organic rice. The organic rice fields are kept in production until aquatic weeds become a sufficient nuisance, and then are returned to pasture (Reiner 1995). The combination of rice and pasture provides excellent habitat for a number of waterfowl, from sandhill cranes to Tundra swans, which feed on

Figure 20-5
Cosumnes River Preserve Property Ownership



Source: TNC 1997

Table 20-1
Acreage in Cosumnes River Preserve, by Type

Land Use	Approximate Acreage (as of 1997)	Percent of Total Preserve Land	Management Prescriptions
Riparian Forest	1,900	16	• Maintain existing forests • Restore additional forests
Seasonal Wetlands	1,000	8	• Maintain existing wetlands • Establish additional wetlands
Permanent Wetlands	2,000	17	• Establish and manage wetlands • Maintain and restore forests
Grazing	4,750	39	• Maintain grasslands and vernal pools
Farming	1,500	12	• Maintain compatible agriculture
Other Areas	900	7	• Monitor local land-use policies • Monitor local property owners and developers • Undertake or promote limited development where appropriate

Note: Total for percent column does not equal 100 because of rounding.
Source: Reiner 1997

leftover rice kernels in the fall. The waterfowl, in turn, improve the productivity of the fields by churning rice straw and their own manure into the soil, which are broken down by microbes to produce rich organic matter (see *Winter Flooded Fields Benefit Farmers and Wildlife,* Chapter 18).

The different sections of the CRP provide a variety of habitats that attract numerous wildlife and waterfowl. For example, the numbers of wintering waterfowl on the CRP have increased over the past nine years. In January 1989, less than 12,000 waterfowl were counted, compared with 28,962 in January 1995, 17,814 in January 1996, 79,424 in January 1997, and 78,694 in January 1998 (Brink 1998). The dramatic increases seen in 1997 and 1998 are partly a result of the operation of the organic rice farm.

The restoration of habitat has occurred concurrently with the restoration of flood regimes. In October 1995 CRP staff, with the help of a Caterpillar D-9, deliberately breached a levee to create an "intentional forest." Within two years, healthy stands of cottonwood and willow trees encircled the original "accidental forest," so that a total of 100 contiguous acres of Cosumnes River bottomland had been re-opened to natural flood processes (Eaton 1997). Another levee—this time constructed to protect a 250-acre farm field—was breached in late 1997. The levee breaching was coupled with the construction of a new low levee designed to keep floodwaters from late spring to early fall storms off of actively farmed fields, and "floodproofing" measures to protect pumps, irrigation ditches, selected roads, and other farm infrastructure. The levee breaching, in conjunction with the low levee, added 90 acres to the active riparian zone of the river and allowed the CRP to avoid repairing historic levees damaged in the January 1997 storm (Eaton 1998). Both the accidental and intentional levee breaches, in addition to having habitat benefits, have reinforced the notion that it is better to "live with the river rather than fight it" (Reiner 1995).

When 23 additional levee breaches occurred on the Cosumnes during the 1997 floods, local, state, and federal officials opted to repair them, although there was some talk of levee set-backs (Eaton 1998). Levees on the CRP, however, were not repaired. Major damages, notably the inundation of 84 homes and 33,000 acres of crops, occurred along the Cosumnes where existing levees were breached and overtopped, but not in the accidental forest and intentional forest zones (for the obvious reason that the use of the land in those floodplains is compatible with flood waters). Although the commitment to traditional approaches is deeply ingrained, the experience on the Cosumnes River Preserve has helped promote the acceptance of new approaches. "People are realizing that with levee set-backs—actually moving them back from river banks—there would be a larger, more natural floodplain that probably could have handled even this big flood" (Christensen 1997).

Studies are under way for further levee breaching and set-backs (PWA 1997). Levee alteration would occur only in places where floodplain inundation "would not threaten homes, crops, or livestock, and where property owners are willing to participate" (CBC 1997). Levee modification in any stretch of the Cosumnes River, however, will have the effect of increasing "floodplain conveyance and storage and reduc[ing] the reliance on levees, thereby reducing the risk of levee failure and decreasing future levee maintenance requirements" for the entire river (PWA 1997). This is particularly important for urban areas downstream of leveed sections where flooding is generally worsened by the constriction of flood flows upstream (see Figure 20-1).

Why is the Cosumnes River Preserve a Success?

CRP staff have shown that the ostensibly conflicting land uses of agriculture, grazing, habitat restoration, and floodplain management can, in fact, be compatible. One reason TNC and its collaborators have been successful in doing so is that they have been flexible: they have continually used new information gained through experience to adapt their philosophy and objectives. Thus, they have made the restoration of wetlands, and not just oak forest, a primary goal, and used natural processes to facilitate ecosystem restoration, in addition to small-scale vegetation plantings.

A portion of this "new information" has come from the partnerships themselves—between TNC and local, state, federal, and private organizations, including key government agencies like the California Department of Water Resources and the California Department of Fish and Game. TNC has also aimed to work closely with local landowners, most successfully with Allen Garcia, the director of Living Farms. Although other landowners play less of a role in the CRP itself, and there is no formal mechanism for taking neighboring landowners' needs into account, CRP staff do attempt to take these needs into account on an informal, but regular basis. Indeed, TNC realizes that simply purchasing large tracts of land is not sufficient for ensuring the long-term ecological health of the watershed. Rather, "healthy, productive watersheds will be sustainable into the future only when local landowners and government agencies develop a common vision, mutual goals, and shared responsibility for the entire watershed" (Reiner 1995).

The results at CRP will undoubtedly be durable: since TNC and its collaborators' rights to CRP property are protected in perpetuity, the CRP will remain intact as long as the managing organizations remain committed to their restoration and floodplain management goals. The avoidance of future flood damages, and the implementation of set-back levee schemes, will be made possible by the fact that much of the floodplain is now dedicated to natural preserve uses. Further, the CRP represents an environmentally affordable solution to floodplain management, since there are no redirected impacts from natural process restoration.

Conclusions/Lessons Learned

The importance of sensible floodplain management will grow for state water managers and planners as existing levees become increasingly unreliable and costly to maintain and the pressures for urbanization in floodplains increase in the Central Valley and elsewhere. Some important lessons to be taken from this case are the following:

- Unless relocation of flood control structures is pursued, levees will continue to be useful in stretches of rivers where existing structures need to be protected;
- Human land uses can be compatible with

natural floodplain behavior as well as with riparian and wetland ecosystem needs;

- Set-back levees and levee breaches—which act as pressure relief valves for the fluvial system—should become an integral part of the floodplain manager's toolbox; and
- The most cost-effective floodplain management strategy is to keep structures out of the floodplain altogether.

It is possible that setting back and breaching levees are not feasible options for all parts of every floodplain. Where homes and other structures exist, they need to be protected by well-maintained levee systems. Nevertheless, the restoration of natural flood processes through levee breaching and levee set-backs has both riparian habitat and floodplain management benefits. Obtaining these benefits requires that human activities in the floodplain be compatible with periodic inundation. As farmers in the Cosumnes River watershed have understood for years and as the CRP has shown, these floodplain-compatible land uses include seasonal croplands and rangelands. Seeking more compatible uses of land in floodplains has environmental benefits as well, as illustrated by the increase in waterfowl that resulted from the innovative operation of the organic rice farm.

As shown in Figure 20-1, since set-back or breached levees may allow some flooding, acting as pressure relief valves in the riparian system, they may reduce the risk of flooding in downstream areas. For this and other reasons, the benefits from set-back levees are likely greater than the benefits from conventional levees, although there has been little work done to show that this is the case. With set-back levees, floodplain users enjoy downstream flood control benefits due to flood storage upstream and ecological rehabilitation of the floodplain, for the costs of new levee embankments (which can be lower than existing levees for a given design event); land; relocation; and annual inspection and maintenance. Existing, conventional levees apparently allow more intensive use of the floodplain; however, the high costs of damages when levees breach or fail, of annual inspection and maintenance, and of the loss of floodplain ecological function also need to be taken into account (Shields 1998).

In addition to having a different balance of costs and benefits, set-back levees also distribute those costs and benefits differently than conventional levees. The burden of financing flood control has historically fallen on federal, state, and local governments, and therefore the general taxpayer. These agencies have provided emergency funds to repair floor damages, and subsidized and funded the construction of levees, although we are increasingly seeing a reluctance on the part of governments to continue bearing the costs of damages in flood-prone areas. Further, emergency relief from government agencies is rarely enough to cover the entire loss inflicted by a flood. Setting back or eliminating levees shifts some of the burden of financing flood control to the landowner. In the long-run, however, non-structural solutions, or modest structures combined with good management, may well prove less costly for everyone.

The preferred floodplain management strategy, however, is to keep structures out of floodplains altogether. As TNC has illustrated by establishing the CRP in the lower Cosumnes floodplain, it is possible to dedicate—through assiduous purchase of lands and cooperation with existing landowners—non-urbanized floodplains as natural preserves and resource areas. Alternatively, or in concert with land purchase, zoning floodplains for nature preserves and other compatible uses can be an efficacious way to preserve and restore natural habitat and avoid future flood damage costs.

Contacts

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Allen Garcia, Director, Living Farms
Rich Reiner, Ecologist, The Nature Conservancy

References

Brink, H. 1998. The Cosumnes River Preserve. Galt, CA. Personal communications.

California Biodiversity Council (CBC). 1997. "Cosumnes River Habitat Inspires New Flood Control Situation." In *Biodiversity News* 4(4):1-4. Summer.

California State Lands Commission (CSLC). 1993. *California's Rivers: A Public Trust Report*. Sacramento, CA.

Christensen, J. 1997. "A Flood of Lessons." *Nature Conservancy*. July/August: 8-9.

Cooper, R. 1998. The Cosumnes River Preserve. Galt, CA. Personal communications.

Dunne, T. and L. Leopold. 1978. *Water in Environmental Planning*. New York, NY: W.H. Freeman.

Eaton, M. 1998. The Cosumnes River Preserve. Galt, CA. Personal communications.

Eaton, M. 1997. *Restoration of Natural Processes on the Cosumnes River Preserve: Overview and Status Report*. Sacramento, CA: The Nature Conservancy.

Michael Swanson and Associates (MSA). 1994. *The Cosumnes River Preserve: Hydrologic Analysis of Planned Habitat Restoration From Interstate-5 to Twin Cities Road Crossing*. Santa Cruz, CA: Mitchell Swanson and Associates.

Mount, J. 1995. *California Rivers and Streams: The Conflict Between Fluvial Processes and Land Use*. Berkeley, CA: University of California Press.

Philip Williams and Associates (PWA). 1997. *Analysis of Opportunities for Restoring a Natural Flood Regime on the Cosumnes River Floodplain*. San Francisco, CA: Philip Williams and Associates, Ltd.

Reiner, R. 1998. The Cosumnes River Preserve. Galt, CA. Personal communications.

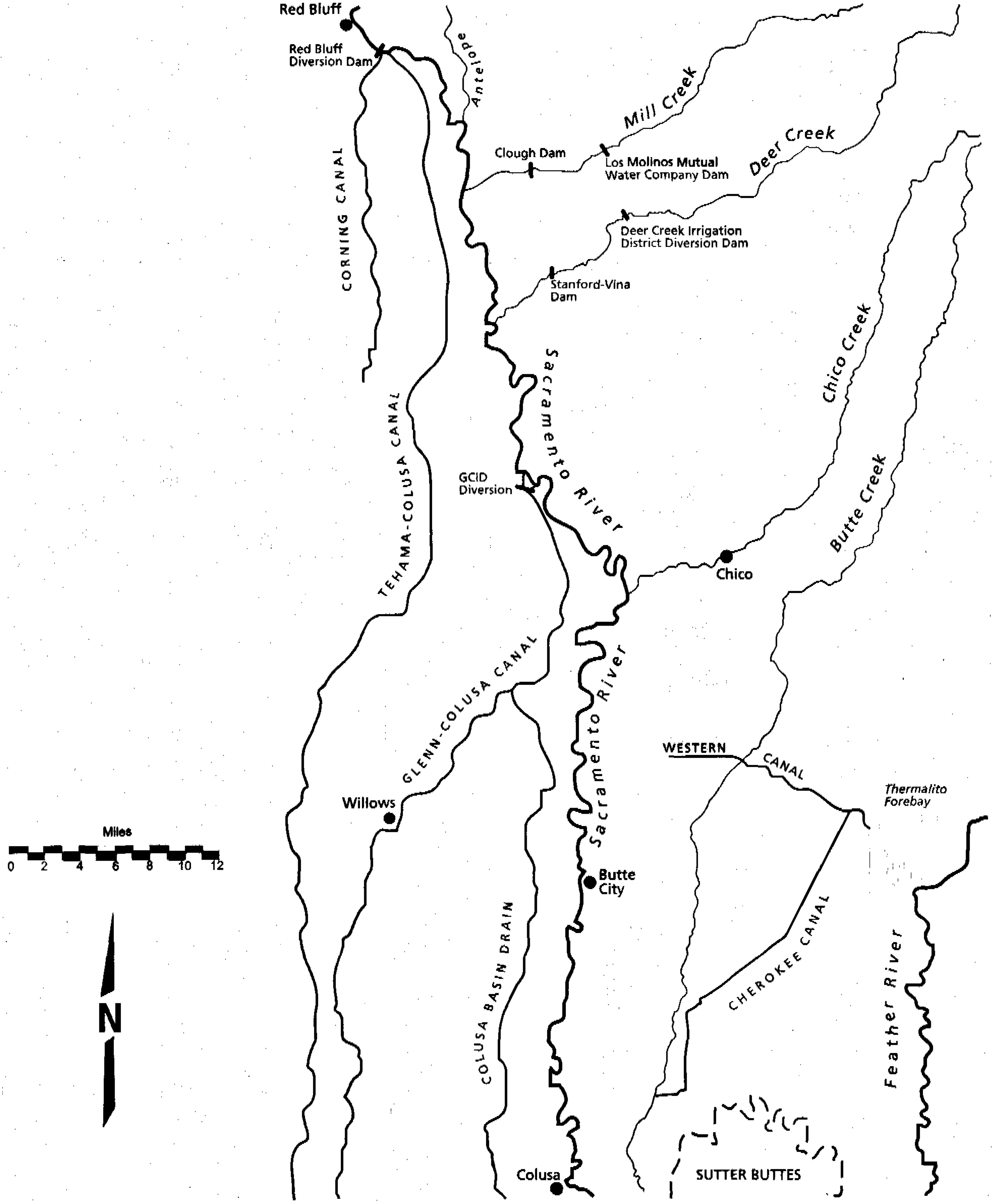
Reiner, R. 1997. The Cosumnes River Preserve. Galt, CA. Faxed communications.

Reiner, R. 1995. "The Cosumnes River Preserve: 1987-1995—Fertile Ground for New Conservation Ideas." *Fremontia* 24(1):16-19.

TNC (The Nature Conservancy). 1997. Unpublished data on acquisition of Cosumnes River Preserve lands. Sacramento, CA.

Figure 21-1

Deer, Butte, and Mill Creeks



Source: Adapted from the Upper Sacramento River Fisheries and Riparian Habitat Management Plan, January 1989, the Resources Agency

Chapter 21

Improving Passage for Spring-Run Salmon: Cooperative Efforts on Deer, Mill, and Butte Creeks

Lisa Owens-Viani and Arlene K. Wong

Introduction

Natural flows in California rivers and streams have been declining since the late 1800s and the advent of hydraulic mining and agricultural diversions. These declines accelerated when the large dams of the state and federal water projects were built, permitting even greater withdrawals of water for California's cities and farms. One consequence of these reduced flows has been the decline in the populations of California's once-abundant salmon. Along with flows, stream and river temperatures and other habitat conditions have also been altered. In recent years, numerous programs have been implemented in an effort to try to restore salmon runs. Those programs include the U.S. Fish and Wildlife Service's Anadromous Fish Restoration Program (mandated by the Central Valley Project Improvement Act), California Department of Fish and Game's 1993 plan for restoring Central Valley streams, the Resources Agency's Upper Sacramento River Fisheries and Riparian Habitat Management Plan (established by SB 1086), state proposition 204, CALFED's Ecosystem Restoration Program, and a Category III habitat improvement program established by the 1994 Bay–Delta Accord. Decade-long efforts to restore the Sacramento River winter-run[1] Chinook appear to be meeting with some success (McClurg 1998). Now spring-run Chinook, once so abundant they supported an extensive inland fishery, are the focus of intensive restoration efforts, in part in an attempt to forestall listings under the state and federal Endangered Species Acts (McClurg 1998).

Deer, Mill, and Butte Creeks are considered key habitat for the remaining wild, genetically-isolated spring-run: in other parts of the Sacramento River system, spring- and fall-run Chinook may have hybridized as early as the 1930s (McClurg 1998) and are no longer believed to be genetically distinct from one another. The upper stretches of Deer and Mill Creeks, which offer key salmon spawning habitat, have been studied by the Forest Service for designation under the National Wild and Scenic Rivers Act. Although the Service recommended that Congress designate these sections, no formal designations have been made since local conservancies succeeded in passing other legislation to protect these watersheds (Evans 1998). Similarly, the Bureau of Land Management (BLM) determined that approximately 14 miles of upper Butte Creek were eligible for Wild and Scenic status. Although the upper stretches of all three streams offer prime spawning habitat, the middle and lower reaches of all three streams remain problematic. These areas are the focus of cooperative efforts to remove obstacles and to improve flows and instream conditions for fish.

In late August 1998, the California Fish and Game Commission decided to list the spring-run Chinook as a threatened species under the state Endangered Species Act; by March 1999, a decision must be made on whether the run will be listed under the federal Endangered Species Act (ESA). Both listings could further constrain the salmon fishery industry, since it can sometimes be difficult for fishermen to distinguish spring- from fall-run (which are not listed as endangered) during the time they

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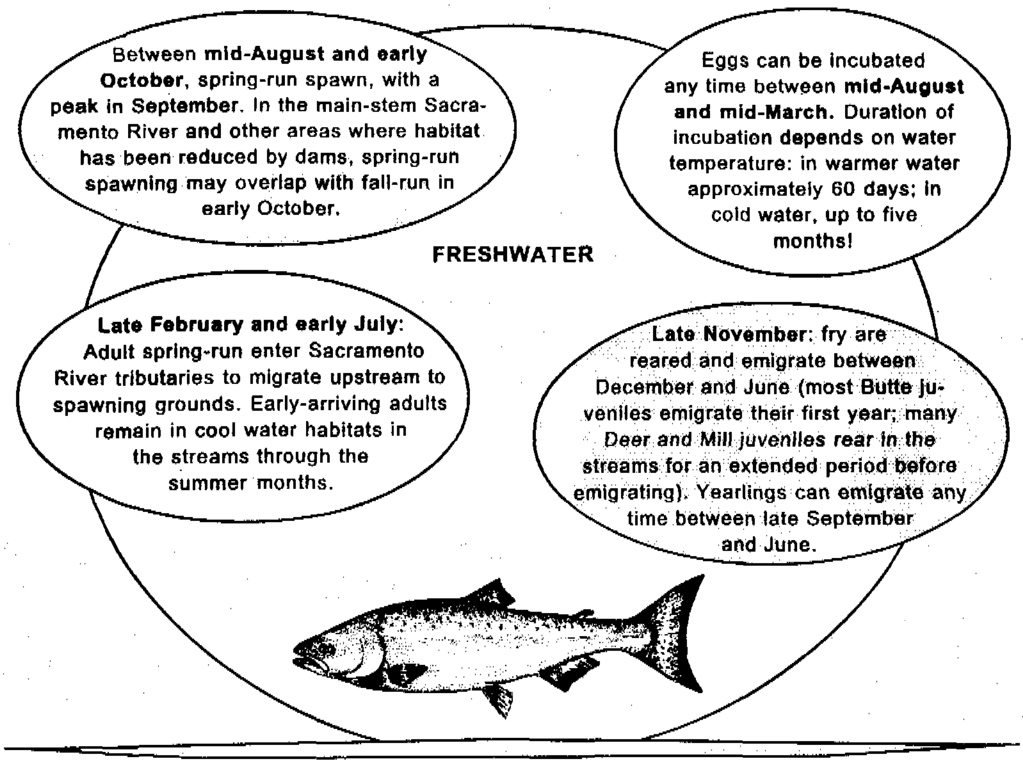
[1] The Sacramento River system has four runs of salmon that can be found year-round within the system. The runs are designated by the approximate time of year during which they pass under the Golden Gate Bridge—fall, late fall, winter, or spring—on their upstream migrations.

Figure 21-2
Life Cycle of Spring-Run Chinook At and Upstream of Red Bluff



Between **mid-August and early October**, spring-run spawn, with a peak in **September**. In the main-stem Sacramento River and other areas where habitat has been reduced by dams, spring-run spawning may overlap with fall-run in early October.

Eggs can be incubated any time between **mid-August and mid-March.** Duration of incubation depends on water temperature: in warmer water approximately 60 days; in cold water, up to five months!

Late February and early July: Adult spring-run enter Sacramento River tributaries to migrate upstream to spawning grounds. Early-arriving adults remain in cool water habitats in the streams through the summer months.

Late November: fry are reared and emigrate between December and June (most Butte juveniles emigrate their first year; many Deer and Mill juveniles rear in the streams for an extended period before emigrating). Yearlings can emigrate any time between late September and June.

During their time in the ocean (which can range from months to years), Chinook rest and mature, putting on weight before their journeys back to their native streams.

OCEAN

Source: CDFG; Chinook image from Bay Fishes of Northern California, *Mariscos Publications, 1971*

spend in the ocean.[2] Irrigation districts and farmers are concerned that such listings will require changes in dam and diversion operations to support instream needs of fish, at the expense of providing reliable water supplies to irrigators. These concerns have motivated such seemingly diverse interests as commercial fishermen, landowners, Sacramento Valley rice growers, San Joaquin Valley farmers, and state, federal, and local agencies to join together to improve spring-run habitat on these three critical salmon streams, with the hopes of forestalling listings under the Endangered Species Acts.

Motivated by the potential actions and listings by resource agencies, all of the stakeholders made Deer, Mill, and Butte Creeks the focus of some of the most innovative and collaborative efforts to improve habitat for salmon. These efforts include implementing water exchange programs (to improve instream flows), restoring spawning gravel (to improve habitat conditions), improving fish ladders (to help fish surmount instream obstacles), screening diversions (to prevent fish from becoming trapped and killed), and removing dams (to remove obstacles and improve instream flows). The following cases describe two types of successful efforts to improve instream flows—water exchanges on Deer and Mill Creeks, and dam removal on Butte Creek.

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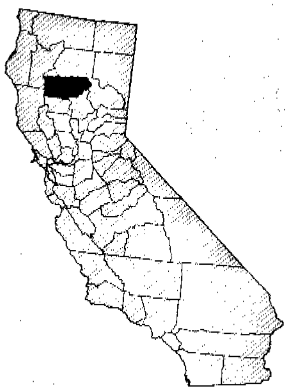
[2] Different runs, populations, and even individual fish spend variable lengths of time in the ocean before returning to their streams to spawn. Although the size of the fish and the location where they are found can sometimes differentiate the runs (attempts at protecting the endangered winter-run have been based on location), these factors are not always reliable as fish of different ages, sizes, and runs can be in the ocean at the same time.



The Projects

Deer and Mill Creeks

Introduction

Deer and Mill Creeks, located in Tehama County, historically supported and continue to support spring- and fall-run Chinook salmon and steelhead trout. These runs are among the last wild stocks in the system, and many wildlife managers fear these fish may be threatened with extinction. Of primary concern are irrigation diversions that reduce flows in the creeks, making passage difficult for fish during late spring and fall,[3] critical periods of in-migration for spawning as well as out-migration.

In the case of Deer and Mill Creeks, the California Department of Fish and Game (DFG), Department of Water Resources (DWR), and local landowners came together to fashion an agreement to provide better instream flows for fish. Local landowners agreed to forego their diversions during critical periods as determined by DFG, in exchange for pumping groundwater. The state, through DWR, pays for the construction of wells, pumping, and other operation and maintenance costs. These water exchanges have increased the base flow in Mill Creek to 25 cubic feet per second (cfs), and negotiations for a base flow of 50 cfs on Deer Creek continue (DFG 1996). Voluntary actions by diverters on Deer Creek provide for pulsing of flows during critical periods. While these flows are a fraction of the historic natural flows of the creeks (which were well over 100 cfs), they represent an important effort by local water users to adjust management practices to allocate water for ecosystem benefits.

Background

The Mill and Deer Creek watersheds encompass approximately 135 and 200 square miles respectively. The watersheds are defined by the streams' upper reaches in mountain and meadow areas, middle reaches in which the creeks flow through steep narrow canyons, and lower reaches where the streams cross the valley floor before joining the Sacramento River (see Figure 21-1). Water rights holders in the valley on both streams may legally divert the entire summer flow in each of the streams. This does in fact happen once every few years, presenting serious problems for fish from late spring through early fall. There are two diversion dams[4] located on the lower 10 miles of Mill Creek, and two diversion dams located on the lower 12 miles of Deer Creek. These diversions result in flows too low for fish passage in late spring and fall of dry or critically dry years, seriously impacting the upstream migration of adult spring-run salmon to summer holding areas and the downstream migration of salmon and steelhead juveniles during the late spring and early summer (see Figure 21-2).

At the time the Upper Sacramento River management study was undertaken, both Mill and Deer Creeks had shown declines in all of their fishery runs. As illustrated in Figure 21-3, these runs have varied from a few hundred to a few thousand fish. The spring-run salmon averaged 1,400 on Mill Creek and 1,760 on Deer Creek over this 48-year period. In 1986 and 1987, those numbers had declined to 291 and 90 adult salmon on Mill Creek, and 543 and 200 adult salmon on Deer Creek for the two years respectively.

The state, acting through the DWR and DFG, was looking for ways to restore stream flows to Deer and Mill Creeks to improve fish passage. In each location, they found water rights holders willing to pump groundwater at state expense, in exchange for leaving an equal amount of natural flow in the streams for fish migration.

Mill Creek

Exchanges on Mill Creek were conducted in two phases, involving several formal agreements. In 1990, two 15-year agreements were put in place to accomplish the water exchange

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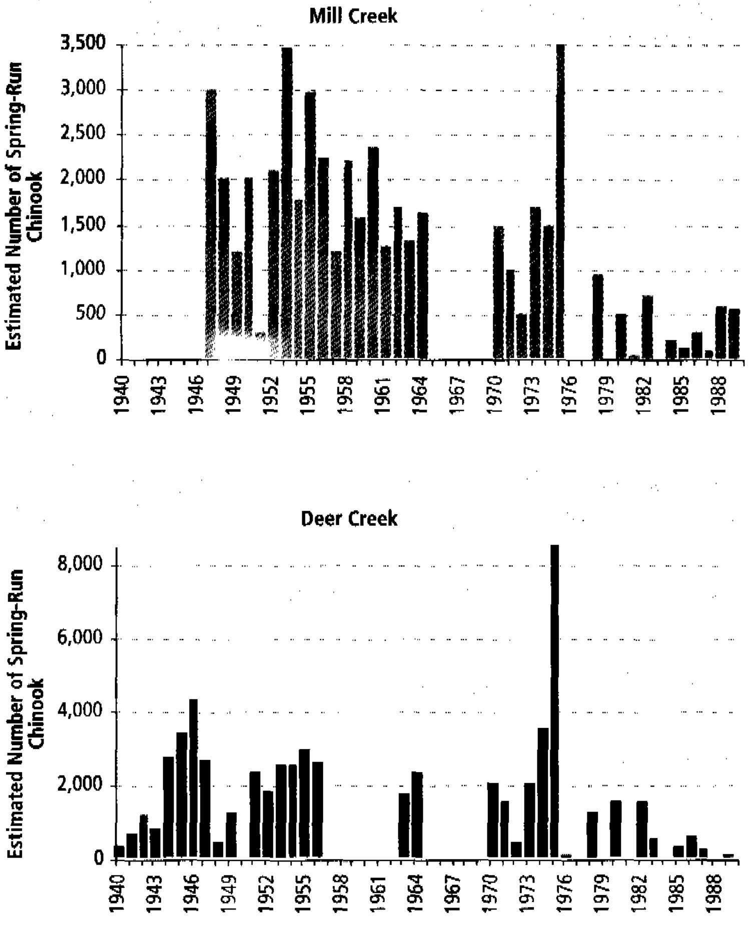
[3] May through June, and October.

[4] A third, Clough Dam, was destroyed in the 1996–1997 floods. The dam allowed diversion and delivery of water to landowners on the north side of the creek. The diversion dam had long been considered a problem for fish passage. Instead of rebuilding the dam, Los Molinas Mutual Water Company will construct an inverted siphon to allow for the diversion to be taken from an existing canal on the south side and delivered to water users on the north side.

Figure 21-3

Historical Population Estimates of Spring-Run Chinook Salmon, 1940–1989[a]



[a] Zero values indicate that data was not available for that year.

Source: Ward (California Department of Fish and Game) 1998

on Mill Creek. A Three-Party Agreement was reached among DFG, DWR, and Los Molinos Mutual Water Company (LMMWC) for the first phase of the water exchange. LMMWC is the largest water rights holder on Mill Creek with rights[5] to about 70 percent of the flow. The company has around 650 shareholders that farm about 7,000 acres, mostly orchards and pastures. Under the agreement, the state would pay for construction of a new well and restoration of an existing well, both located on The Nature Conservancy's Dye Creek Preserve. A second agreement was established between DWR and The Nature Conservancy to allow for the construction and operation of wells. During critical migration periods designated by DFG, LMMWC will forego its diversions. In exchange, LMMWC will be able to pump groundwater from the two wells in an amount equivalent to the water left in Mill Creek. The capacity of the state's wells is 9 cfs, which cannot match the water bypassed by LMMWC on a one-for-one basis over the same time period. However, the agreement allows for the bypassed flows to be credited to LMMWC and repaid through groundwater pumping over several irrigation seasons rather than all at once. This flexibility in repayment allows LMMWC to better manage its water supplies since the company can use the groundwater to supplement creek supplies during peak irrigation periods in the summer months.

Phase II allows the state to expand the flows available on demand as well as create more flexibility in repaying the bypassed flows. It involves a third agreement among the state, LMMWC, and a local landowner with priority water rights (about seven percent) to Mill Creek. The agreement was finalized in 1996. Under the agreement, the landowner has leased his water right to the state in exchange for the cost of constructing and operating groundwater wells to replace the surface supply. With this water right, the state has an additional 16 cfs available when the water is needed for spring-run salmon migration. The state allows LMMWC to exercise the water right when it is not required for fishery purposes.

With both phases in place, the state is able to provide at least 25 cfs in Mill Creek, increasing the base flow available for salmon transportation and spawning, and, through the exchange mechanism, can also provide additional water when DFG determines additional flows are needed. The banking provisions allow for the "repayment" of flows achieved above 25 cfs. The water exchange allows for some flexibility in the scheduling and use of water, but does not change the amount consumed since water left in the stream is "repaid" with groundwater.

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[5] Rights were adjudicated by a Tehama County Superior Court decree.

Deer Creek

Similar agreements are being negotiated with Deer Creek Irrigation District (DCID) and Stanford Vina Ranch Irrigation Company (Stanford Vina) on Deer Creek. The two water suppliers exercise rights to the flows in the lower portion of the creek, with DCID owning rights to one-third of the flow and Stanford Vina two-thirds. DCID services approximately 2,500 acres of irrigated farmland for 21 landowners. About half of the acreage is in orchards, with the remainder in pasture and a small amount of row crops. Stanford Vina is a mutual water company that serves about 5,000 acres, owned by about 35 property owners. Nearly three-quarters of the acreage is in orchards with the remainder in row crops or pasture.

In 1990, DFG approached DCID and Stanford Vina about foregoing diversions to improve instream flows for fish during critical periods, and both agreed to cooperate. The success of the early water exchanges on Mill Creek helped to convince Deer Creek water right holders of the effectiveness of such actions. For several years, both DCID and Stanford Vina voluntarily bypassed flows without exchanges—farmers simply had to adjust to disruptions in their irrigation schedules when diversions were interrupted. Continuation of the program, and the possibility of extending the period for pulsing flows (it had normally lasted 48 to 96 hours) convinced water managers of the value of working out formal agreements for exchanging the water. Negotiations began in 1994 and though there is agreement in principle, the final agreement has yet to be completed, pending a ruling on some tax liability issues. However, the parties have moved forward to begin identifying the appropriate locations for groundwater wells, and DWR will begin establishing a monitoring program and conducting studies for placing the wells this year.

Working out formal agreements to assist the two local companies has taken longer than the agreements on Mill Creek because of several notable complications. First, the increase of local actors from one to two, each with their own framework for administering their water rights, increases the complexity of the negotiations. Second, unlike the Mill Creek situation, groundwater wells would have to be developed on private lands rather than state lands and would thus involve negotiations with individual landowners.[6] And third, as negotiations proceeded, it turned out that state assistance for constructing the groundwater wells introduced a tax liability for the mutual water company that needed to be addressed before it could accept the terms of exchange (Cepello 1997).

Under the 15-year agreements, a minimum of 50 cfs that would otherwise be diverted for irrigation will be left in the stream to assist fish passage during critical migration periods as determined by DFG. Instream flows will be "repaid" by a combination of groundwater pumping and renovation of canals. DCIC and Stanford Vina will own the wells, leasing the property from the owners of the land where the wells are placed. Water banking provisions will be included in the agreements to allow groundwater pumping to vary in time so groundwater can be used when most needed, and, as in the case of Mill Creek, so that flows above 50 cfs can be pulsed through and repaid over time.

Results

The goal of the water exchange projects is to increase the low spawning migration flows, which have been a significant impediment to restoration of the spring-run stocks on both streams at times. Reversing the trends in the declining spring-run population is both a longer-term and larger-scale process that involves not only other restoration activities in the Deer and Mill Creek watersheds, but all the waterways through which the spring-run pass. Given the life cycle of the fish in both the ocean and freshwater ecosystems, the stresses on the population are numerous and difficult to isolate. Thus, while the exchange activities clearly help eliminate a significant impediment to fish passage, their impact on fish population counts can

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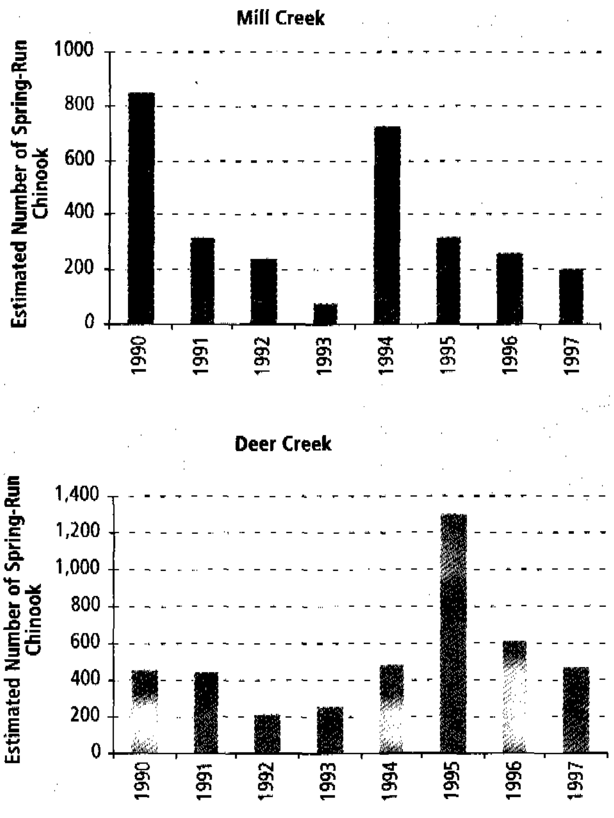
[6] In the Mill Creek situation, the wells are being constructed on Dye Creek Preserve, over 37,500 acres of land held in trust by the state and managed by The Nature Conservancy through a 25-year lease with the State Lands Commission. The Nature Conservancy manages an economically viable cattle ranch while also maintaining and restoring the ecological values of the lands.

Figure 21-4

Estimate of Spring-Run Populations, 1990–1997



Year	Mill Creek	Deer Creek
1990	844	458
1991	319	449
1992	237	209
1993	73	259
1994	723	485
1995	320	1,295
1996	256	614
1997	200	466

Source: Ward (California Department of Fish and Game) 1998

be difficult to interpret. Figure 21-4 shows counts for both creeks between 1990 and 1997.

In May and June of 1990, trial flow exchanges were conducted on Mill Creek. During a 36-hour exchange flow period, an estimated 200 salmon passed through the electronic fish counter at Clough Dam, compared to the passage of three adult salmon during the previous three days (Cepello 1995). The trial demonstrates the value of additional flows in increasing the number of adult fish that can pass upstream. Exchanges on both creeks are expected to improve passage to nearly 70 miles of suitable holding, spawning, and rearing habitat that otherwise would not be available during dry periods (DFG 1996).

The creek flow actually required to meet instream fish transportation needs varies from year to year based on rainfall. The agreements on the two creeks establish a higher base flow through the creeks than had existed since diversions began. Though some may argue whether the base flows established by the agreements are sufficient to support a large population of fish, the agreements with local water users have allowed resource agencies to establish better monitoring (including real-time monitoring) and a flexible system to improve instream flows and better determine how a more optimal level might be achieved. When the water exchanges began, DWR and DFG expected that exchanges would be required one-third of the time (5 out of 15 years) for each of the streams, based on historical water data for the past 77 years. In fact, since the water exchange agreements commenced, there has been some water exchange activity nearly every year (Cepello 1998). This program has provided both agencies and local water users with a tool to better manage water to meet the competing demands of humans and fish.

Costs

The project is funded by DFG and the State Water Contractors. Many of the initial capital costs for Mill Creek were paid for from the Lump Sum Account, and the annual operating expenses are funded from the Annual Fish Loss Credit Account. These accounts were set up as part of a mitigation settlement for the operation of the four pumps south of the Delta for the State Water Project ("the Four Pumps Agreement"). In this settlement, the State Water Contractors agreed to set up and fund both a $15 million Lump Sum Account and an Annual Fish Loss Credit Account.

The project costs include the construction of the groundwater wells, operation and maintenance of the wells, and costs related to monitoring the fish and accounting for the water. The capital costs for Mill Creek's wells totaled about $500,000 and included planning, design and construction of a test well, aquifer tests, and bringing the two wells into full production on Dye Creek Preserve. Phase II required payment of $25,000 to the landowner for construction of wells on his property, and a lump-sum payment of $78,750 to cover annual operating costs for the wells over the 15-year agreement. Though the Deer Creek agreements have not been finalized, it is expected that each agreement will likely result in at least three wells to operate for DCID exchanges and three to six wells for Stanford Vina exchanges. The annual cost for operating and maintaining the wells and administering the exchange will vary depending on water needs.

The average annual cost for the Mill Creek water exchange over five years of operations was $40,000. This figure includes fuel expenses, repair/maintenance, water quality monitoring, and salaries. Operating costs for both projects over the 15-year period are estimated to total $1,638,750.[7]

Evaluation of Success

As one of the participants pointed out, though the water exchange program was intended to improve fish transport to assist in the restoration of spring-run salmon, another success has been the involvement of local communities in developing a practical solution to the problem (Cepello 1995). The projects have helped forge a level of trust between local communities and resource management agencies as they work to balance the need to preserve fisheries habitat with the community's need to maintain economically productive land uses and protect private property rights (Cepello 1995).

The water exchange program did not change water consumption, but it did improve the management of water resources to allow for changes in its timing and use to benefit both fish and farmers. The additional flows during critical transport periods provided water for environmental needs in exchange for groundwater pumping. This arrangement gave local water companies increased flexibility to provide farmers with more water during peak periods, a service they could not otherwise afford to offer. It has also given water managers the ability to "store" groundwater that can be used to smooth out deliveries to better meet irrigation needs.

Key to the program's success was the willingness of local participants to play a role. The leadership from the board of directors of the various water companies and irrigation districts was vital. The directors, themselves local landowners, could credibly represent the benefits of the projects to other local landowners. Many of the landowners in the area have owned and worked the land in these watersheds for several generations. The fact that these streams still provide excellent spawning and rearing habitat for spring-run Chinook salmon is, in part, a reflection of past land stewardship provided by these families (Cepello 1995), and there is a strong commitment to local control and management. Locals are sensitive and sympathetic to the need to maintain the richness and diversity of their natural resources and were willing to explore ways to improve conditions for the fish runs in their streams. As they saw it, the stronger the fish runs, the stronger their water rights (Lowden 1997). Farmers were eager to meet fishery needs without facing challenges to their water rights and existing water allocations. Many were convinced of the value of finding a local solution instead of risking protracted legal battles that could result from pitting water rights against environmental needs.

Another important factor in determining the success of the program was the availability of groundwater for the exchange. Groundwater pumping in both areas is relatively uncommon

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[7] In calculating this figure, DWR and DFG assumed that water for the spring-run Chinook migration would be required for 12 out of the 15 years of the project life, and that water for the fall-run Chinook and steelhead would be required for about 5 years out of the 15-year project. These estimates were based on historical water-year information for the past 77 years and the performance for the first 5 years of Mill Creek operation.

because it is a more expensive alternative than taking surface water from the two streams. John Edson, president of DCID, noted that groundwater pumping increased in the area as orchard owners decided to invest in wells. Such conversion is probably limited to the larger landowners who are able to take on the added expense of constructing, operating, and maintaining wells. In Mill Creek, DWR carried out extensive studies to measure the impact additional wells and pumping might have on the groundwater basin and the other pumpers. Steps were taken to minimize impacts, including the appropriate placement and depth of the wells. With limited groundwater activities, the additional wells are expected to have minimal impacts. DWR continues to monitor both groundwater levels and water quality. Similar studies and monitoring will be carried out for Deer Creek. Since groundwater wells will have to be placed on private property, further negotiations with individual landowners will have to take place. With more landowners using groundwater in the Deer Creek watershed, groundwater impacts are more of a concern. As in the case of Mill Creek, DWR will establish a groundwater-monitoring program.

A third factor contributing to success was the availability of funding. This program is largely funded by the mitigation funds from the Four Pumps Agreement. Thus, many of the program costs were paid by the State Water Contractors and not borne directly by any of the participants. Costs for local participants were primarily the cost of negotiating the agreements and the managerial and operational costs of implementing the flow changes. The time committed to negotiating the agreements is not trivial. In some cases, legal assistance was required to ensure that water rights were not endangered. While both regulators and property owners wanted to avoid protracted legal battles, neither wanted to restrict their own claims and rights to use the water for their own purposes.

A significant outgrowth of the work done to develop the water exchange activities is the community's commitment to taking a major role in finding solutions to other resource problems. Efforts to restore the fisheries have brought increased attention to local communities such as these, and the residents want to ensure that they are part of the solution rather than leaving decisions to "outsiders." Local watershed conservancies have now been formed in both areas to represent residents and landowners in actions taken to preserve and improve the watersheds. The conservancies took the lead in crafting a Memorandum of Understanding between private property owners, state and federal agencies, and environmental and special interest groups, spearheaded legislation to restrict potentially harmful future water development in Mill and Deer Creeks (AB 1413), and are engaged in developing watershed management plans. Central to the watershed management plans is the idea that actions are led by local residents and that a forum is created for all interested parties to get involved and provide input.

The Mill Creek Conservancy's management report recommends actions such as supporting efforts to secure additional instream flows without adversely impacting local water supplies; educating landowners regarding conservation easements and riparian reserves; supporting projects and programs that monitor and improve fish habitat; and continuing to support student stewardship of the watershed, which involves water quality and stream flow monitoring, revegetation, and developing other resource management activities. The Deer Creek Conservancy is in the process of preparing its own watershed management program. The water exchange programs were a precursor to these system-wide efforts, and provided a catalyst for the relationships and trust that were developed to address broader goals.

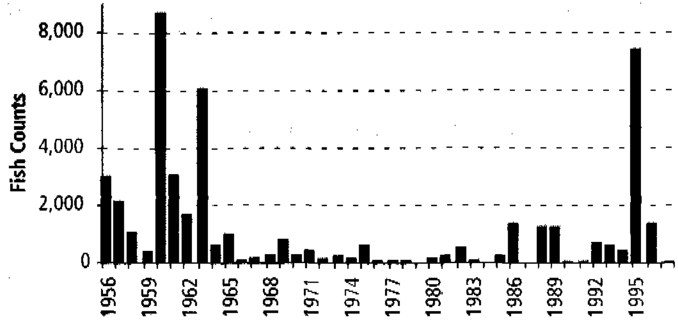
Butte Creek

This story is dedicated to the memory of Gary Brown, General Manager of the Western Canal Water District for four and one-half years, who passed away on March 29, 1998. His vision and commitment to restoring Butte Creek was crucial in making this project happen.

Over the past three and a half decades, the number of spring-run salmon in Butte Creek dropped from a high of 8,700 (in 1960) to only 1,400 in 1996 (McClurg 1998).[8] (See Figure 21-5.) In the Sacramento Valley reach of Butte Creek alone, eight diversion dams (primarily for rice irrigation) had been built; much farther upstream are two small Pacific Gas & Electric (PG&E) hydropower dams and one privately-owned hydropower project that lies between the PG&E dams. For salmon numbers to recover, fish need access to the more pristine habitat in the creek's upper reaches, at least to just below the PG&E dams.[9] Removing dams, improving fish ladders, and screening diversions are among the projects underway to help fish in Butte Creek.

Figure 21-5

Population Estimates of Naturally Spawning Spring-Run Chinook Salmon in Butte Creek[a]



[a] Zero values indicate that data was not available for that year.

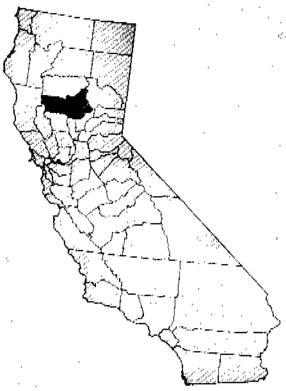
Source: Ward (California Department of Fish and Game) 1998

Background

Most of the diversion dams on Butte Creek belong to rice farmers (although a few do supply water to wildlife refuges). When farmers divert water to grow rice in the spring, flows in Butte Creek are altered or reduced, and fish migration is impeded. In recent years, growers have tried to comply with the Rice Straw Burning Act by shallow-flooding their fields in the winter to decompose rice stubble (see *Winter-Flooded Fields Benefit Farmers and Wildlife,* Chapter 18). This has also threatened fish by reducing flows during critical periods. In lower flows, fish can be sucked into diversion structures and killed, or transported onto rice fields where they become stranded.

Two of the dams on Butte Creek belong to the Western Canal Water District (WCWD), which irrigates close to 60,000 acres of farmland (primarily rice), and a small amount of pasture and orchard crops. Two-thirds of the acres served by WCWD are in Butte County; the rest are in Glenn County. The WCWD, together with the Joint Water Districts (Richvale Irrigation District, Biggs-West Gridley Water District, and Butte Water District), import 610,000 acre-feet of Feather River water into the Butte Basin every year (WCWD 1997). Feather River water flows first into Lake Oroville and then the Thermalito Afterbay (which stores some of the water released from Lake Oroville) (see Figure 21-6). The water flows from the Thermalito Afterbay into the Western Canal and continues west, irrigating about 30,000 acres of rice fields, until it reaches Butte Creek (Reisner 1997).

Until November 1997, WCWD's two dams allowed water in the Western Canal to cross Butte Creek and continue on its way westward into the Butte Basin. These dams kept this water from flowing down Butte Creek and raised the water level in the creek high enough to allow pumps and gravity-driven diversions on the west side of the creek to suck the water back into the canal in order to continue delivering irrigation water to the WCWD's remaining 30,000 acres of rice (to the west of the creek). The pumps and diversions weren't screened, however, and easily sucked up inch-long juveniles as well as adult salmon. The dams, the subsequent alterations in flows, and the many unscreened diversions in the creek either killed or stranded large numbers of salmon each year.



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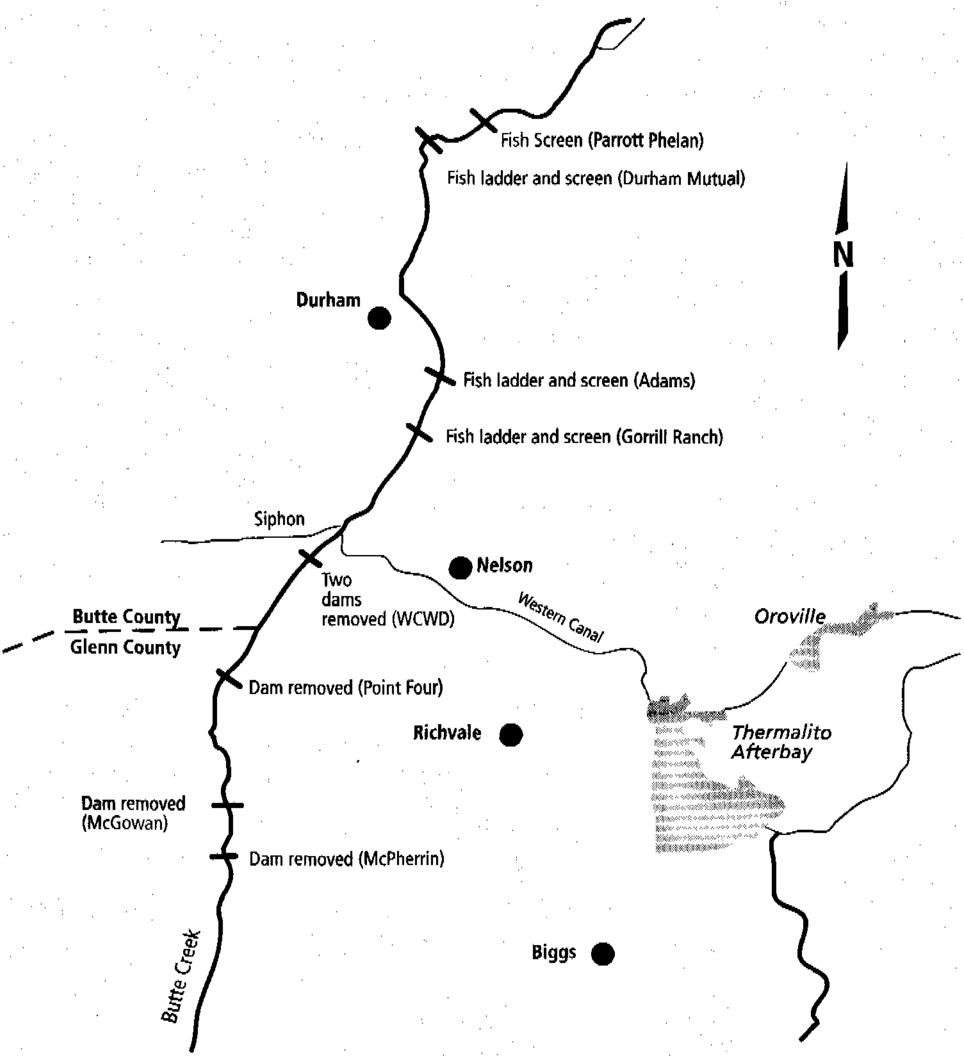
[8] 1995 was an exception in an overall pattern of decline; Fish and Game biologists suspect that excellent water conditions that year allowed for better-than-average passage of juvenile and adult fish (Ward 1998).

[9] Although PG&E has promised to consider the possibility of removing or at least modifying its dams if studies recommend such action, Fish and Game biologists believe the historic uppermost reaches for salmon in Butte Creek may have been just below these dams and that prior to the dams, fish were impeded from swimming further upstream by natural barriers such as steep rock waterfalls (Ward 1998).

Figure 21-6

Butte Creek, between Lomo (to the North) and its Confluence with the Sacramento River (to the South)



Source: Adapted from California Department of Fish and Game map

The Siphon

As a solution, the Butte Creek siphon was built. The water that formerly passed through the creek via the canal and the dams is now carried 30 feet beneath Butte Creek in the siphon to the delivery canals on the west side of the creek. The siphon (and the associated new delivery canals) eliminated the need for at least 12 unscreened diversions as well as the two Western Canal dams (Roberts 1998).[10] It also enabled two additional downstream dams to be removed: in July, with the help of Interior Secretary Bruce Babbitt, McPherrin Dam was

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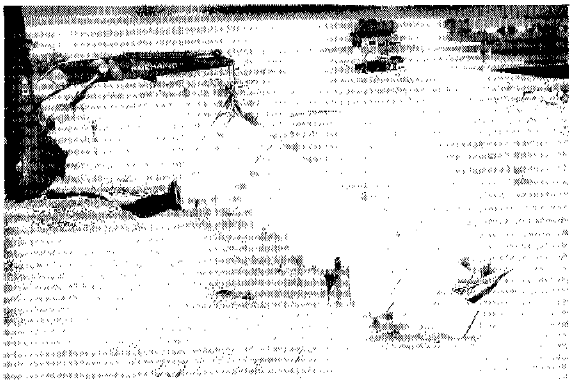
[10] Prior to the siphon, the WCWD was diverting water from Butte Creek under an adjudicated right of 33 cfs through June 15 of each year. The WCWD has since negotiated with an upstream diverter and has relocated its water right upstream, to the Gorrill Ranch (see Figure 21-6), where, as part of a CALFED Category III project, an improved fish ladder and screen are being installed.



Installing the siphon. (Photo courtesy of the Western Canal Water District)

The siphon takes the water from the canal beneath Butte Creek, improving instream conditions for fish. (Photo courtesy of Western Canal Water District)

demolished, and the McGowan followed in August (the demolitions were scheduled between fish migrations).

According to Gary Brown, WCWD General Manager, growers in his district recognized that the wild fall-run Chinook in the Sacramento River system were the gene pool for the hatchery fish that keep the salmon industry alive (Reisner 1997). Farmers also knew that if spring-run Chinook were listed under the Endangered Species Act, the commercial ocean fishery would be further restricted, because the spring-run rear off the coast with the fall-run, and fishermen wouldn't necessarily be able to tell them apart. According to Brown, the farmers decided to take action to improve conditions for fish—and to preempt serious repercussions to farmers that a listing under the Endangered Species Act might entail (such as limits on the amount of water available to them during the spring and fall)—by removing the dams and then "[going] to work on the rest of the watershed" (Reisner 1997). Ideas on how to bring Feather River water across Butte Creek had been discussed in meetings and the WCWD's newsletter throughout the five years prior to the project's implementation (Rogers 1998). But in light of the project's enormous cost, it took the cooperation of multiple funders to see it realized.

Cost

Benefit-cost analyses of the project indicated that to install fish screens on WCWD's huge inflow and outflow pipes (on the east and west sides of the creek just above the dams), would have cost between $6 million and $7 million. In addition, other diversions that pulled water from the "pool" above the dams would have had to be screened, and the pumps might have had to be shut down during crucial fish migration periods (Roberts 1998). Lance Tennis, President of the WCWD's board, says that taking the costs of operating and maintaining the screens into account easily made the siphon more cost-effective in the long run. The WCWD was also concerned, based on the experience of a neighboring water district, that the fish screens might not be effective, and that, after a substantial investment, it might find itself in the position of seeking another solution.

The siphon project was funded by four contributors/stakeholders: the WCWD; the United States Department of Interior (Bureau of Reclamation and Fish & Wildlife Service) through the CVPIA; the CALFED Bay-Delta Category III Program; and the Tracy Pumps Mitigation Fund as follows:

WCWD	$3,095,874
CVPIA	3,095,874
Category III	3,095,873
Tracy Pumps Mitigation Fund	170,000
Total	**$9,457,621**

Evaluation of Success: Diverse Interests and Common Goals

The goal of each stakeholder in the Butte Creek Siphon project was to improve fish access to better spawning habitat in the upper reaches of Butte Creek while maintaining reliable water deliveries across Butte Creek (Brown 1997). Parties with very diverse interests were able to cooperate to make that goal a reality: this project, in conjunction with several other separately funded projects,[11] has already improved conditions for salmon, opening up 18 miles of Butte Creek that previously inhibited salmon from migrating freely up- and downstream (McClurg 1998). As a result of removing these diversions, the streambed is returning to a more natural state, which also improves conditions for fish (and other wildlife) (Ward 1998). As a result of the siphon and its associated structures, along with the completion of the upstream projects, base flows in lower Butte Creek during critical periods of fish migration (spring and fall) are expected to eventually increase, since several diversions have or will be eliminated (Tennis 1998; Ward 1998). Recipients of water from those former diversions now receive Feather River water from the new canals built as part of the siphon project, since the District had never used all of its Feather River allocation anyway (Rogers 1998).

In addition to the project's stated common goals, however, each stakeholder had a vested interest in its success: for the Metropolitan Water District and other urban water suppliers funding Category III projects, that interest was ensuring enough water for the residents of Southern California. The Metropolitan Water District and other Southern California water agencies worried that if spring-run salmon were listed as an endangered species, the pumps in the Delta that send water south could be turned off for long periods of time. San Joaquin Valley farmers had the same concern. And having enough water to grow rice in the spring and decompose rice straw in the fall was crucial to Sacramento Valley farmers, who realized that they would be "very vulnerable to interruption during [their] critical irrigation period" if they did not take action to remove some of the hazards to migrating salmon (Tennis cited in Cox 1997). Despite their diverse interests—urban water supply, mitigation, or agriculture—the parties were able to come together, find, and fund a means of ensuring enough water to meet the needs of human users while improving conditions for salmon. The Butte Creek case shows that previously unthinkable acts—like removing dams—can become a reality when diverse interests with a common goal are able to think creatively about how to conserve and allocate scarce and valuable resources, like salmon and water.

Conclusions/Lessons Learned

With the pending decision on federal endangered species protection for spring-run salmon, and the host of federal and state programs to restore both wildlife and habitat, an increasing number of regulatory, community, and economic tools are becoming available to "save the fish." The CVPIA elevated fish to a higher status, recognizing fish as a "beneficiary" of the federal project; the DFG code recognizes the beneficial and public trust use of water for fish and wildlife; the threat of endangered species listings focused great attention on restoring fisheries; and Wild and Scenic River designation could lead to some controls on land use (see *Legal Protection for Rivers,* Chapter 28). In the face of such pressure, local landowners and water-rights holders searched for ways to both restore fisheries and preserve their own water rights and livelihoods without costly litigation.

Key throughout the process were the relationships established among the stakeholders as they shared perspectives, arrived at mutual understandings, and developed respect for each other. In Deer and Mill Creeks, local water users had developed solid working relationships with local resource agencies over the years. This formed the basis for finding participants willing to engage in water exchange activ-

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[11] Upstream of the Butte Creek siphon project, the Gorrill, Adams, and Durham Mutual Dams (all agricultural diversions) are undergoing structural improvements including fish screens and improved fish ladders. Downstream of the Butte Creek siphon, the Point Four Dam was removed as part of a separate project.

ities. In Butte Creek, many of the major stakeholders had been exploring partnerships to meet competing water needs through statewide forums such as the CALFED and CVPIA processes.

In these three cases, local landowners and water users acted to cooperate with regulatory and resource agencies rather than face challenges to their water rights or existing use of water. Central to each of these solutions has been local residents' ability to maintain control in finding solutions to better manage resources to meet all stakeholders' needs. Local residents' commitment to being part of the solution has grown, with the realization that their own livelihoods could be gravely jeopardized if endangered fisheries are not restored. Local water-rights holders were willing to change the delivery method and timing of their water use to better accommodate fish transport needs and improve fish habitat. These actions were taken in conjunction with a host of other activities to improve fish passage and habitat. In each case, the affected communities were able to find alternatives that flexibly accommodated both human and environmental needs. This local consensus-building approach can be seen on a larger scale in watershed-wide activities now underway.

Finally, key to each of these projects was the availability of funding. While the Western Canal Water District paid nearly one-third of the Butte Creek siphon project costs, it also relied on additional user-funded sources. All three projects took advantage of mitigation funds provided by the State Water Contractors through the Four Pumps Agreement. In addition, the Butte Creek project also tapped funds provided by agricultural water users through the CVPIA and urban water agencies through Category III.

Contacts

Deer, Mill, and Butte Creeks:

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Jim Lowden, Manager, Los Molinos Mutual Water Company

Kerry Burke, Resource Coordinator, Mill Creek Watershed Conservancy

Chris Leininger, President, Deer Creek Watershed Conservancy

Butte Creek:

John Rogers, Western Canal Water District

Lance Tennis, President, Western Canal Water District Board of Directors

References

Deer, Mill, and Butte Creeks:

California Department of Fish and Game. 1995. Central Valley Salmon and Steelhead Fact Sheet No. 2. December 7. Red Bluff, CA.

Butte Creek:

Brown, G. 1997–1998. Western Canal Water District. Richvale, CA. Personal and faxed communications.

Cox, J. D. 1997. "Salmon now face one less obstacle," *Sacramento Bee.* November 5.

FOTR (Friends of the River). 1997. "California Rivers Eligible For National Wild and Scenic Status." Sacramento, CA.

McClurg, S. 1998. *Western Water*. Water Education Foundation. Sacramento, CA. January/February.

Reisner, M. 1997. *High Country News 29:20.* October 27.

Rogers, J. 1998. Western Canal Water District. Richvale, CA. Personal communications.

Tennis, L. 1998. Board of Directors, Western Canal Water District. Richvale, CA. Personal communications.

Ward, P. 1998. California Department of Fish and Game. Red Bluff, CA. Personal communications.

Deer and Mill Creeks:

Berens, W. 1998. Stanford Vina Irrigation Company. Vina, CA. Personal communications.

California Department of Fish and Game. 1996. "Analysis and Project Proposal to Fund the Deer and Mill Creeks Water Exchange Projects Pumping Operation and Maintenance."

Cepello, S. 1997–1998. California Department of Water Resources. Red Bluff, CA. Personal communications.

Cepello, S. 1995. "Mill and Deer Creeks: An Emerging Ecosystem Management Approach." Proceedings of the 20th Biennial Ground Water Conference, J.J. DeVries, J. Woled, editors. Water Resources Center Report No. 88. University of California, Davis.

Edson, J. 1998. Deer Creek Irrigation District. Vina, CA. Personal communications.

Leininger, C. 1998. Deer Creek Conservancy. Vina, CA. Personal communications.

Lowden, J. 1997. Los Molinos Mutual Water Company. Los Molinos, CA. Personal communications.

Mill Creek Conservancy. 1997. "Executive Summary Mill Creek Watershed Management Strategy Report: Lassen Watershed Project." Prepared by CH2M Hill. Redding, CA.

The Resources Agency. 1989. *Upper Sacramento River Fisheries and Riparian Habitat Management Plan.* Prepared for The Resources Agency by an Advisory Council established by SB 1086.

The Resources Agency. 1996. "The Status of the Sacramento River Spring-run Chinook Salmon." A Special Report to the Fish and Game Commission. Prepared by the Interagency Ecological Program, Spring-run Salmon Project Work Team.

Ward, P. 1997. California Department of Fish and Game. Red Bluff, CA. Personal communications.

Collaborative Watershed Management "Above the Dams": Feather River Coordinated Resource Management

Anna Steding

Introduction

Watershed management, a catch phrase of the 1990s, is being implemented in a wide range of settings around California. While watershed management projects and programs vary in their goals and methods, they share the underlying assumption that environmental problems can not be remedied unless the linkages among soil, vegetation, and water in both upstream and downstream areas are recognized and understood. The Feather River Coordinated Resource Management (FRCRM) project provides a positive example of watershed management in the rural, higher-elevation regions of the Sierra Nevada. Guided by 21 federal, state, local, and private member agencies, the FRCRM was convened in 1985 in response to concerns about economic viability and environmental quality in the upper Feather River watershed. Since its inception, 45 projects have been implemented in the roughly 3,200 square-mile program area, including an array of plans, education efforts, and real on-the-ground projects. These efforts have been instrumental in restoring meadows, wetlands, and streams, as well as expanding regional understanding of what does and doesn't work for restoring hydrologic systems. Like other coordinated resource management efforts, the FRCRM has focused on participatory planning and consensus-based decision making. These aspects of the program have been critical for watershed stakeholders in cooperating to find solutions, rather than fighting over conflicting goals. They have also been critical for providing a space in which learning by doing is encouraged.

Background

Watershed Management

There are many ways to define "watershed management." One definition, often used by hydrologists, is

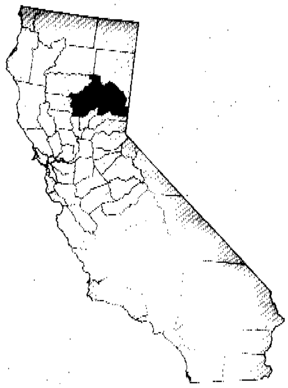
> *"The process of guiding and organizing land and other resource use on a watershed [scale] to provide desired goods and services without affecting adversely soil and water resources . . . [and with] the recognition of the interrelationships among land use, soil and water, and the linkages between uplands and downstream areas" (Brooks 1991).*

This all-encompassing description is a modern one, but reflects the early watershed management efforts of the Soil Conservation Service (now the Natural Resource Conservation Service) aimed at preventing soil erosion from farm, range, and forest lands. An alternative definition is suggested by the U.S. Environmental Protection Agency's "watershed protection approach," which is based on targeting priority problems, involving stakeholders, integrating solutions, and measuring success (EPA 1995). Today, watershed management can have many goals, from water quality amelioration to pollution control, ecological restoration, habitat preservation, maintenance of biodiversity, and community and economic development (EPA 1995). The commonality among all watershed management efforts remains the scale at which management and planning take place.

Coordinated Research Management and Planning

Although there are many ways to approach watershed management, the coordinated resource management process—more fully known as coordinated resource management and planning, or CRMP—is especially suited to solve complex resource issues "involving multiple landowners and special interest groups over large geographic areas and across multiple jurisdictions" (Lindquist et al. 1997). The CRMP template dates to the Soil Conservation Service's model program in the 1950s, and was recognized by California policymakers in 1980, when 11 state and federal agencies with jurisdiction in California signed a memorandum of understanding outlining their authority to engage in and commit resources to CRMP (UC Davis 1997). Currently, 60 active CRMPs cover more than six million acres of land in California.

CRMP programs are based on the premise that coordinated planning of resource use is necessary to minimize or avoid conflicts, and that the best way to achieve coordinated management is through face-to-face communication between interested groups and individuals. All parties with a stake in land and resource issues are ideally involved in the CRMP, although participation is voluntary, and decisions are generally made by consensus (FRCRM 1997). While the process is usually overseen by a state agency, all decisions are made at the local level.



Upper Feather River Watershed

The Feather River is a major tributary of California's largest river—the Sacramento. Before merging at Lake Oroville, the North, Middle, and South Forks in the upper Feather basin drain 3,222 square miles (see Figure 22-1).[1] The drainage area consists of variable terrain, with elevations ranging from 900 to 7,200 feet and annual precipitation from 80 inches on the west slope of the Sierra Nevada to under 12 inches in the rain shadow in the east. Approximately 60 percent of the upper drainage is under the management of the Plumas National Forest, with industrial and non-industrial private timberlands and agriculture accounting for most of the rest. Very little of the watershed—less than one percent—is urbanized (Wills and Schramel 1992).

Like many watersheds in the Sierra Nevada and elsewhere in the West, the upper Feather River is suffering the effects of more than a century of intensive human use. The major impacts in the watershed are from mining, wildfire, livestock grazing, and timber harvesting[2] with its associated roads, skid trails, and landings (Wills and Schramel 1992). These land uses have accelerated erosion in the watershed by disturbing vegetation and soils and leaving uplands and stream banks barren (Lindquist et al. 1997).

The result has been a series of unintended adverse impacts related to stream degradation (see sidebar) that have been felt by all watershed users. Livestock producers enjoy less forage for their cattle because of lowered water tables in meadows and a reduction in topsoil and vegetation. Fish are faced with inhospitable habitat caused by poor water quality from increased sediment loads, warm water temperatures from less riparian vegetation shade, and increasingly intermittent streams that once flowed year-round. Waterfowl and other wildlife species must cope with reduced habitat because of inadequate vegetation cover. Urban residents suffer an increased risk of flooding from more intense and concentrated runoff, as well as reduced property values and revenues from recreation. At the start of the FRCRM process, in the 763,000-acre East Branch watershed alone, 770 stream miles were severely degraded, 152,000 acres of wetlands, meadows, and rangelands were showing signs of adverse impacts, and a wide range of other problems had become evident (Wills and Schramel 1992).

Impacts are also felt far downstream. The East Branch of the North Fork Feather River

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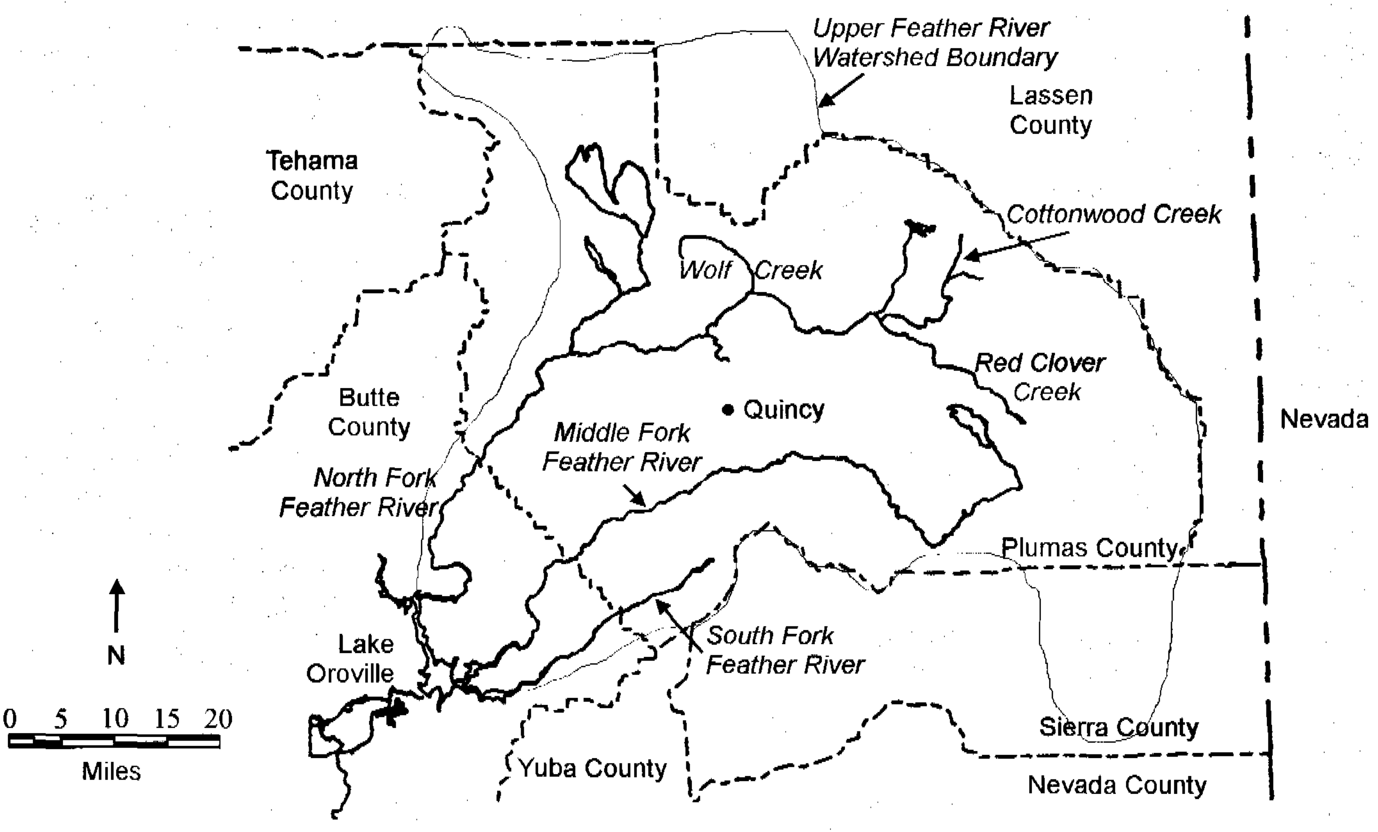
[1] The North Fork drains more than 2,000 square miles, of which the East Branch accounts for approximately 50 percent. The Middle Fork drains roughly 1,000 square miles, with the balance drained by the South Fork (USGS 1997).

[2] Between 85 and 200 million board-feet have been harvested annually from the East Branch of the North Fork Feather River watershed since the early 1900s (Wills and Schramel 1992).

Figure 22-1
Upper Feather River Watershed



Sources: FRCRM 1996a and Lindquist et al. 1997

alone supplies 25 percent of State Water Project supplies, or 12 percent of all developed municipal and industrial water in California (Wills and Schramel 1992). Upstream activities that lead to increased erosion and sedimentation therefore affect the quality of domestic water supply for many people outside the watershed. Similarly, the impacts on hydroelectric production are tangible: Pacific Gas & Electric (PG&E) estimates that two out of ten of their reservoirs on the North Fork had accumulated enough sediment by the 1980s to displace nearly 60 percent of their original water storage capacity (Lindquist et al. 1997). Biologists have long noted that the construction of the dams and reservoirs on the North Fork "seriously damaged what was once the state's finest trout fisheries" (CSLC 1994). This ecological problem—although in need of attention—was beyond the purview of the FRCRM, which focused instead on erosion control *above* the dams.

The Project: Feather River Coordinated Resource Management Group

History and Players

During the 1980s, Plumas County—which encompasses most of the North, South, and Middle Fork drainage areas (see Figure 22-1)—was suffering economic decline. At that time, the unemployment rate was twice the California average and Plumas had the third highest rate of female-headed households in poverty among all counties in the state (Wills and Schramel 1992). Public meetings were convened to address these issues and consider the economic future of the county. In 1984, as an outgrowth of those meetings, Plumas Corporation, the local non-profit economic development group, was charged with responsibility for facilitating the location and expansion of economically and environmentally sustainable businesses and opportunities.

At the same time, environmental problems generally, and the adverse effects of sedimentation specifically, were becoming increasingly apparent. Consequently, Plumas County Supervisor John Schramel initiated discussions on water problems with other local resource managers that culminated in a number of public meetings on watershed issues in 1984 and 1985. In 1985, 15 agencies joined PG&E to sign the original memorandum of agreement in which they pledged to jointly pursue an erosion control plan for the East Branch of the North Fork of the Feather River (FRCRM 1997 and Lindquist et al. 1997). That same year the coalition of agencies adopted the coordinated resource management approach and thus became known as the Feather River Coordinated Resource Management (FRCRM) group. Plumas Corporation was delegated responsibility for FRCRM coordination in 1988. Five additional agencies joined the effort in 1993 for a total of 21 (see sidebar next page). In 1994, the geographic extent of the FRCRM was expanded to include the remaining North Fork and the Middle and South Forks of the Feather River, bringing coverage to approximately 90 percent of the Feather River watershed above Lake Oroville.

Goals and Approach

From the outset the FRCRM group has aimed to address both economic viability and environmental quality problems by working on "cumulative watershed effects."[3] As noted above, the cumulative watershed effects that initially received the most attention were erosion and the sedimentation that accompanies it. Thus, FRCRM initially strove to identify erosion

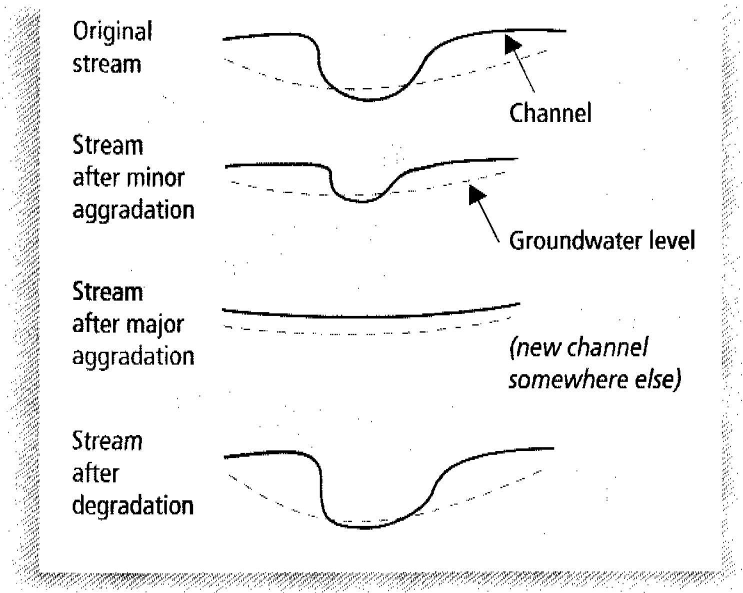
Changes in Stream Channels

The shape of a stream channel is determined by both sediment factors (how much sediment is carried and what the size of the sediment particles are), and hydraulic factors (how much water flows into the channel and when it flows). The shape of the channel determines, in turn, how much water can be carried and the extent of the floodplain. Changes in the amount of sediment or runoff entering a stream will induce a response in the shape of the channel.

Changes in vegetation coverage—such as those caused by mining, timber harvesting, and grazing in the Feather River watershed—will change the amount and timing of sediment and runoff being introduced into streams. With less vegetation, evapotranspiration (the sum of water loss from evaporation to the atmosphere and that taken up by plants) is lower and the bare soil will be more moist and thus subject to movement into stream channels. Further, the loss of vegetative root structure also destabilizes the soil.

In response, streams may either undergo *aggradation*—an upward change in the level of the streambed—or *degradation*—a downward change in the streambed. Although it is impossible to predict which will occur, both lead to unstable streams that change their form rapidly and frequently. For example, in a *degrading* stream channel, more sediment causes the banks to be cut away and erode into the stream, thus introducing more sediment and causing more erosion.

Changes in the streambed, and therefore the water level of the stream, will also change the level of the local water table (shown as dotted line below). Changes in the channel shape will impact the capacity of the channel, and therefore the frequency of flooding. Theoretical cases of aggradation and degradation are shown below.



Sources: Dunne and Leopold 1978 and Mount 1995

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[3] The FRCRM defines cumulative watershed effects as water quality, fuel hazard, desertification, and biodiversity problems that cannot be solved by management changes alone within a reasonable period; that have been caused by many people over many years; that cannot be solved with quick-fix approaches; that cause increasing conflicts among resource users; and that involve situations which are amenable to monitoring (Wills and Schramel 1992).

sources and develop a cooperative regional erosion control plan. The focus of the FRCRM was broadened in 1992 to include the protection, maintenance, and enhancement of ecosystems and community stability in the Feather River watershed generally (Wilcox 1997). Thus, the FRCRM added water quality, fish habitat, wildlife habitat, forage, riparian zone, land productivity, recreation, aesthetics, water yield and timing, and flood control to its list of concerns (Lindquist et al. 1997).

The philosophy of the FRCRM stems from its belief that cumulative watershed effects are "political, environmental, and economic manifestations of shared problems" (Wills and Schramel 1992). The CRMP process is not used to document blame, but rather to seek shared solutions through participatory, consensus-based decision making. The FRCRM group oversees the process by encouraging local initiative and participation in resource management, promoting the development of interdisciplinary technical teams to plan and manage projects, and coordinating requests for federal and state technical and financial assistance (Lindquist et al. 1997 and FRCRM 1997).

Projects are initiated under the FRCRM umbrella by any public or private landowners who take the lead in requesting action on their lands. The lead landowner approaches the Feather River Resource Conservation District first. After adoption by the Resource Conservation District, the project is referred to the FRCRM steering committee which, in turn, invites any other landowners or interested parties that might be affected to participate in making decisions about the project. The steering committee then evaluates the proposed project in light of its contribution to the achievement of the FRCRM's overarching goals. If the steering committee endorses the project and if the participants agree to "achieve shared goals, assist in securing required project permits, and use monitoring to document the success or failure of the project" (FRCRM 1997), a technical advisory committee is formed to evaluate the site and design the project. The technical advisory committee serves as a mediator: conflicts that surface during project design and implementation are brought back to the advisory committee and any issues must be resolved before proceeding (Wilcox 1997).

Members of the Feather River Coordinated Resource Management Group

Federal
Army Corps of Engineers
Farm Services Agency, USDA
Fish and Wildlife Service
Plumas National Forest, USFS/USDA
Natural Resource Conservation Service, USDA
North Cal-Neva Resource Conservation and Development Area

State of California
Department of Fish and Game
Department of Forestry and Fire Protection
Department of Parks and Recreation
Department of Transportation
Department of Water Resources
Regional Water Quality Control Board, Central Valley
University of California Cooperative Extension

Local
Feather River College
Feather River Resource Conservation District
Plumas County
Plumas County Community Development Commission
Plumas Unified School District

Private/Non-Profit
Pacific Gas and Electric
Salmonid Restoration Federation
Plumas Corporation

Source: FRCRM 1997

Projects may be of many types, from the formulation of plans to the undertaking of studies, to outreach and education efforts, to constructed restoration projects. Education, innovation, and demonstration projects, rather than regulatory approaches, are used to encourage cooperation and participation.

Results

Forty-five projects have been implemented in the program area since 1985, including seven studies, seven plans, seven education, outreach, or training efforts, and 24 on-the-ground projects. Most of the on-the-ground projects have focused on stream restoration and stabilization, as shown in Table 22-1. The Feather River Erosion Inventory, completed in 1989, showed that the majority of sediment (55 percent) was coming from tributary streams and major creek banks (FRCRM 1996), while most of the rest (43 percent) came from road fill and cut. Thus, FRCRM efforts have focused on stabilizing tributary and creek banks for erosion control, with the hope that "effective erosion control measures can reduce future sediment transport [in the Feather River watershed] by as much as 50 percent" (Lindquist et al. 1997).

A description of the Red Clover Creek Demonstration Project (Red Clover Project) provides an example of how these on-the-ground projects take shape. The Red Clover Project was designed to be a small demonstration project as a first step in developing a regional erosion control plan (Lindquist et al. 1997). Funded by PG&E, the California Department of Water Resources, the California Department of Forestry, the California Department of Fish and Game, and others, the project focused on a one-mile reach of Red Clover Creek, a tributary to Indian Creek, which is in turn a tributary to the North Fork of the Feather River. The study aimed to

- "Test and evaluate the effectiveness of several low-cost, innovative erosion control methods that could be implemented elsewhere in the watershed; and
- Develop and test an organizational process to coordinate the contributions of various stakeholders in current and future projects" (Lindquist et al. 1997).

In 1985, four rock check dams were installed, fencing was erected to control cattle (see sidebar) and vehicular access, plantings were used to encourage recovery of vegetation on stream banks, and stream banks were reinforced with willow matting and pine revetment structures. In addition, a monitoring plan was implemented to track water table levels, vegetation cover, diversity, and ecosystem community trends, streambank stabilization, fish and water quality, wildlife species density and richness, and baseflow augmentation by streambank storage (Lindquist et al. 1997). Conditions at a control site and the project site were recorded and compared. The most striking result from the Red Clover Project was the elevation of the groundwater table as a result of the check dams raising the stream elevation and causing seasonal recharge of the shallow water table. Average depth to groundwater decreased substantially, from seven feet in 1987 to one foot in 1989, and continued to decrease after 1989 at a slower rate (Sagraves 1994). The rising water table coincided with an increase in the mean percent vegetative cover between 1988 and 1990 from 40 to 60 percent in some regions of the project area and from 60 to more than 80 percent in others (Lindquist et al. 1997). The higher water table, in concert with grazing exclusion, caused a shift from xeric to mesic[4] vegetation. In one portion of the study area, xeric vegetation decreased 30 percent, while mesic vegetation increased 60 percent (Lindquist et al. 1997).

Streambank stabilization was apparently improved by the project since the channel narrowed—from 60 feet to 4 feet in some places—as sediment was deposited on the inside banks (Flint 1998). Channel narrowing, in turn, caused the number of speckled dace fish to decrease between 1994 and 1996. The number of trout, however, increased after the project so that rainbow trout were captured at the project site in higher numbers than at the control site.[5] Complete rehabilitation of the trout, however, will depend on the restoration of the stream channel and the associated riparian and upland areas within Red Clover Valley (Longanecker and Sagraves 1994). The project improved

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[4] Xeric vegetation is vegetation suited to dry soils, and thus usually found in the upland areas of a watershed. Mesic vegetation, in contrast, prefers soils that are more moist. Lowering of water tables has the effect of drying out the soil, causing a shift from mesic to xeric vegetation. A rising water table would have the opposite effect (CSLC 1994).

wildlife habitat for most species, with bird density 21 percent greater and species richness (number of species) 94 percent greater under post-project conditions. In addition, there was a statistically significant increase in neotropical migrants—a group of birds considered at risk—using the project area, and waterfowl use increased 700 percent (Lindquist et al. 1997).

Other projects have been successful, like the Red Clover Project, in attaining their goals. The objectives of the Big Flat Meadow Re-watering Project were to prolong flow duration of Cottonwood Creek, reduce stream channel erosion, and raise groundwater levels, thereby improving fish habitat, reducing downstream sedimentation, and improving grazing conditions. These goals were targeted by restructuring 4,050 feet of creek into a shallow channel, revegetating the project area, and changing grazing management practices.[6] Post-project conditions suggest that efforts have been successful in increasing the flow duration of the creek by a month—instead of ceasing from mid-May to mid-July, flows will now cease in mid-June to as late as mid-August. This prolonged flow means that 6 to 18 acre-feet of water will be released in late summer to the benefit of fisheries and downstream water users (Sagraves 1997).

Other projects have not been successful in attaining their goals, but have instead offered an opportunity for learning. The Greenhorn Creek Trout Habitat Enhancement Project involved reconstructing meander bends, reshaping the existing floodplain, revegetating the project area, and excluding livestock. Before flooding in 1997, the site showed a significant decrease in streambank erosion, high vegetation success rate, and an increase in the brown trout population (FRCRM 1996b). However, heavy scouring of the channel occurred during the 1997 flooding, causing aggradation and abandonment of the channels, and weakening the structural reinforcements (Flint 1998). The outer banks of Greenhorn Creek were not destroyed, however, thanks to the vegetation that had taken root on them. This experience served to emphasize the importance of vegetation in restoration.

Rangeland Management and Riparian Systems

Grazing livestock contribute to accelerated erosion on many of the 60 million acres of rangeland in California by compacting soil, stripping vegetation, and trampling stream banks. Livestock do not necessarily have to destroy riparian ecosystems, however, if a few simple management principles are followed. First, vegetation should not be grazed beyond the point at which it can function to collect sediment and runoff both on upland slopes and stream banks. Second, riparian and upland areas should be grazed uniformly so that livestock are kept from overusing riparian areas in summer months. Fences may be erected to control access to riparian areas and thus the distribution of grazing.

Third, rangeland needs to be given time to rest during the growing season so that the vegetation can regenerate. Grazing fewer animals (called "light" grazing) or using a rest/rotation system (in which animals are rotated between five or more pastures with approximately 50 percent of total pasture acreage going unused at any one time) are both ways to regulate the seasonal intensity of grazing. Fourth, the right kind and class of animals should be grazed. Herded sheep, for example, are easier to control than cattle and therefore may be less harmful to riparian areas.

In addition to these management principles, a wide variety of structural measures are available to help reduce erosion. These include grade stabilization to control erosion in natural or artificial channels; construction of pipelines to convey water to livestock instead of relying on natural lakes and streams; construction of sediment basins to collect and store sediment and debris; construction of stock trails and stream crossings; and streambank protection.

Sources: Heady and Child 1994 and Humiston 1995

The Wolf Creek Restoration Project aimed to protect urban property adjacent to the creek,

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[5] The following shows the number of trout captured at control and project sites for the Red Clover Project, according to Longanecker and Sagraves (1994).

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993
	Number of Rainbow Trout Captured								
At Control Site	3	1	4	0	0	0	1	0	1
At Project Site	0	18	5	5	8	12	32	9	1

[6] Under pre-project conditions, 317 pair of cattle were allowed to graze for four months; the riparian pasture was used for two to three weeks per year; and the grazing system was based on two pastures. Under post-project conditions, 317 pair of cattle were allowed to graze for three months, and 167 pair for one month; riparian pasture was only used for two to three days per year; and the grazing system was transformed into a five pasture rotation (Flint 1998).

Table 22-1

Feather River Coordinated Resource Management On-The-Ground Projects

Project	Date	Participants	Goal(s)	Accomplishments	Cost
Red Clover Creek Demonstration	1985	Landowner, PG&E, IAVRCD, USFS, CDF&G, CDF, DWR, NRCS, PCCDC	Reduce streambank erosion, raise groundwater table, trap sediments, promote fish and wildlife	4 check dams and fencing, monitoring wells	$172,000
Poco Creek	1986–1989	USFS, PG&E	Stabilize 1,200 foot long section of Poco Creek	13 check dams on 1,200 feet of creek, bank and channel shaping, willow planting, exclusion fence	$128,000
Dotta Canyon	1988–1990	Landowner, CDF, PG&E, ASCS, SCS, PC	Stabilize stream banks to reduce erosion	8 drop structures, revegetation	$30,200
Noble-Red Clover Creek	1991	Landowner, USFS, PG&E, ASCS	Stabilize stream banks	2 drop structures, fencing, re-watering 30 acres of meadow	$14,000
Wolf Creek I, II, and III	1989–1990	Landowners, 71 property owners, GCSD, PC, 21 other agencies	Slow erosion on two-mile stretch, improve water quality, protect urban property	Reconstruction of 29 acres of floodplain, reconstruction of meanders on 9,636 feet of creek, revegetation	$850,000
Rush Creek and Soda Creek	1989–1990	PCCDC, WCB, PCF&G, CDT, PG&E	Remove blockages to fish passage	2 fish ladders	$25,300
Greenhorn Creek	1991	PCCDC, landowners, 15 other agencies	Restore channel stability and riparian habitat to increase trout population	Reconstruction of 2,800 feet of creek and 17.6 acres of floodplain, revegetation	$406,000
Dunn Pasture	1992	USFS, PG&E, PC	Test the effectiveness of various revegetation treatments	Plowing and revegetation of 9 cattle pasture acres, cattle exclusion	$12,000
Clarks Creek	1992–1994	USFS, SCA, DWR, CDF&G, JHS, CDC, MGA	Stabilize 2,000 feet of stream, improve fisheries	Revegetation and rock placement	$24,000
Haskins Creek	1993	Landowner, CDF, PC, GCSD	Stabilize 800 feet of eroded stream	Revegetation, installation of rock step pools	$40,000
Walker Mine Tailings	1994–1995	PCCDC, SWRCB, USFS	Restore 100 acres of tailings	Geomorphic channel reconstruction, revegetation, installation of wind fences, development of five acres of wetland to demonstrate passive restoration	$430,000

PG&E - Pacific Gas & Electric; IAVRCD - Indian/American Valley Resource Conservation District; USFS - U.S. Forest Service; CDF - California Department of Forestry; DWR - California Department of Water Resources; CDF&G - California Department of Fish & Game; NRCS - National Resource Conservation Service; PCCDC - Plumas County Community Development Commission; ASCS - Agricultural Stabilization & Conservation Service; GCSD - Greenville Community Services District; PC - Plumas Corporation; WCB - Wildlife Conservation Board; PCF&G - Plumas County Fish & Game; CDT - California Department of Transportation; CDC - California Department of Corrections; SCA - Student Conservation Organization; JHS - Janesville High School; MGA - Milford Grazing Association

Sources: FRCRM 1996a and Wilcox 1997

Table 22-1 (continued)
Feather River Coordinated Resource Management On-The-Ground Projects

Project	Date	Participants	Goal(s)	Accomplishments	Cost
Bagley Creek	1993–1995	USFS, SCA, PC, private contractors	Stabilize/rehabilitate 700 acres in Bagley Creek subwatershed	4 check dams, bank modification, revegetation, grazing exclusion	$48,000
Red Clover Creek II	1994–1995	USFS, private contractors	Stabilize 2,600 feet of stream bank	Revegetation, lowering floodplain, and installation of weirs and rip rap	$39,000
Big Flat Meadow Re-Watering	1995	USFS, PCCDC, PG&E, SWRCB, CDF&G, MGA	Reduce amount of sediment produced, improve water quality, restore spawning/rearing habitat for rainbow trout, elevate meadow groundwater	Filling of incised channel and diversion of creek to new 4,500 foot shallow channel, revegetation, grazing management changes	$189,000
Jamison Creek	1995	CADP&R, PC, PCCDC, SWRCB, JITW	Bank stabilization for 2,000 feet of creek	Reformation of braided stream channels into one channel, cutting back of banks and floodplains, revegetation	$180,000
Poplar Creek	1994–1995	SWRCB, PG&E, WCB	Stabilization of 400 foot section of stream	Installation of step pools, cutting of entrenched banks to a more gentle angle	$35,000
Willow Creek	1996	USFS	Stabilization of channel, fish habitat improvements, meadow re-watering	Filling of incised channel and diversion of creek to new 1,600 foot shallow channel, revegetation, grazing management changes	$90,000
Blackrock Creek	1996	USFS	Restoration of channel function and fish habitat	Spot channel treatment using geomorphic techniques	$14,000
Benner Creek	1996	PG&E	Restoration of montane riparian ecosystem	Channel restructuring	$65,000
Boulder Creek	1997 on	USFS	Channel stabilization, fish habitat restoration, and meadow re-watering	Incorporation of large woody debris for channel stability	$35,000 to date
Rowland Creek	1997 on	USFS	Channel stability and beaver re-introduction	Incorporation of large woody debris	$5,000 to date
Spanish Creek	1997 on	USFS, PCRD	Demonstration of "vortex gravel sampler" as "river-friendly" gravel harvesting technique	Four-year study of bedload supply/geomorphic analysis, installation and operation of vortex sampler in California	$200,000 to date

PCCDC - Plumas County Community Development Commission; SWRCB - California State Water Resources Control Board; USFS - U.S. Forest Service; SCA - Student Conservation Association; PC - Plumas Corporation; PG&E - Pacific Gas & Electric; CDF&G - California Department of Fish & Game; MGA - Milford Grazing Association; CADP&R - California Department of Parks & Recreation; JITW - Jobs in the Woods; WCB - Wildlife Conservation Board; PCRD – Plumas County Road Department

Sources: FRCRM 1996a and Wilcox 1997

stop erosion of stream beds and banks, and improve water quality and fish and wildlife habitat. These goals were accomplished by reconstructing the braided[7] stream channel into one meandering channel, reconstructing 29 acres of floodplain to accommodate more flood waters, reinforcing the outside of meanders in the stream channel, revegetating the floodplain and stream banks, and establishing maintenance agreements with the 70 creek-front property owners. The project was tested in both the 1995 and 1997 floods, and in the first case little erosion occurred and minimal private property was lost on most sections of the restored creek (FRCRM 1996c). In the second case, however, most of the reinforcements and vegetation were washed out. The lesson learned here was that in order to stop erosion in a deeply entrenched stream channel, the extreme edge of the *internal* stream banks should be heavily reinforced (Flint 1998).

The list of project results continues beyond the four described here. Each project has incorporated monitoring into project design and implementation. To date, there is no single summary of overall project results and thus it is difficult to get a sense of watershed-wide results. This will be remedied in part by the installation of a network of stations throughout the watershed that will measure stream flows, water temperature, and possibly turbidity and macroinvertebrate populations (Wilcox 1997).

Cost

Close to $4 million was spent on Feather River CRM restoration and research between 1985 and 1995, using a mix of funds and in-kind contributions from PG&E, landowners, government agencies, state and federal grant programs, and private donors. Nearly 66 percent of funding was devoted to on-the-ground projects, while 15 percent, 5 percent, and 4 percent went to studies, plans, and education, respectively. The balance (10 percent) was used for program coordination (FRCRM 1997). The funding amount and mix varied from project to project, but was coordinated by the FRCRM group and Plumas Corporation. An additional $409,000 has been spent on on-the-ground projects since 1995.

Why is the FRCRM a Success?

One of the most notable aspects of the FRCRM is its scale. By focusing on a large watershed, and a large portion of that watershed, the FRCRM has been able to consider systemic hydrologic and ecological interactions, and by doing so will not redirect environmental problems to other parts of the region. Further, the FRCRM group has established itself as a region-wide coordinator for bringing landowners together to improve the management of the watershed, such that the whole is greater than the sum of its parts. Despite its large size, the use of small-scale and demonstration projects, the revisiting of goals and objectives, and the involvement of interdisciplinary technicians in project design have helped maintain flexibility and adaptability in management in the FRCRM system.

Since a primary purpose of the CRMP process is to induce the involvement of all affected parties, the FRCRM by nature promotes stakeholder and community participation in making decisions. Since stakeholder involvement is voluntary, the prospective participants must decide whether the costs of participation are outweighed by the benefits (FRCRM 1997). The consensus-based ethic provides an incentive to resolve disputes over water and land resources, including disputes between government agencies. The FRCRM has led to better planning coordination among the government agencies with a stake in the upper Feather River watershed.

Controlling erosion has been the primary focus of the FRCRM activities and, in all, the FRCRM has aimed to stabilize more than 5 miles of stream channel and 900 acres of meadows. Although not all projects have been successful in meeting their objectives, environ-

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[7] A braided stream channel is one that separates around islands. A braided stream may be two channels that form around a single island, or it may be many channels forming around multiple islands. A meandering stream is one that, when viewed from plan view, shows a single channel with rounded curves of repetitive and uniform shape. Braided stream systems are inherently more unstable—they change more rapidly and more frequently—than meandering stream systems (Dunne and Leopold 1978).

mental water needs are increasingly met in many cases through establishment of the proper sediment and hydraulic balance. As we saw in the case of the Red Clover Creek Project, a focus on erosion control brought about increases in desirable vegetation, and bird and waterfowl populations. In Big Flat meadows, a lengthened flow period will ultimately lead to beneficial impacts on vegetation and fish species. While these achievements are localized, the approach that the FRCRM has adopted means that the lessons learned from the individual projects—both successful and unsuccessful—may be generalized to other problems both within the FRCRM itself and in other CRMP and watershed management efforts.

Conclusions/Lessons Learned

Although there are many watershed management groups around the state, and just as many approaches to watershed management, the lessons learned from the FRCRM are particularly useful for large-scale, CRMP-based groups above the dams. Some of these lessons are the following:

- Local initiative and commitment to the problem are important for sustained operation of the program.
- It is helpful to start out by handling the immediate, downstream needs (in this case, severe stream degradation), and then, once institutional capacity is developed, move on to the upstream problems (grazing and timber practices and other unsustainable land uses).
- Any watershed restoration or management effort should focus on solving problems, rather than assigning blame.

The formation of the FRCRM was an outgrowth of local concern about economic and environmental well-being. Action on the part of the local non-profit development corporation and the county board of supervisors, in combination with concern on the part of PG&E, ultimately led to the adoption of the CRMP method and implementation of projects. All projects continue to be initiated by local landowners, which has been important for appropriately defining the problems and maintaining the durability of the institution to date.

While the concern of the FRCRM has always been watershed-wide erosion, and the causes of erosion and sedimentation, it focused first on fixing the immediate, downstream problem, namely stream instability in downstream meadows. As Rich Flint notes: "Regardless of what is going on upstream, you need to take care of what is happening in your meadow" (Flint 1998). This strategy seems to have been efficacious for achieving interest in and cooperation among stakeholders. While coordinating a series of stream restoration projects, FRCRM has been able to build institutional capacity that will enable the group to undertake watershed-wide efforts, such as the planned quantitative monitoring network, as well as to address the root causes of erosion and sedimentation. The group also gets experience in, and the name for, attracting government funds.

Also critical for stakeholder involvement was the focus on solving problems, not assigning blame. For example, some might argue that PG&E should be responsible for damages to its own dam structures, as well as damages that accrue from these structures. Focusing on PG&E as the culprit of environmental concerns would have made it more difficult to achieve progress in the watershed as a whole. Instead, the FRCRM realized that the goals of erosion control for PG&E purposes and erosion control for environmental restoration for recreationists and economic vitality are compatible.

Contacts

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John Schramel, Plumas County Board of Supervisors
Jim Wilcox, Plumas Corporation

References

Brooks, K. N. 1991. *Hydrology and the Management of Watersheds*. 1st ed. Ames, IA: Iowa State University Press.

CSLC (California State Lands Commission). 1994. *California's Rivers: A Public Trust Report*. Sacramento, CA: California State Lands Commission.

Dunne, T. and L. Leopold. 1978. *Water in Environmental Planning*. San Francisco, CA: W.H. Freeman.

Flint, R. 1998. California Department of Fish and Game. Rancho Cordova, CA. Personal communications.

EPA (Environmental Protection Agency). 1995. *Watershed Management: A Statewide Approach*. Washington DC: U.S. EPA, Office of Water.

Feather River Coordinated Resource Management Group (FRCRM). 1997. *Fact Sheet #1: Organization Profile*. University of California Cooperative Extension, Plumas-Sierra Counties. Quincy, CA.

FRCRM. 1996a. *Fact Sheet #2: Project Summary, 1985 to 1995*. University of California Cooperative Extension, Plumas-Sierra Counties. Quincy, CA.

FRCRM. 1996b. *Fact Sheet #4: Greenhorn Creek Trout Habitat Enhancement Project*. University of California Cooperative Extension, Plumas-Sierra Counties. Quincy, CA.

FRCRM. 1996c. *Fact Sheet #5: Wolf Creek Restoration Project*. University of California Cooperative Extension, Plumas-Sierra Counties. Quincy, CA.

Heady, H. F. and R. D. Child. 1994. *Rangeland Ecology and Management*. San Francisco, CA: Westview Press.

Humiston, G. 1995. *California Rangeland Water Quality Management Plan*. Rio Nido, CA: AGvocate, in conjunction with the Range Management Advisory Committee and California State Water Resources Control Board.

Lindquist, D. S., L.Y. Bowie, and L.L. Harrison. 1997. *Red Clover Creek Erosion Control Demonstration Project Ten-Year Research Summary: 1985-1995*. San Ramon, CA: Pacific Gas & Electric, Department of Research and Development.

Longanecker, D. R. and T. H. Sagraves. 1994. *Erosion Control Demonstration Project in Red Clover Valley: Fish and Water Quality*. San Ramon, CA: Pacific Gas & Electric, Department of Research and Development.

Mount, J. 1995. *California Rivers and Streams: The Conflict Between Fluvial Processes and Land Use*. Berkeley, CA: University of California Press.

Sagraves, T. H. 1994. *R&D Erosion Control Demonstration Project: Water Table Evaluation, 1993 Final Report*. San Ramon, CA: Pacific Gas & Electric, Department of Research and Development.

Sagraves, T. H. 1997. "Cottonwood Creek-Big Flat Meadow Restoration Preliminary Stream Flow Evaluation." Internal document: Plumas Corporation. Quincy, CA.

Sommarstrom, S. 1992. "Moving Mountains to Keep a Mountain from Moving: The French Creek Watershed Case Study." In *Proceedings of the Fourth Biennial Conference on Watershed Management*. J. Woled, editor. Davis, CA: University of California, Water Resources Center Report No. 81.

UC Davis. 1997. Information Center for the Environment web site. *http://ice.ucdavis.edu*

USGS. 1997. Water Resources of the United States web site. *http://h20.usgs.gov*

Wilcox, J. 1997. Plumas Corporation, Quincy, CA. Personal communications.

Wills, L. and J. Schramel. 1992. "A Grass Roots Perspective: Feather River Coordinated Resource Management." In *Proceedings of the Fourth Biennial Conference on Watershed Management*. J. Woled, editor. Davis, CA: University of California, Water Resources Center Report No. 81.

Working for Healthy Urban Watershed Communities: Santa Ana River Basin and Napa River Watershed

Anna Steding

Introduction

Each one of California's hundreds of watersheds is unique, offering a combination of fish, bird, and human life, as well as habitat and hydrology found nowhere else. At the same time, each watershed faces a particular set of problems, ranging from non-point-source water pollution to streambank erosion, habitat degradation, flooding, and others. Just as there are numerous watershed problems, there are numerous viable institutional arrangements that can successfully anticipate and manage those problems. The two examples discussed in this case study illustrate two very different approaches for doing so.

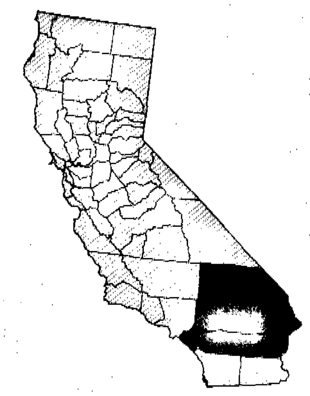
The first example is from the Santa Ana River basin in Southern California. Because of their experience with past litigation and their desire to avoid future litigation, four local water agencies formed the Santa Ana Watershed Project Authority (SAWPA) in 1968. As a regional planning and project management body, SAWPA has worked closely with the Santa Ana Regional Water Quality Control Board and its member agencies to implement large-scale water cleaning and recycling projects to solve regional water quality problems. This water agency-driven approach has been successful in removing large amounts of salts—the worst water quality problem in the basin—and arming the member agencies with the tools needed to deal with future water quality problems.

The second example is a more recent effort from the Napa River watershed in Northern California. Based on the results of a small, successful project on one of the Napa River's tributaries, the Napa County Resource Conservation District began facilitating management of the entire watershed in the late 1980s. The list of management activities is long and diverse and includes a demonstration of sustainable vineyard practices, watershed-wide volunteer monitoring, the development of a watershed management plan, use, and others. Although the Resource Conservation District has been important for coordinating the watershed management work, the real heroes are the community members themselves. Indeed, the Resource Conservation District does not view watershed management as a finite project with a finite goal but is striving instead to establish a long-term stewardship ethic that encourages and assists individual participation.

The Projects

Santa Ana Watershed Project Authority

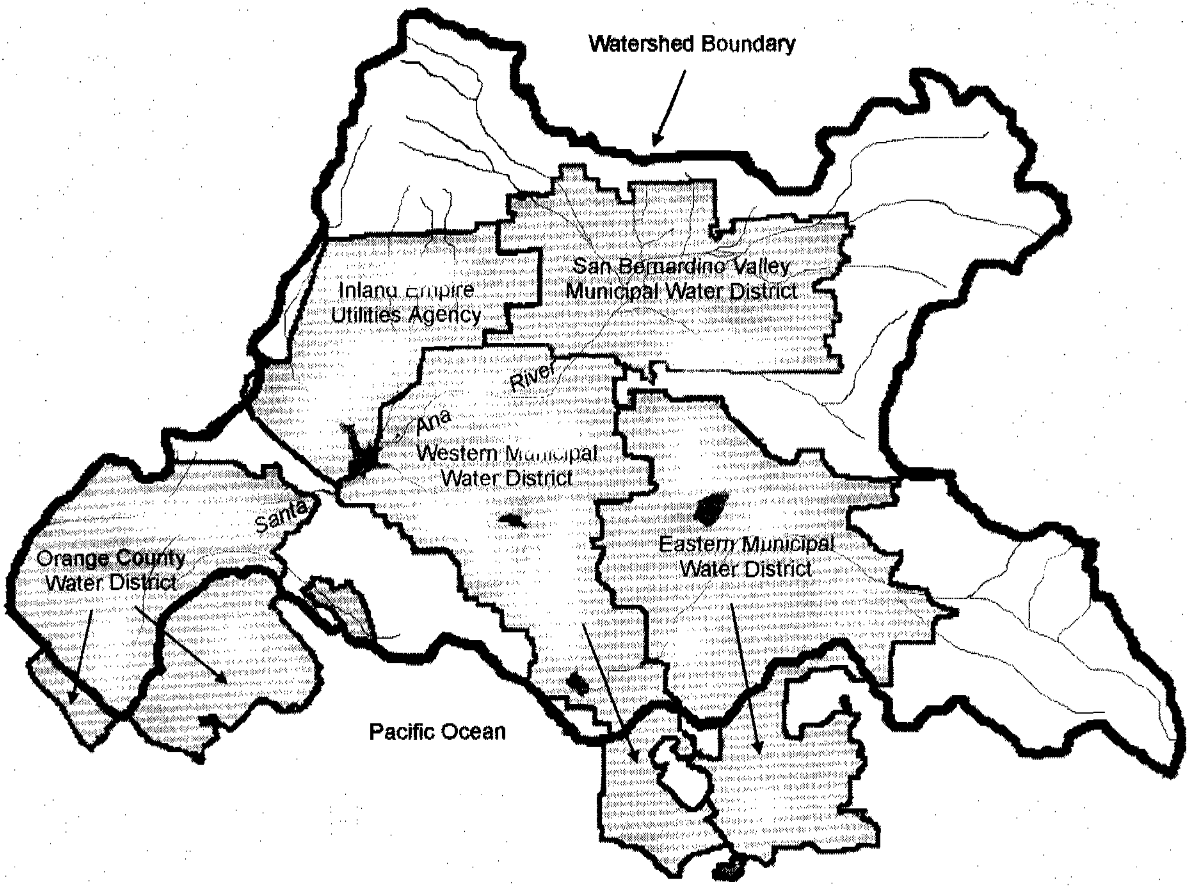
Background



The Santa Ana River basin, including both the Santa Ana River watershed and the San Jacinto River watershed, encompasses the largest stream system in Southern California (Figure 23-1). The basin is home to more than four million people, and includes parts of San Bernadino, Riverside, and Orange counties. The Santa Ana River drains the southern portion of the San Bernardino and San Gabriel mountains, 2,650 square miles in all, and flows 100 miles before meeting the Pacific Ocean at Huntington Beach (SAWPA 1993).

The river generally does not sustain much aquatic or riparian habitat since its flows are limited (Santa Ana Regional Board 1995). The Prado wetlands, located near the confluence of Temescal Creek and the Santa Ana River, is an exception, with its dense riparian wetland habi-

Figure 23-1
Santa Ana River Basin



Source: SAWPA 1993

tat. Most of the flow in the Santa Ana River is effluent from municipal wastewater treatment plants and agricultural return flow, and the water contains high levels of salts, nitrates, and, occasionally, viruses. Groundwater quality in the 29 groundwater basins is variable, with the highest levels of salts and nitrates found in the Chino groundwater basin. Agriculture in the region dates to the Spanish Mission and Rancho Periods and has, until recently, been the major use of water. Over the past two decades urban uses—which now account for more than three-quarters of water use in the basin—have displaced agriculture as the primary consumer of water. Total demand in the region was 1,282,000 acre-feet in 1995, and is projected to increase 45 percent to 1,864,000 acre-feet by 2020 (SAWPA 1998). During that period agricultural demand is projected to decrease by half, while municipal and industrial demand is projected to increase by nearly 70 percent.

Early water demands for irrigation in the region were satisfied by local surface supplies. As surface supplies diminished, the growers turned to groundwater. In the 1930s, the Metropolitan Water District of Southern California began supplementing the local supplies with water from the Colorado River through the Colorado River Aqueduct. The State Water Project also began augmenting local supplies upon completion of the East Branch Aqueduct in 1973. Despite the availability of imported supplies, water users in the basin preferred the cheaper local supplies, but these supplies had become increasingly scarce and saline as a result of extensive use and reuse of the water in the upper watershed (Anderson 1992). Currently, local surface water satisfies 6 percent of demand in the basin, while the State Water Project, Colorado River, and local groundwater satisfy 25, 30, and 39 percent, respectively (SAWPA 1993).

SAWPA and Salinity Control

In 1963, because of the growing scarcity of water, the downstream urban users in Orange County filed a class action lawsuit seeking an adjudication of water rights against upstream users in Riverside and San Bernardino Counties. Six years later the court in *Orange County Water District v. City of Chino et al.* judged that the users in Orange County have a right, as against the upstream users, to 42,000 acre-feet of base flow at Prado Dam, as well as the right to all storm flow reaching Prado Dam (SAWPA 1990 and Santa Ana Regional Board 1995). These flows could be provided with a combination of natural runoff, wastewater, and imported water. The stipulated judgement also required that the base flow right at Prado Dam be adjusted on the basis of water quality: higher quality water would require less base flow.

The court further decided that Orange County Water District, Chino Basin Municipal Water District (later renamed the Inland Empire Utilities Agency), Western Municipal Water District, and San Bernardino Valley Municipal Water District had adequate power and financial resources and therefore should implement the stipulated judgement. In 1968 these four water agencies (Table 23-1) formed the Santa Ana Watershed Planning Authority, or SAWPA, as a joint powers authority governed by a commission made up of two representatives from each member agency. The districts believed that collaboratively planning the use of water in the watershed would be mutually beneficial and would help avoid future litigation (Anderson 1992). The agencies were particularly concerned about the threat of worsening water pollution.

SAWPA's first planning task was to characterize the water quality management problem in the basin and make projections of what the

Table 23-1
Member Agencies of the Santa Ana Watershed Project Authority

District	Population Served	Area Served (square miles)	Services Provided
Orange County Water District	2 million	355	Groundwater management, reclamation, wellhead treatment, conserves storm water
San Bernardino Valley Municipal Water District	600,000	328	Water management, coordination with local agencies, delivery of SWP water
Western Municipal Water District	620,000	510	As a member agency of MWD, serves both retail and wholesale water to customers, as well as retail sewer service to 2,600 people
Inland Empire Utilities Agency (formerly the Chino Basin Municipal Water District)	646,000	242	Wastewater treatment and disposal, supplemental water supply, groundwater management, industrial waste or non-reclaimable waste disposal, and water conservation and reclamation
Eastern Municipal Water District*	445,000	555	Water reclamation, desalination, groundwater management, retail and wholesale water supply, wastewater collection and treatment

**Note: Eastern Municipal Water District became a member of SAWPA in 1984*
Source: Norton 1998

Salts and Salinity

Salts come in more than just the sodium chloride flavor found at your dinner table. Technically, a salt is any ionic crystalline compound in which the hydrogen of an acid has been replaced by a metal or something acting like a metal. In addition to being sodium-based compounds, salts can also be magnesium- or calcium-based, for example, as in the case of magnesium sulfate and calcium bicarbonate. Salinity is a measure of the concentration of salts in water, and can be expressed as total dissolved solids (TDS) or electroconductivity. Drinking water should contain less than 1,000 milligrams per liter of TDS for taste considerations, while water for irrigation should have less than 700 milligrams per liter. Electroconductivity is a measure of the ability of the solution to conduct electricity, and ideally should be less than 0.7 decisiemens per meter for irrigation use.

Where does salinity come from? When large amounts of water are applied to land and allowed to evaporate, the dissolved salts are left behind. Salts are harmful to agriculture because they reduce the permeability of soil to water. The water does not penetrate to the roots where it is needed, and evaporates, thus concentrating the salts further. Some salts are also toxic to plants. Salts, in particular sodium-based salts, can have adverse effects on human health, especially for persons suffering from cardiac, renal, and circulatory diseases.

Sources: Tchobanoglous and Schroeder 1987 and Santa Ana Regional Board 1995

future might hold if nothing were done (SAWPA 1990). SAWPA completed a water quality control plan in 1972 in which it identified major water quality issues and project areas of need in the basin. The most urgent and widespread problem was the buildup of salts in groundwater and surface water caused by water recycling in agricultural and dairy operations (see sidebar). In addition, SAWPA anticipated that the commingling of poor quality groundwater with good quality water from the Santa Ana River would lead to a degradation of local surface supplies (SAWPA 1990). In 1972, with the completion of its initial planning work, SAWPA assumed the responsibility for developing, planning, financing, constructing, and operating programs and projects for water quality management and changed its name to the Santa Ana Watershed Project Authority. Its mission as a project entity became to "develop and maintain a program to protect . . . vital local water supplies for successive beneficial uses at a minimum cost, while preserving and enhancing the environment of the Santa Ana River" (SAWPA 1993).

While SAWPA was engaged in its planning activities in the early 1970s, the Santa Ana Regional Water Quality Control Board (Santa Ana Regional Board) began investigating the salt balance in the upper Santa Ana basin. The Regional Board subsequently worked with SAWPA to write the first water quality control plan for the Santa Ana River basin.[1] The plan, completed in 1975, initiated a "total watershed approach" to salt source control that called for controls on salt loadings from residential, industrial, and agricultural uses throughout the watershed (Santa Ana Regional Board 1995). The Santa Ana Regional Board developed different water quality objectives for each "reach," or section, of the Santa Ana and San Jacinto Rivers and each groundwater basin. The objectives were based on the beneficial uses of water served by that reach; environmental conditions within the reach; what could be reasonably achieved; economic factors; and the nature of the need for developing housing in the area (Santa Ana Regional Board 1975). The Board defined objectives for hardness, sodium, chloride, total inorganic nitrogen, sulfate, biochemical oxygen demand, chemical oxygen demand, and, most importantly, TDS, for which the

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[1] Water quality control plans are required under the 1969 Porter-Cologne Act (codified as Division 7 of the California Water Code, sections 13000 et seq.) The Act also set up the State Water Resources Control Board and the nine regional water quality control boards.

water quality objectives ranged from 110 to 2,000 milligrams per liter (mg/L). The Santa Ana Regional Board then developed wasteload allocations for each controllable wastewater discharger (i.e. for each direct discharger with a National Pollution Discharge Elimination System permit) by using regional water quality and quantity models to allocate a fair share of the total acceptable contaminant load. Calculation of a "fair" share for each discharger was based on the location of the discharger, the availability of reasonable source control programs, plant performance, downstream uses of the wastewater, and other factors (Santa Ana Regional Board 1975).

The process of wasteload allocation undertaken by the Santa Ana Regional Board was similar to wasteload allocation procedures in the other eight regional water quality control boards around the state. What was unique in the Santa Ana case was the close working relationship the Santa Ana Regional Board enjoyed with SAWPA and the fact that SAWPA would coordinate the development and implementation of large-scale engineering projects to help reach the water quality objectives. In the 1975 plan, three projects were targeted for development:

- Recharge of the Chino groundwater subbasin with large volumes of low-TDS water imported from the State Water Project;
- Construction of a large wellfield to extract poor quality water from the lower part of the Santa Ana River basin; and
- Construction of a pipeline to the Pacific Ocean to convey water with very high TDS—or brines—from the upper basin.

But just as the Santa Ana Regional Board revised its wasteload allocations in 1984 and 1995 to reflect updated information and changing conditions (Santa Ana Regional Board 1984 and 1995), SAWPA has also changed its project list. To date, it has implemented, or coordinated implementation of, five large-scale projects.

The first project SAWPA constructed was a pipeline designed to carry brine from the basin to the Pacific Ocean for disposal (SAWPA 1990). The pipeline, known as the Santa Ana Regional Interceptor, became operational in 1985 and currently carries wastewater for 55 miles. An upstream extension to the city of San Bernardino has already been completed and will soon be operational. The pipeline, designed to carry 30 million gallons per day of wastewater, is currently conveying approximately eight million gallons per day with an average TDS in excess of 900 mg/L (Norton 1998). The majority of waste discharged to the Santa Ana Regional Interceptor comes from domestic wastewater treatment plants, with a limited amount from industry and the Arlington Desalter (discussed below). In addition, SAWPA has issued 22 trucked waste permits that allow discharge of approximately 0.25 million gallons per month of water softener brine.

The second project—the Arlington desalter—was completed in 1990 in cooperation with the Metropolitan Water District of Southern California and the California State Water Resources Control Board. The desalter pumps water from the Arlington groundwater subbasin in the Upper Santa Ana watershed and uses reverse osmosis technology to produce six million gallons per day of potable water and one million gallons per day of concentrated brine for discharge to the Santa Ana Regional Interceptor. The influent into the desalter has 1,100 mg/L TDS. The potable effluent has 450 mg/L TDS, while the brine discharged to the Interceptor has 5,000 mg/L TDS (Norton 1998). The desalted effluent is distributed for use by Orange County Water District and Western Municipal Water District.

Third, SAWPA worked with the U.S. Environmental Protection Agency and the California Department of Health Services to construct the Stringfellow Treatment Plant at the Stringfellow Superfund site near Riverside. Completed in 1993, the project employs a series of wells and a wastewater treatment facility to remove heavy metals and organic pollutants from the groundwater supplies (SAWPA 1993). The treated water is then transported to the Santa Ana Regional Interceptor for disposal.

Fourth, the 20-mile long Woodcrest Pipeline was constructed in 1992 to import less saline State Water Project to the Arlington Heights–Woodcrest area of Riverside County. The imported water has a TDS concentration of 250 mg/L, compared with a concentration of more than 700 mg/L TDS in the Colorado River water previously being used by Arlington Heights growers (Santa Ana Regional Board 1984 and Norton 1998).

Fifth, the Rapid Infiltration/Extraction Wastewater Treatment Plant, developed by the cities of San Bernardino and Colton in conjunction with SAWPA, became operational in 1996 (Norton 1998). In 1975 and 1984 the Santa Ana Regional Board had called for tertiary treatment of municipal wastewater in the Riverside area to maintain water quality objectives in the Santa Ana River (Santa Ana Regional Board 1975 and 1984). To comply with the Santa Ana Regional Board's directive, Riverside and Colton employ an experimental process that takes secondary treated water from the cities' treatment plants and applies it to a percolation basin. The wastewater is allowed to percolate through the soil, where physical and biological processes remove pollutants. After the water has infiltrated 15 feet, it is extracted through shallow wells and discharged to the Santa Ana River. The facility is currently treating 29.9 million gallons per day, and has a capacity of 40 million gallons per day (Norton 1998).

In addition to the completed projects, a number of other projects are in the construction phase. The Western Riverside County Regional Wastewater Treatment Facility is scheduled for completion in 1998. This facility is being constructed by a joint powers authority with SAWPA, Western Municipal Water District, Home Gardens Sanitary District, Jurupa Community Services District, and the city of Norco. It will be an eight million gallons per day treatment plant with primary, secondary, and tertiary treatment processes designed to recover wastewater treatment flows presently being discharged to the Santa Ana Regional Interceptor (SAWPA 1993 and Norton 1998).

A number of desalters are planned for the Chino groundwater subbasin, the first of which will come on-line in 1999. This initial plant will produce eight million gallons per day of potable drinking water which will be purchased by the Metropolitan Water District of Southern California for use in the Inland Empire Utilities Agency and Western Municipal Water District service areas (SAWPA 1993). Approximately 1.5 million gallons per day will be discharged to the Santa Ana Regional Interceptor from the first Chino desalter. Additional desalters in the Chino basin will be constructed over the next 30 years, up to an ultimate capacity of 30,000 acre-feet per year, as the demand for potable effluent from the desalters appears.

The SAWPA projects are a subset of many large-scale water projects in the Santa Ana River basin. Each of SAWPA's member agencies has a strong commitment to water recycling. The Inland Empire Utilities Agency reclaims 17 percent, or 8.7 million gallons per day, of the wastewater it treats (Inland Empire 1996). The Eastern Municipal Water District is one of the state's largest recycled water producers with a capacity from five wastewater treatment plants of 43 million gallons per day (SAWPA undated). Orange County Water District reclaims 22.5 million gallons of water per day (Orange County Water District 1998). The region is expected to experience a three-fold increase in reclamation in the next 20 years, showing that the SAWPA projects are not substitutes for water recycling, but rather complements to them (Santa Ana Regional Board 1995).

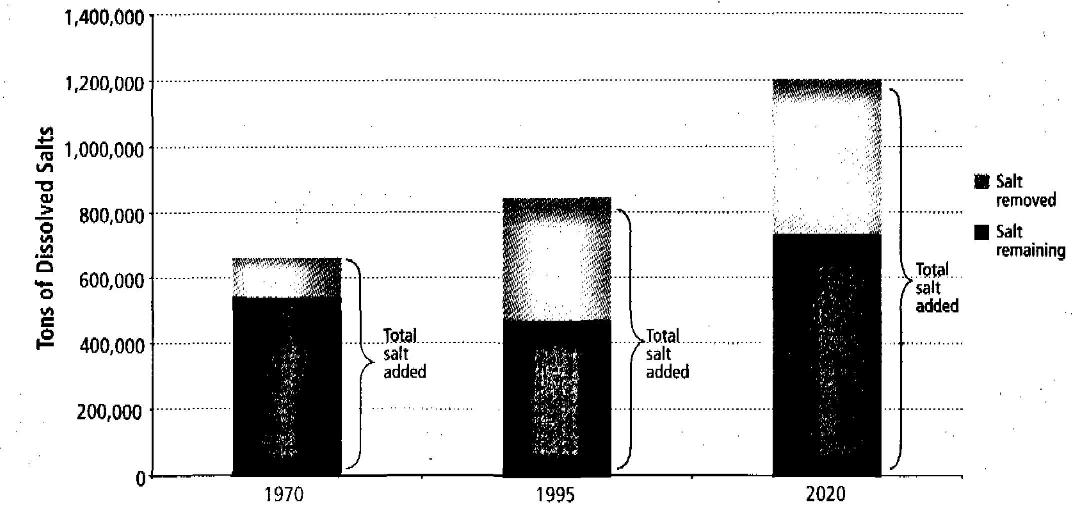
Results

Working together through SAWPA, the member urban water agencies have made progress toward protecting beneficial uses in the basin. They are now producing six million gallons per day of desalted groundwater for potable use, with the eight-million-gallons-per-day Chino facility scheduled to be operational in 1999. The majority of the wastewater dischargers to the Santa Ana River now provide tertiary treatment instead of secondary treatment, which has provided a cleaner river overall.

The SAWPA projects, in concert with the other projects in the region, have helped improve the salt balance in the basin. In 1970, only 20 percent of the salts were removed from the basin, with about 500,000 tons remaining (Figure 23-2). In 1995 there were 375,000 tons of salts removed from the Santa Ana River basin, or 45 percent of the total 850,000 tons of salts added, with 475,000 tons of salt remaining

Figure 23-2

Salt Balance for the Santa Ana River Basin, 1970 to 2020



Note: Total salt added – salt removed = salt balance.

Source: SAWPA 1998

(Norton 1998). The percentage of salts removed will continue to increase, but at a slower rate than the total amount of salts added because historic land uses have left salts in the soil which will slowly leach into the groundwater and surface water. More than 40 percent of the salts will be removed with SAWPA projects in 2020 but it is estimated that 740,000 tons will remain (Norton 1998). The benefits of increased salt removal are reflected in improvements in the quality of the Santa Ana River. The 1997 water quality of the base flow at Prado Dam was 514 mg/L TDS, or below the Santa Ana Regional Board's water quality objective of 700 mg/L. This is a decrease from the high of 965 mg/L TDS during the summer of 1971 (Santa Ana Regional Board 1984).

Napa River Watershed Management

Background

Four hundred miles to the north of the Santa Ana River basin lies the Napa River watershed, which drains 426 square miles of Northern California in the Central Coastal Range (Figure 23-3). The river flows from its headwaters on Mount St. Helena through the city of Napa and into extensive salt marshes before emptying into the San Pablo Bay (Whyte et al. 1992). The Napa River watershed is contained within Napa

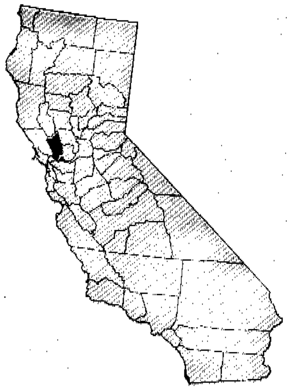


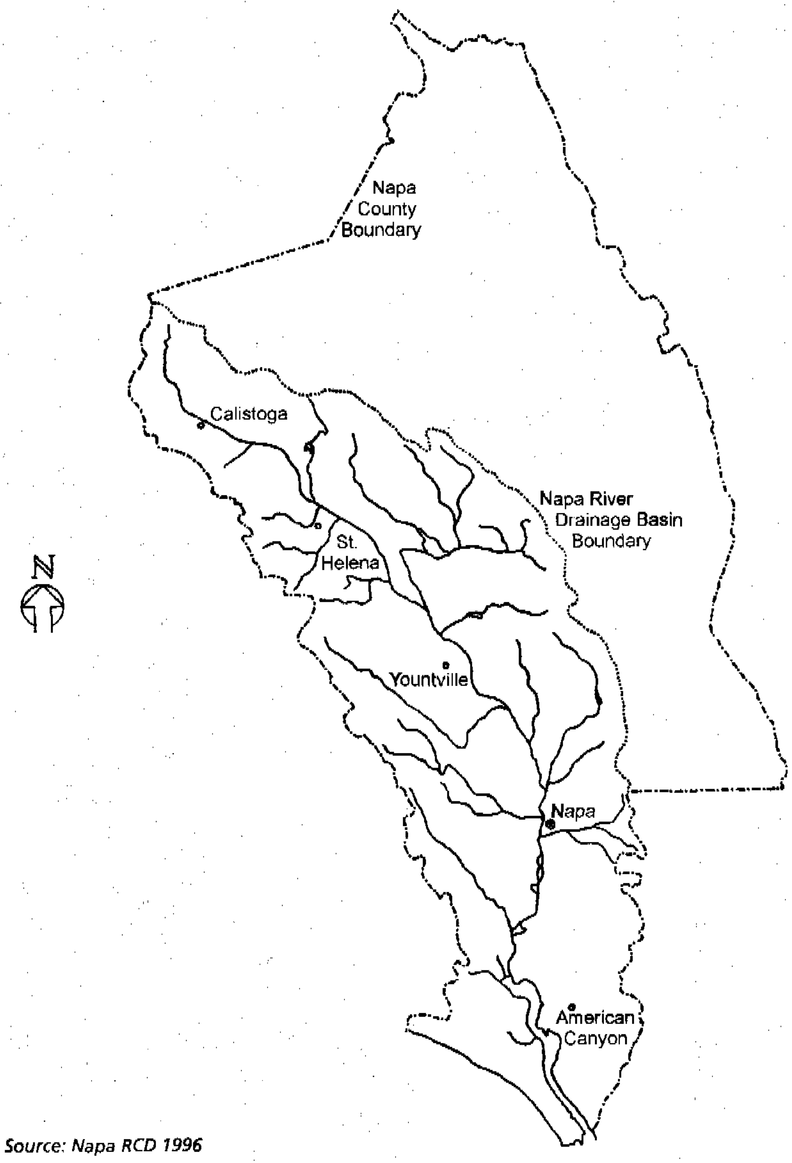
Table 23-2

Costs for Completed SAWPA Projects

Project	Capital Cost
Santa Ana Regional Interceptor	$43,304,000 (cost covered by SRF: $37,300,000)
Arlington Desalter	$15,000,000
Stringfellow Treatment Plant	$4,100,000
Rapid Infiltration/Extraction Wastewater Treatment Project	$31,000,000

Source: Norton 1998

Figure 23-3
Napa River Watershed



Source: Napa RCD 1996

County, and itself contains the communities of Calistoga, St. Helena, Yountville, Napa, and American Canyon.

The Napa River watershed receives 20 to 35 inches of rain per year in the valley, and 55 to 60 inches of rain near Mount St. Helena, although recent winters have seen exceptionally high rainfall. The Napa River is intermittent in its upper portion, but commonly floods in the valley in the lower portion. Low flows can exacerbate water quality problems and cause high levels of bacteria and nitrates and low levels of dissolved oxygen. High flows bring a different set of problems, including damage to crops and buildings (Napa RCD 1996).

Water from three groundwater basins in the watershed is closely connected with Napa River water. The safe yield of the groundwater basins is estimated to be 28,200 acre-feet per year, and there is little monitoring or coordination of groundwater pumping among users. Regular sampling of groundwater wells by the Napa County Agricultural Commissioner's office shows that there is little well pollution, and that the water is generally suitable for agricultural use (Bowker 1998).

The Napa River watershed is rich in biotic resources and supports a large variety of habitats, from chaparral to riparian to salt water marsh to vernal pool to grassland. The Napa Marsh, extending 46,700 acres, is an important resource for a number of waterfowl and shorebirds. Large runs, of 6,000 adult steelhead and silver salmon, made their way up the Napa River in the past. The silver salmon were extirpated from the river by the late 1960s, although a small steelhead population remains today (Bowker 1998).

The groundwater and surface water from the Napa River watershed provides 85 percent of Napa County's water demand, while the balance is provided by water from the State Water Project via the North Bay Aqueduct. The total water demand in Napa County is 57,100 acre-feet, of which more than half goes to agriculture. Not counting land used for grazing, approximately 90 percent of agricultural land is in grape production. Groundwater is used for 60 percent of agricultural water demand, but only five percent of municipal demand.

Community Watershed Management

The multiple community watershed management activities taking place in the Napa River have their roots in an early project on Huichica Creek, one of the Napa River's tributaries. In 1988, the Napa County Resource Conservation District (Napa RCD) brought together a group of 63 landowners and more than a dozen local, state, and federal agencies, citizen interest groups, individuals, and trade organizations. Known as the Huichica Creek Stewardship, the group was motivated by concerns over the endangered California freshwater shrimp, water rights, soil erosion, biological diversity, and the commercial viability of agriculture (Bowker 1998). The Huichica Creek Stewardship employed interest-based planning to restore riparian habitat, plant new vegetation on overgrazed lands, and develop alternative farming systems. Such a collaborative approach was necessary, since most of the land adjacent to the stream from its headwaters to San Pablo Bay is privately owned (California Biodiversity Council 1995).

Recently, this collaboration resulted in the development of the Sustainable Agriculture Demonstration Vineyard, where 14 acres of land in the Huichica Creek watershed have been planted with Chardonnay and Pinot noir grapes. The management of the acreage is different than conventional viticulture in that native perennial grass cover crops have been planted adjacent to the vines, including pure meadow barley *(Hordeum brachyantherum)*, California barley prostrate *(Hordeum californicum)*, blue wildrye *(Elymus glaucus)*, California brome *(Bromus californica)*, and nodding needlegrass *(Nassella cernua)* (Napa RCD 1997).

Growing out of their experience in the Huichica Creek case, and maintaining their commitment to leadership from and driven by the community rather than any one individual, the Napa RCD sought to facilitate management activities for the Napa River watershed as a whole. Their first step toward this end was the preparation of an integrated resource plan for the watershed, and in 1993 the Napa RCD put together a 39-member Technical Advisory Committee with members from a variety of organizations to oversee the preparation of the plan. The result of the Technical Advisory Committee meetings, as well as extensive community input through formal (community forums) and informal (conversations with Technical Advisory Committee members) mechanisms, was the first edition of the Napa River Watershed Owner's Manual in 1996 (Napa RCD 1996). The Napa RCD and the Technical Advisory Committee decided this would only be an initial version of the integrated watershed resource plan. Subsequent editions would be produced, which would incorporate the experiences of implementing prior Watershed Owner's Manual recommendations and include a "watershed assessment report" examining progress made toward each objective (Bowker 1998).

The Owner's Manual was designed to help the Napa River watershed community maintain a sustainable river ecosystem. For water resources in particular, the Owner's Manual sought "to improve water quality in the watershed, and to increase water quantity available for beneficial use of watershed human, plant, and animal communities" (Napa RCD 1996). These goals were further broken down into the following nine objectives:

- Promote stream stabilization using natural processes
- Promote contiguous habitat
- Increase biological diversity
- Increase migratory and resident fish habitat
- Coordinate natural resource protection and planning efforts
- Encourage land stewardship
- Reduce soil erosion
- Promote sustainable land-use concepts
- Promote and improve water management

Under the objective to promote and improve water management, the Owner's Manual set out five sub-objectives. First, the Manual called for estimating water budgets for the tributary watersheds of the Napa River. Such budgets would be developed for use in local land-use planning with the involvement of the California State Water Resources Control Board, and would include information on the distribution and amounts of existing diversions. To date, one tributary watershed—Huichica Creek—has completed and accepted a water budget (Bowker 1998). Second, the Manual called for the conjunctive use of groundwater and surface water, specifically the use of groundwater during dry times and the capture of floodflows for groundwater recharge. The Napa Sanitation District is currently developing an agreement with the city of Napa for supplying recycled wastewater to the Kennedy Business Park for golf course,

Agencies and Organizations Represented on the Technical Advisory Committee

California Department of Conservation
California Department of Forestry and Fire Protection
California Department of Fish and Game
California State Coastal Conservancy
City of American Canyon
City of Calistoga
City of Napa
County of Napa
Greg Holquist Consultants
M & L Vineyard Management
Napa County Agricultural Commissioner
Napa County Farm Bureau
Napa County Flood Control & Water Conservation District
Napa County Resource Conservation District
Napa Sanitation District
Napa Valley Gateway Business Park
Napa–Solano Audubon Society
Natural Resource Conservation Service
Nielson Underground and Excavating
Robert Mondavi Vineyards
San Francisco Bay Regional Water Quality Control Board
Sierra Club
State Water Resources Control Board
Sterling Vineyards
Sutter Home Winery
Town of Yountville
U.S. Army Corps of Engineers
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service

Source: Napa RCD 1998

park, and cemetery irrigation in lieu of groundwater to insure that groundwater will be available during dry times (Slutzkin 1998).

The third sub-objective in the Manual calls for increasing the reuse of treated wastewater for irrigation and wildlife habitat enhancement and restoration, including investigating the feasibility of dual-plumbing systems and utilizing graywater systems. One quarter of Napa County's wastewater is currently being reused, an average of two million gallons per day (Rogers 1998). The Gateway Business Park in southern Napa County, as well as the airport zone, will be served by dual plumbing by 2000. Many of the buildings there already have dual-plumbing pipes installed but are waiting to be connected to trunk lines from the Napa Sanitation District; other buildings have trunk line connections but no dual plumbing yet (Slutzkin 1998).

Fourth, the Manual called for the use of California Irrigation Management Information System (CIMIS) data for lawn irrigation and irrigation for public parks, golf courses, industrial parks, cemeteries, and other large irrigated areas (see *The Power of Good Information*, Chapter 16). In 1996, the Napa RCD set up an array of computerized CIMIS weather sensors at a site in the Huichica Creek watershed. These weather stations were sponsored by the Carneros Quality Alliance and will integrate Napa River watershed-specific data into the wider CIMIS network (Bowker 1998).

Finally, the Manual called for increasing the awareness and use of efficient urban water management in urban areas. All cities in Napa County have established water education and conservation programs, notably toilet replacement efforts (Bowker 1998). The Toilet Retrofit Program of the city of Napa, for example, is designed to allow development to continue in the city without causing an increase in water demand. The program requires that before a new development is allowed to proceed, the developer must make changes to existing residential development that will permanently reduce water use equal to the needs of the new development. The city also helps administer a cash rebate program by the Napa Sanitation District, and in 1997 implemented its own cash rebate program for toilet replacement. It also undertakes residential water audits based on biweekly monitoring of usage, and identifies and contacts the 50 largest residential users (City of Napa 1997).

All objectives in the Owner's Manual included a recommendation for data management and outreach based on the following:

> *"Communication, education, and monitoring are critical aspects of systems management. More complete knowledge of watershed conditions allows more creative options for maintaining system balance. A commu-*

> *nity that has a high degree of awareness of the condition and trends of their watershed is better equipped and more likely to manage the watershed in a thoughtful sustainable manner" (Napa RCD 1996).*

An important part of fulfilling this commitment to data collection and outreach has been the Napa River Watershed Volunteer Monitoring Program. Started in 1996, the program focuses on collecting data on water quality (dissolved oxygen, temperature, conductivity, water appearance, streambed coating, odor, habitat, water depth), stream channel morphology, rainfall, resident and migratory bird populations, stream flow and velocity, and land surface permeability (Edson 1998). In the future, additional data will be collected on benthic macroinvertebrates, erosion, vegetation, and watershed histories. Volunteers take data every other week in the summer and once a month in the winter. The protocols used by the volunteers were developed by drawing on a variety of existing protocols from the San Francisco Estuary Institute, Roesgen's Stream Channel Morphology classification system, the U.S. Environmental Protection Agency's Monitoring Methods Manual, and elsewhere, and refining them through initial volunteer tests. A large volunteer recruitment campaign was never required, since individuals as well as school groups were eager to get involved in monitoring (Edson 1998).

Parallel to the development and implementation of the Owner's Manual, the Napa RCD has maintained a strong commitment to developing comprehensive watershed curricula for Napa County schools through its AmeriCorps Watershed Project. Started in 1994, the AmeriCorps volunteers first focused on implementation of Adopt-A-Watershed programs in classrooms around the county (Napa RCD 1997). The volunteers served as school-site coordinators and assisted classrooms in undertaking monitoring and restoration projects. The school-site coordinators have also facilitated the hands-on critical thinking program Envirothon, in which high school students study natural resource management issues through a combination of written materials and workshops given by professionals (Napa RCD 1998).

All of the efforts facilitated by the RCD have been aided by two important pieces of legislation. First, the 1996 passage of a county parcel tax has generated $500,000 annually for watershed management (Bowker 1998). Second, the 1998 Napa River Flood Protection and Watershed Improvement Sales Tax Ordinance will generate $6 million annually for the next 20 years for implementation of the Napa River Flood Protection Project, including many watershed habitat restoration projects called for in the Owner's Manual (Martin 1998).

Results

The watershed management programs described above have had a variety of results:

- The Huichica Creek Sustainable Agriculture Demonstration Vineyard culminated in the harvest of 12 tons of sustainably-grown grapes from six acres in 1997. The grapes were purchased by Robert Mondavi Winery (Napa RCD 1998).
- Five additional creek stewardships have been formed on Dry, Bell, and Selby Creeks, as well as Salvador Channel and the Napa River between Lodi Lane and Larkmead. The Bell Creek stewardship has already reshaped the creek's channel in its effort to minimize future flood damages, while the others are gathering data and developing management plans (Napa RCD 1998).
- Through the end of 1996, the city of Napa had helped replace—through its own programs and assistance in administering the Napa Sanitation District programs—more than 10,000 toilets, for a savings of 97 million gallons of water per year.
- The Volunteer Watershed Monitoring Program has generated two years worth of a variety of data collected at 31 sites. These baseline data will prove to be important in the development of future watershed management projects.
- The AmeriCorps Watershed Project has facilitated watershed education in 52 schools with the participation of up to eight AmeriCorps volunteers in any year. It has also coordinated the implementation of three

restoration projects, including a 120-foot willow revetment[2] of Salvador Channel in 1997 (Napa RCD 1998).

One of the most significant results of the Napa RCD-led water management has been the development of close working relationships among agencies, and the development of a community willingness to tackle watershed-wide problems. This "institutional capacity" spilled over into the participation of many of the groups involved in Napa River watershed management in the Community Coalition for Floodplain Management. The Community Coalition for Floodplain Management, led by Friends of the Napa River and the Napa County Economic Development Commission, developed a unique "Living River" Flood Control Plan for the Napa River.

Why Are These Projects Successful?

The two projects described above are very different. The first focuses primarily on a single watershed problem—salinity control—while the second promotes a variety of watershed restoration and management programs. Both have employed a number of common tools to attain their successful results.

First, both SAWPA and the Napa County RCD attempted to anticipate problems before they arose. One of the primary reasons for the founding of SAWPA was that the member agencies wanted to avoid litigation over the deteriorating water quality. Watershed management in the Napa River watershed, as stated in the Owner's Manual, is designed to "maintain" a sustainable river and keep it healthy. The emphasis the Owner's Manual places on monitoring and education will increase the awareness of watershed conditions among agencies and watershed citizens, and thus make it possible to address problems as they arise. The baseline information will be critical for implementing appropriately designed watershed management projects.

Second, both have emphasized the importance of building strong relationships with other agencies and collaborating actively with those agencies. In SAWPA's case, the five member agencies worked with each other, but also coordinated regional planning activities with the Regional Water Quality Control Board in the Santa Ana Region. In the Napa River case, the Napa River RCD worked closely with 28 public and private groups in preparing the Owner's Manual. The RCD has continued to maintain formal working relationships with these groups, as well as informal relationships with individuals from these groups and from the watershed public at large. The high degree of collaboration in both cases, in part necessitated by the magnitude of the watershed problems, will increase the chance for long-term success. With so many interests vested in the watershed management work, the participants are less likely to leave the work unfinished.

Finally, in both cases the groups have gone beyond establishing a plan to actual implementation of the plan. Although this may sound trivial, the U.S. Environmental Protection Agency notes that it is all too common that watershed groups formulate a sound plan but fail to implement it (EPA 1998). Both SAWPA and the Napa RCD have been successful in this regard because they have continually incorporated new information into their planning and remained flexible. This is illustrated in the SAWPA case by the fact that the original list of salt-removing projects in its 1972 plan only slightly resembles the list of projects actually implemented. SAWPA has changed its course of action periodically as a result of input from updated hydrologic models and from member agencies. The Napa RCD will also employ this type of "adaptive management" when it updates its Napa River Watershed Owner's Manuals.

Conclusions/Lessons Learned

Good watershed management strategies vary from watershed to watershed. These cases offer a number of lessons for the diverse watersheds around the state:

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[2] A willow revetment involves the planting of live willows in a streambank to stabilize the creek channel; i.e. to keep it from getting washed away in a flood (Napa RCD 1998).

- Common interests among watershed stakeholders are ideal, but common strategies may be more realistic;
- Watershed management is a long, complex process that requires an investment for the long run;
- The importance of monitoring and adaptive management cannot be underestimated; and
- Large-scale engineering projects may be called for in some situations, whereas at other times smaller-scale, innovative sustainable practices are more appropriate.

As Dennis Bowker notes (Bowker 1998), a common interest that unifies stakeholders in watershed management is ideal, but in many cases unrealistic. However, a common *strategy* might be something that all stakeholders can agree upon. In the SAWPA case, a common interest—namely the removal of salts from the watershed—did offer a unifying force. This was also the case in some of the activities in the Napa River case, such as the effort by the Huichica Creek Stewardship to protect an endangered species, but the overall philosophy of watershed management in Napa is based on the common strategies of extensive monitoring, education, and involvement. It is always clear that insisting on individual gain to the detriment of others, as the SAWPA member agencies did before the creation of SAWPA, will generally lead to more conflict at the expense of solutions.

The complex nature of a watershed dictates that solutions to watershed problems cannot be realized on a short time scale. The history of SAWPA extends back 30 years, and the agency is attempting to manage problems resulting from land-use practices that extend even farther back in time. Although it has made some progress in correcting the salt imbalance, it still has a lot of work to do. The Napa RCD is just getting started and thus has less dramatic results to date. Both entities illustrate the importance of investing in watershed management for the long-term. To be truly effective, long-term watershed management should be based on good baseline data and should incorporate information from periodic monitoring.

Finally, there is no single "best" management solution to watershed-wide problems. Rather, the technologies and management techniques will vary from watershed to watershed. For SAWPA, large-scale, costly engineering projects were suitable because of the magnitude of the salt problem it was confronting, and the fact that it was dealing with land-use practices that had already ceased for the most part, but continued to influence the water quality in the Santa Ana River basin. In other words, they could not adopt low-cost approaches, such as changes in land use. Further, much of the water in the Santa Ana River basin is used for urban purposes, and thus has a high enough "value" from the perspective of consumers to necessitate the expenditure of large amounts of money to protect it. In the Napa River case, smaller-scale solutions were more commensurate with the nature of the watershed problems and the resources of the agencies involved in watershed management efforts.

Contacts

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References

Anderson, G. K. 1992. "Progress Report: Twenty Years of Watershed Planning in Southern California's Santa Ana River Basin." Riverside, CA: California Regional Water Quality Control Board, Santa Ana Region.

Bowker, D. 1998. Napa County Resource Conservation District. Napa, CA. Personal communications.

California Biodiversity Council. 1995. "Huichica Creek Vineyard Demonstrates Agriculture and Biodiversity in Harmony." *California*

Biodiversity News 2(4):1.

Inland Empire Utilities Agency. 1996. Fact sheet. Inland Empire Utilities Agency. Fontana, CA.

City of Napa. 1997. *Water Conservation History*-unpublished materials. Napa. CA.

Martin, G. 1998. "Freeing Napa from Floods: Unique River Plan Goes Before Voters." *San Francisco Chronicle*. March 2.

Napa County Resource Conservation District (Napa RCD). 1996. *Napa River Watershed Owner's Manual: An Integrated Resource Management Plan*. Napa, CA.

Napa County Resource Conservation District (Napa RCD). 1997. "RCD Anticipates First Harvest at Huichica Creek Vineyard." *Napa County Resource Conservation District Newsletter.* January. Napa, CA.

Napa County Resource Conservation District (Napa RCD). 1998. *Napa County Resource Conservation District Newsletter.* January. Napa, CA.

Norton, M. 1998. Santa Ana Watershed Project Authority. Riverside, CA. Personal communications.

Orange County Water District. 1998. Recycled water brochure. Fountain Valley, CA.

Rogers, G. 1998. Napa Sanitation District. Napa, CA. Personal communications.

Santa Ana Regional Board (California Regional Water Quality Control Board, Santa Ana Region). 1975. *Water Quality Control Plan: Santa Ana River Basin*. California Regional Water Quality Control Board, Santa Ana Region. Riverside, CA.

Santa Ana Regional Board (California Regional Water Quality Control Board, Santa Ana Region). 1995. *Water Quality Control Plan: Santa Ana River Basin*. California Regional Water Quality Control Board, Santa Ana Region. Riverside, CA.

Santa Ana Watershed Project Authority (SAWPA). 1990. Unpublished material on SAWPA. Riverside, CA.

Santa Ana Watershed Project Authority (SAWPA). 1993. SAWPA brochure. Riverside, CA.

Santa Ana Watershed Project Authority (SAWPA). 1998. *SAWPA Water Resources Plan*. Riverside, CA.

Slutzkin, C. 1998. Napa Valley Gateway Business Park. Napa, CA. Personal communications.

Tchobanoglous, G. and E. D. Schroeder. 1987. *Water Quality: Characteristics, Modeling, Modification.* Addison-Wesley. Menlo Park, CA.

Whyte, D., H. Hill, and T. Mumley. 1992. *Napa River Watershed: Draft Background Information Report, Watershed Resource Information and Institutional Framework.* California Regional Water Quality Control Board, San Francisco Region. Oakland, CA.

Chapter 24

Restoring Urban Streams Offers Social, Environmental, and Economic Benefits

Lisa Owens-Viani

Introduction

Natural areas within cities are important to urban residents—both human and wild. Urban streams and their associated riparian habitats are often the most ecologically valuable areas within cities (Haltiner 1997), and restoration of degraded urban streams can offer significant social and economic benefits to communities. These areas offer corridors for wildlife, opportunities for urban children to experience a bit of the natural world, and aesthetic areas where residents can escape the stresses of the urban environment. Restoration can increase these benefits, improve water quality, and control flooding in a more attractive and effective way than traditional concrete channels or culverts. Restoration can also offer economic and social benefits, by enhancing urban streams as amenities that draw visitors to a city or a downtown, and by employing people from local communities to work on and maintain restoration projects. In California, urban stream restoration also provides a way to increase the amount or improve the quality of some of the rarest habitat in the state.

Three examples of urban stream restoration projects, in San Luis Obispo, Berkeley, and Richmond, are presented below. All three projects improved the quality of riparian habitat, and one the quantity (Strawberry Creek), by creating habitat where none existed. All of the projects led to increased community awareness and involvement in local watersheds, and the formation of both formal and informal environmental education programs. Two of the projects improved water quality by decreasing erosion (downtown San Luis Obispo) and by identifying and eliminating serious sources of pollution (Strawberry Creek on the Berkeley campus). All three projects led to economic benefits. In San Luis Obispo, the restored creek became an attraction that boosted downtown business. The Wildcat and Strawberry Creek Park projects both employ local teenagers to maintain the restoration sites and monitor water quality. The Wildcat project also provides flood control benefits to the community of North Richmond, while preserving and enhancing riparian habitat.

Background

California has lost over 95 percent of its riparian habitat (Pollock 1991; RHJV). In urban areas, that loss is closer to 99 percent (Schemmerling 1997), and what little is left is usually not in good shape. As E.A. Keller and Hoffman (1977) write, ". . . many urban streams represent a sad testimony to our civilization. They tend to be straightened, deepened, paved over, or lined with concrete and filled with every imaginable type of urban trash." As they also point out, many urban residents flee the cities on weekends and holidays to seek out areas where free-flowing streams and more natural landscapes can still be found. But they remind us that not everyone is so mobile, and that those who are not may "exist in a sensually substandard environment." The lack of natural areas in cities particularly impacts children, with the National Audubon Society identifying "making the environment accessible to urban children" as "one of the most daunting challenges in environmental education today" (Flicker 1998). But adults are affected too. Studies show that "nearby nature"—natural areas within a few minutes' walking distance—is critical to the psychological well-being of urban residents and their sense of satisfaction with their communities (Kaplan and Kaplan 1989). With 60 percent of the world's population predicted to be concentrated in urbanized settings by the year 2025 (Platt 1994), and 80 percent of California's population already living in urban locations,[1] the quality of life in these areas will be of increasing concern.

The loss of natural areas—and in California, particularly riparian areas—has also impacted wildlife, with most California birds and mammals (including many endangered and threatened species) dependent upon riparian habitat for at least some portion of their life cycles (Department of Fish and Game 1993). Although the value of riparian habitat has long been known to biologists and wildlife managers, recent studies at the Coyote Creek Riparian Station in San Jose have confirmed its importance, even in heavily urbanized areas, particularly for migrating songbirds (Otahal 1997). Otahal found that Coyote Creek—in the midst of San Jose—is a crucial "stopover" point for migrating warblers in the fall, where they are able to refuel and gain weight before continuing on to their wintering grounds in Central and South America (Otahal 1997).

Despite the ecological importance of riparian areas, however, little attention has been given to preserving them, particularly in urban settings. Once the large water-supply systems like Hetch Hetchy and others were built in the early part of this century, urban residents no longer depended upon their local watersheds for water supply, and local creeks were no longer seen as important (Richard 1993). As populations in the cities grew, urban streams came to be seen as nuisances and health hazards, and were frequently put underground in culverts (Dury 1995). Raw sewage was often even dumped into them. In many cities, buildings and parking lots were then built on top of these underground waterways, contributing to a greater lack of connection with the natural environment on the part of most urban residents: the creeks were "out of sight, out of mind." The few urban streams left flowing freely were blamed for urban flooding, while the true culprit—faster and larger volumes of runoff from the increase in paved surfaces that accompanies urbanization—was ignored. Most of these remaining open streams were then put into channels, which was erroneously thought to prevent flooding.

In California, a new interest in urban streams and subsequent efforts to "restore" them emerged in the 1980s, in a "flurry of grassroots protests over creek channelization plans by local flood control districts" (Steere 1994). Since then, "urban stream restoration" in California has become a movement with life of its own, with close to 100 "friends of creeks" groups working to preserve and protect urban streams.[2] (See Table 24-1 for a sample of these organizations.) These activists have helped change public agencies, influencing them to become more environmentally sensitive and aware of urban streams. Out of these efforts many cooperative interagency "watershed awareness" and planning efforts have arisen (Steere 1994), involving "friends of creeks" groups, municipal agencies, city planners, resource conservation districts, the conservation corps, environmental nonprofits, and, lately, even the U.S. Army Corps of Engineers. As concerns about urban runoff and compliance with the Clean Water Act have increased, many cities have begun looking to urban stream restoration as a means of improving water quality or as an alternative to traditional (and expensive) storm-drain replacement projects (Freitas 1998; Struve 1997; Riley 1998). Restoration projects can also decrease erosion and filter polluted runoff (Kondolf and Michele 1995).

The term "urban stream restoration" means different things to different people, particularly since the terms "urban" and "restoration" themselves can have different connotations. In this story, the term "urban" is used to encompass areas of different size that are "of, relating to, characteristic of, or constituting a city" (Webster's, 9th Ed.). The term "restoration" encompasses a multitude of activities, from physical projects to watershed awareness programs and other educational efforts. One form of restoration involves minimizing or avoiding the

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[1] According to a 1995 Bank of America report on urban sprawl, California has become the most urbanized state in the nation, with 80 percent of all Californians living in metropolitan areas of one million people or more.

[2] In the San Francisco Bay Area alone, over 30 volunteer-based "friends of creeks" groups and at least a half dozen umbrella organizations (both staffed and volunteer-based) provide support and information to the grassroots groups.

Table 24-1

Types of Creek and Watershed Groups

Qualities:	Staffed or Volunteer	Umbrella	Education	Scientific	Restoration	Collaborative	Advocacy	Monitoring	Focus
Mill Valley Watershed Project	S(2)		•			•		•	Local Watershed
Coyote Creek Riparian Station	S(11)	•	•	•		•		•	South SF Bay
SF Estuary Institute	S	•	•	•		•		•	San Francisco Bay
Coalition to Restore Urban Waters	S(2)				•	•	•		National
Urban Creeks Council, Berkeley	S(1)	•	•		•	•	•		California
Waterways Restoration Institute	S(3)		•	•	•	•			National
Golden West Women's Flyfishers	V		•		•	•			SF Bay Area
Bay Area Citizens for Creek Restoration	V		•		•	•			SF Bay Area
Friends of San Leandro Creek	S(1 part-time)		•		•	•		•	Local Watershed
Petaluma River Council	V				•	•	•		Local Watershed

Source: Urban Creeks Council, Creeks and Watershed Awareness Cluster Report

destruction of riparian habitat caused by traditional flood control and channelization projects. This is done by creating low-flow "overflow" channels, by recreating meanders and pools and riffles in degraded streams (for fish and other aquatic organisms), or by stabilizing eroding creek banks using "fascines" (see Figure 24-1) or "poles" (see Figure 24-2) made of live plant material.

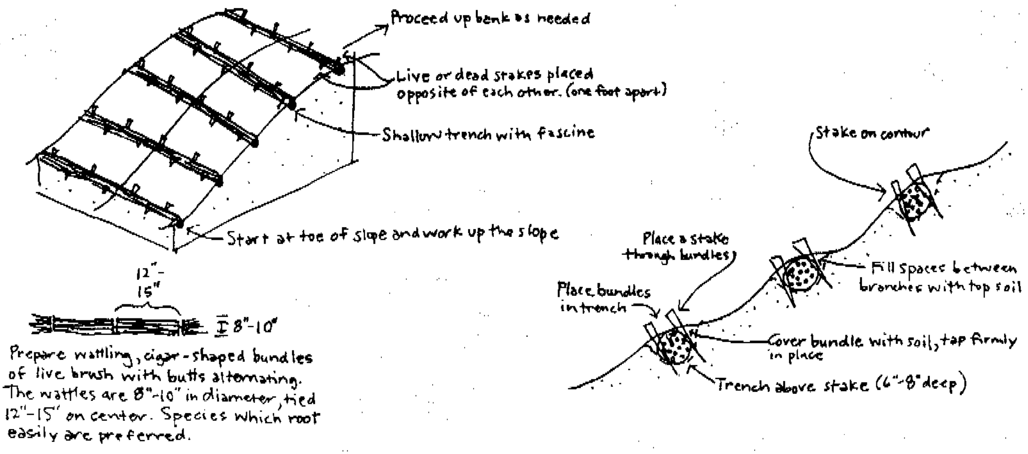
Another form of restoration involves removing invasive, exotic species that have overgrown creek banks, and replacing them with native riparian plants. Restoration can also mean removing trash from a creek's waters, monitoring water quality, or "daylighting" long-buried creeks, digging them up and bringing them back above ground where natural processes can resume.

Many urban stream restoration projects involve a combination of these activities. To choose examples for this story, several benefits urban stream restoration projects provide were identified as indicators of success:

- Nature in urbanized areas (and the corresponding psychological and educational benefits for urban residents)
- Flood control (using natural materials and non-structural, less environmentally-damaging techniques)
- Wildlife habitat and restoration of native vegetation
- Rehabilitation of degraded landscapes
- Water-quality improvements and erosion control
- Citizen and community involvement in decisions about local environments
- Economic benefits to communities

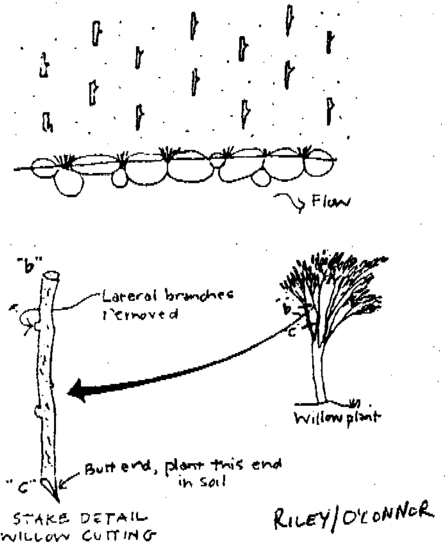
Recognizing that it would be impossible to

Figure 24-1
Bank Stabilization Using Fascines (Live Plant Bundles)



Source: Ann Riley and Dennis O'Connor

Figure 24-2
Bank Stabilization Using Willow Poles



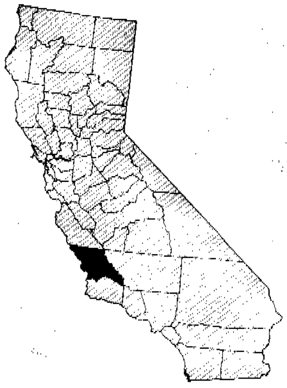
Source: Ann Riley and Dennis O'Conner

evaluate the myriad individual projects taking place, three projects that meet many of these indicators of success were chosen as replicable examples. The projects presented here are also some of the earliest restoration projects undertaken in California, so their performance over the past decade can be evaluated. All of the streams selected flow through urbanized areas but also through natural areas for substantial portions of the watersheds. Because all of the streams flow above ground for more of their lengths than underground, the benefits to these watersheds from additional, future restoration projects will be great, as they will result in more net open stream for fish and riparian habitat for wildlife. As with many urban stream restoration projects, the case studies in this story arose out of some type of land-use conflict—on how to best offer flood control, revive a failing downtown, or rehabilitate a degraded landscape. While each project has met its goal in resolving those initial conflicts, each has also come to offer additional benefits.

The Projects

San Luis Obispo Creek

San Luis Obispo was one of the first California cities to consider restoring the creek that runs through its center. The idea for this restoration actually began in the late 1950s when Ken Schwartz, a member of the city planning commission (who later became mayor), persuaded the commission and the city council



to prepare and adopt the city's first general plan, on which the San Luis Obispo Creek system was identified with green lines. That plan, according to Schwartz, was the first official document to indicate that creeks had some value to the community.

The "green line" of San Luis Obispo Creek flows southwesterly for 18 miles, from a canyon along Highway 101 near Cuesta Ridge, to the Pacific Ocean at Avila Beach. The watershed encompasses 84 square miles, but most people are not aware of the creek's existence until they see it flowing through downtown San Luis Obispo (Schwartz 1997).

Like many other urban areas, downtown San Luis Obispo in the late 1960s/early 1970s began to suffer as two malls on the outskirts of town threatened to out-compete downtown shops. Instead of allowing the downtown to die, however, the city chose to try to revitalize it. A key part of that effort involved restoring the historic Mission San Luis Obispo de Tolosa (founded by the Spanish in 1772), which in turn led to restoration of the nearby section of San Luis Obispo Creek, which today flows through the Mission Plaza area.

Restoring the old mission met with controversy at first: proponents of the restoration also wanted to create a plaza in front of the Mission that would resemble the plaza thought to have existed on the site originally. To do so meant closing Monterey Street, which ran in front of the Mission, and also that downtown merchants would lose some existing parking spaces. This was not viewed favorably, since many merchants felt that the downtown's lack of vitality was a result of inadequate parking. As a solution, in the late 1960s they proposed building a large parking structure on top of the creek. Many local citizens were opposed to the idea, however, since they considered restoring the creek and closing Monterey Street integral parts of the plan to create the Mission Plaza. A group of five citizens, including Ken Schwartz, successfully defeated the parking structure proposal by getting a voter referendum passed to close the street. Schwartz then ran for mayor and won, and hired landscape architect Richard Taylor to come up with a design for the plaza that would incorporate the restored creek (Schwartz 1997). The basic project took place in two phases during 1971 and 1972, and improvements were added during later years (Schwartz 1998). To remedy the parking situation, the city ended up building parking structures at other sites around the periphery of the city, offering a few hours of free parking as an incentive for people to use the garages and walk into the center of town (Havlik 1998).

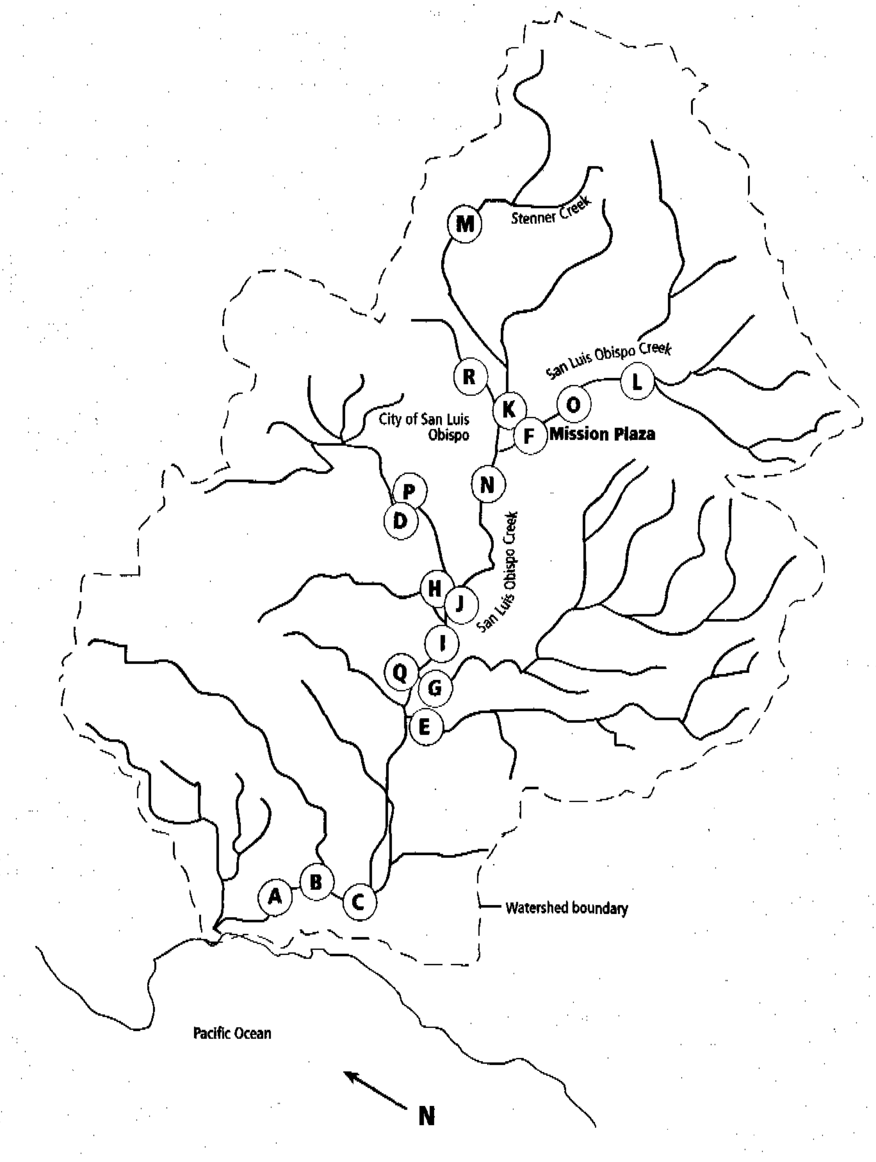
The Mission Plaza/creek restoration project was completed in 1972. Today the Mission opens onto a plaza, with seating areas and a small amphitheater where visitors sit and enjoy the sights and sounds of the creek.

The initial restoration involved removing large amounts of trash from the creek, as well as overgrown exotic vegetation from its banks, and using broken concrete (recycled from Monterey Street) and new vegetation to stabilize the banks. A number of contractors donated time and equipment, and volunteers helped plant the creek's banks. Paved walkways down to and alongside the creek were added in order to

San Luis Obispo Creek, downtown San Luis Obispo (Photo courtesy of San Luis Obispo Chamber of Commerce) allow visitors to the plaza to enjoy the creek without trampling its banks.[3] The goal of this restoration project was to enhance San Luis Obispo Creek as a visual amenity in the city's downtown; the creek has in turn helped revitalize the downtown. Before the restoration project, many people were unaware of the creek's existence. Now that the creek is a central feature of the downtown, people have become more aware of the entire watershed. An old automobile bridge crossing the creek was made pedestrian-friendly, and another wooden

Figure 24-3

The San Luis Obispo Creek Watershed, Showing Water Quality Monitoring and Restoration Sites



Source: Adapted from a map by the Land Conservancy of San Luis Obispo

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[3] Prior to this restoration, the creek's banks in this area had been badly trampled, causing a severe erosion problem (Stark 1997).

pedestrian bridge was built as well. These bridges encourage pedestrians to stroll on both sides of the creek, which in turn has encouraged the establishment of restaurants and other businesses on the south side of the creek. At least four restaurants now have outdoor seating areas looking out onto the creek (Havlik 1997). The restoration of the first 250-foot stretch of San Luis Obispo Creek was accomplished at a cost of approximately $50,000, which came out of the city's general fund, according to Resource Manager Neil Havlik.

Additional Restoration Projects Initiated by the City

In addition to the Mission Plaza project (Figure 24-3, Circle F), the city has undertaken four additional restoration projects, as public interest in the creek has burgeoned. A half mile downstream from the Mission Plaza site (Figure 24-3, Circle N), the city purchased a one-acre property that contained several vacant buildings and an old gas station. These structures, which stood on the edge of the creek's banks, were demolished, the creek's banks graded back more gently and revegetated along a 300-foot stretch, and an adjacent setback area of approximately 30–35 feet was planted with native trees and shrubs.[4] Volunteers installed a wooden fence along the perimeter of the setback area in order to protect the vegetation. Although the fence does not prevent public access to the creek, it does discourage trespassing and delineates the area as wildlife habitat. An additional 30-foot-wide section of land bordering the revegetated area will become a small, adjoining pocket park (Figure 24-3, upper half of Circle N). As part of the restoration, a swale was created to absorb overflows that had caused flooding on an adjacent street.[5] Acquiring the property represented most of the cost of this project—$800,000—with another $100,000 for demolishing the buildings and hauling away debris. According to Havlik, about 50 percent of the project's funding came from the city's general fund and the other 50 percent from state road and gas tax monies and funds for flood control.

In the fall of 1996, a quarter mile downstream from that project, the city cleaned up and restored a 400–500-foot long, 50–60-foot wide section of the creek on a long-neglected city-owned property that had been used to store construction equipment and debris (Figure 24-3, Circle J). The equipment and debris were removed, along with invasive, exotic vegetation, and the area was replanted with native species. Out-of-pocket costs to the city totaled between $5,000 and $6,000 (for new topsoil, plants, and grass and wildflower seeds), with debris removal done by city crews. All of the planting and removal of non-native vegetation was performed by volunteers.

A third restoration project is underway at the city-owned corporation yard/sewage treatment facility (Figure 24-3, just upstream of Circle J). On this site, extensive stands of exotic vegetation[6] were removed along a mile-long section of the creek, which was replanted with native vegetation by volunteers in December 1997. The cost of this project was only $1,200—the cost of the plants themselves. Old plant debris was left on site in brush piles for later use as compost (Havlik 1998).

A fourth small restoration project is ongoing on a 150-foot site that was "adopted" by a local 4-H group, just upstream of Mission Plaza (Figure 24-3, Circle O). In February 1997, the 4-H group planted the degraded and eroding creek banks with native trees and shrubs. Again, with volunteers providing the labor, the cost of this project was the cost of the plants alone.

As part of its ongoing efforts to ensure a vital downtown, the city hopes to uncover an additional 200–300-foot stretch of the creek that has flowed through the downtown area beneath a parking lot for much of this century. That section would be continuous with the restored Mission Plaza section (Figure 24-3, just downstream of Circle F).

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[4] Trees include oaks, sycamores, bays, and box elders; shrubs are wild rose, toyon, coffeeberry, ocean spray, gooseberry, currant, and snowberry.

[5] These overflows were caused by constriction of the creek's channel by the bridge that crosses the road just upstream, according to Havlik.

[6] Primarily castor bean, arundo ("giant reed"), and Germany ivy.

Land Conservancy Projects

In April 1997, just downstream of the city's wastewater facility/corporation yard, the Land Conservancy of San Luis Obispo revegetated 984 feet of streambank (Figure 24-3, area between Circles I and Q). The Conservancy has also restored an area near the mouth of the creek (Stark 1998). In conjunction with the Conservancy (and funded by grants from private foundations) over 60 volunteers regularly monitor the creek's water quality[7] at 13 sites (Figure 24-3, all circles), and report their findings on the Conservancy's website (Stark 1997). The goal of the monitoring program is to provide data that will be used in planning future restoration activities as well as in evaluating completed restoration projects. Other goals of the monitoring program are to detect "seasonal, year-to-year, and long-term changes in water quality," to identify point and non-point sources of pollution, to educate the public, and promote community stewardship of the creek (www.callamer.com/landcon/monitors).

Data collected by the volunteers showing high temperatures in the creek's waters in the stretch between Circles I and Q in Figure 24-3 led to the 984-foot revegetation project described above. By providing canopy and shade, the riparian restoration will help lower temperatures in the creek, which will improve water quality and create better conditions for fish and other aquatic organisms. The volunteer monitors have also received a grant to conduct a watershed awareness program. The group has stenciled storm drains (to educate people that the creeks flow to the ocean and should not be dumped into) and held "Creek Days" (sponsored by the Land Conservancy, Central Coast Salmon Enhancement, Inc. and the city) on which creek clean-ups are performed in conjunction with educational fairs offering interactive watershed displays. Over 700 people attended the last Creek Day in 1997, and 100 volunteers removed close to two tons of trash from the creek. Another goal of the Conservancy is to restore fish habitat. This summer it will undertake an instream habitat restoration project for fish on Stenner Creek (a tributary of San Luis Obispo Creek) and work with students from Cal Poly on restoration within some agricultural areas of the watershed.

Partners In Restoring San Luis Obispo Creek

The **Land Conservancy of SLO** is dedicated to preserving San Luis Obispo's open spaces through land acquisition, conservation easements, restoration, and stewardship. The Conservancy first became involved with the creek in 1986 when it received a **California Department of Water Resources (DWR) Urban Streams Restoration Program Grant** to prepare a plan to protect and restore San Luis Obispo Creek. The final plan calls for "promoting a continuous network of healthy riparian corridors throughout the entire watershed—to protect these corridors where they exist and to restore them where they have been degraded" (www.slonet.org/vv/land_com).

Central Coast Salmon Enhancement, Inc. is a non-profit group dedicated to enhancing salmon fisheries on the Central Coast and to educating the community on the ecology and economy of these resources (www.fix.net/surf/salmon).

The **city of San Luis Obispo's Resource Manager** oversees the various restoration projects within city limits. The **Parks Department** participates in Creek Days and cleanups.

Evaluation of Success

The restoration of San Luis Obispo Creek has provided multiple benefits to the community of San Luis Obispo, including contributing to its now-thriving downtown economy. Although restoration of the creek was certainly not the only factor contributing to this revitalization, the creek is a significant amenity in the city's downtown and illustrates one way in which urban and natural environments can co-exist. And while restoration of natural habitat was not a goal of the downtown restoration project per se, the initial project led to others that do focus on habitat restoration. As a result, the city is currently conducting an inventory of wildlife using the San Luis Obispo Creek corridor (Havlik 1998). Neil Havlik says San Luis Obispo Creek has evolved "from an urban eyesore and dump site to a valued city resource." Restoring the downtown site also eliminated erosion problems and improved water quality (Stark 1997).

Today San Luis Obispo Creek flows openly through much of the city and its watershed;

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[7] The creek is monitored for levels of dissolved oxygen, nitrates, and nitrogen, percent algal cover, flow, turbidity, and pH.

preserving the "green spine" of the creek continues to be the impetus behind coordinated efforts by the city and the Land Conservancy of San Luis Obispo to acquire more open space around the creek throughout the watershed (Stark 1997). The initial restoration project in downtown San Luis Obispo led to a new awareness and appreciation of the creek and its wildlife as well as many additional restoration projects throughout the watershed.

Critics of urban creek restoration sometimes question the relatively small scale of urban restoration projects and whether they can be "meaningful" in an ecological sense. San Luis Obispo is an example of how one small project can generate enough interest to inspire many additional restoration and educational/awareness projects that, cumulatively, offer ecological benefits on a larger scale.

In addition to the economic benefits the downtown restoration of San Luis Obispo Creek provided to the local community, it became a model for other urban stream restoration projects throughout the state, including projects in San Leandro and San Pablo. San Leandro renovated a degraded city park using the San Luis Obispo project as a model, and San Pablo is basing plans to restore a section of Wildcat Creek that runs through that city on the San Luis Obispo project (Ho 1997).

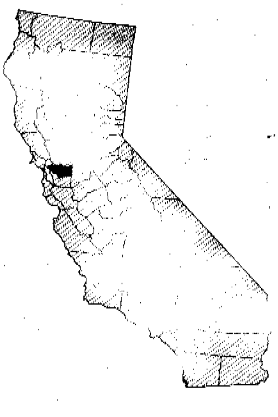
While the restoration projects on San Luis Obispo Creek were not specifically designed to improve fish habitat, revegetation created better instream conditions by stabilizing banks, reducing soil erosion, and absorbing and filtering urban runoff. San Luis Obispo is the southernmost limit of the central coast steelhead runs, and resource managers hope that additional restoration projects (both planned and underway) will further improve conditions for these threatened fish (Stark 1998).

Wildcat Creek: Richmond and San Pablo

Wildcat Creek is classified by the California Department of Fish and Game as one of the last remaining streams in the San Francisco Bay Area with a nearly continuous strip of riparian vegetation along its length. It is also one of the only remaining streams in the Bay Area that still flows into a salt marsh (most of the Bay's salt marshes were filled for development years ago). Wildcat Creek has, however, been altered (dredged, straightened, or damaged by grazing) in many ways over the years (Riley 1998). It carries a very high sediment load, in part because of the rapid urbanization of and frequent seismic activity in its upper watershed, which, prior to the restoration project, contributed to flooding in the community of North Richmond.

During World War II, black shipyard workers were segregated on the floodplains of Wildcat and San Pablo Creeks between the railroad tracks and the Bay (see Figure 24-4), and the area remains an impoverished, minority community today. Prior to the restoration of the North Richmond stretch of Wildcat Creek, North Richmond was flooded on the average of once every three years (Riley 1989). During the 1940s and '50s, the U.S. Army Corps of Engineers (the Corps) studied the possibility of a flood control project for North Richmond, but decided against implementing one because the government's benefit-cost analysis did not consider the homes in this area[8] valuable enough to justify the project (FIFMTF 1996).

Another flood control project was not proposed for North Richmond until 1971. As part of its Model Cities Program for urban renewal, the Department of Housing and Urban Development (HUD) came up with a plan for North Richmond that featured Wildcat and San Pablo Creeks and the San Pablo Bay shoreline as recreational and commercial amenities that could serve as the focus for redevelopment of the area (Riley 1989).[9] HUD's consultants came up with a favorable benefit-cost analysis, and by the late 1970s, the Corps, working with the community, had designed a flood control plan that was fairly traditional but still preserved some environmental values and offered a recreational component. Federal policy, however,



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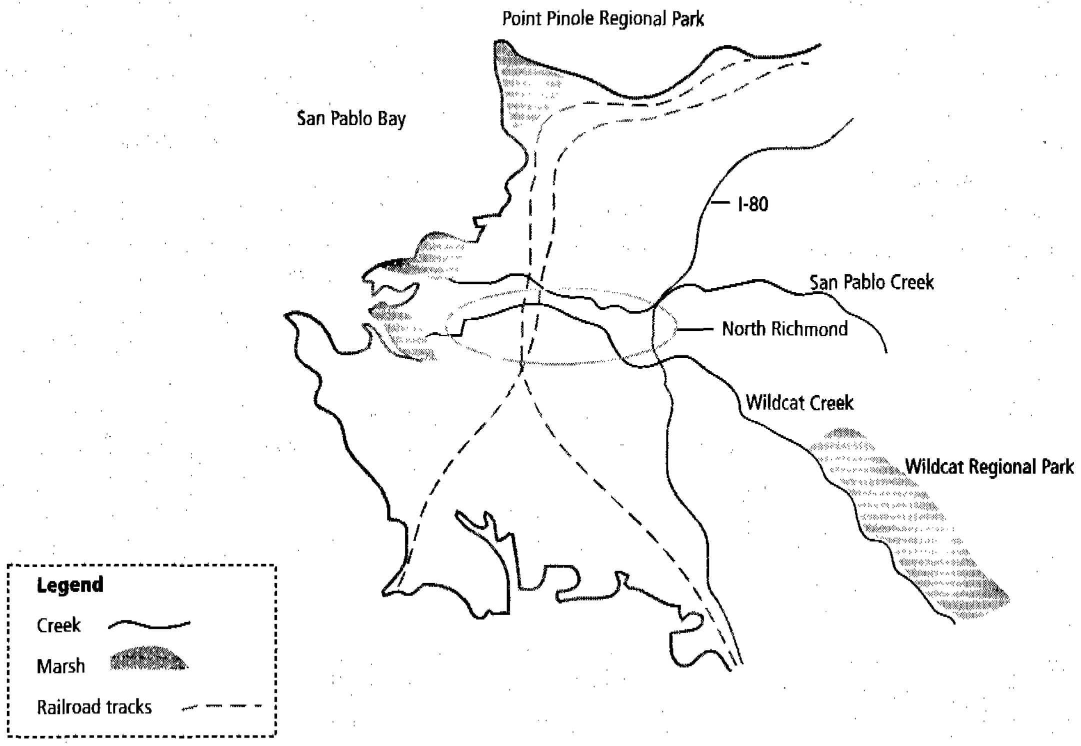
[8] The U.S. Department of Housing and Urban Development classifies North Richmond as one of the poorest communities in the country.

[9] The flood control project centered on Wildcat, however, since San Pablo Creek did not cause frequent flooding.

Figure 24-4
North Richmond And Vicinity



Source: Adapted from Environment, Vol. 31, No. 10, 1989

required that 50 percent of the cost of any recreational component be shared by the community, and the community of North Richmond was unable to come up with its required share, in part due to the lack of help from local industries (Riley 1989). The project was dropped once again.

In 1982, the Contra Costa County Flood Control District presented the community with a "take it or leave it," "bare-bones," traditional structural flood control type project for the stretch of Wildcat Creek that flows through North Richmond, to be built in cooperation with the Corps (Riley 1989). By that time some members of the community were resigned to any form of flood control at all. But others were determined to obtain a project that more closely resembled the original Model Cities Plan, one that would include environmental and recreational values. These citizens joined with various neighborhood groups, the Urban Creeks Council, Save San Francisco Bay Association, and the Contra Costa County Shoreline Parks Committee (among others), and formed a coalition that came up with an alternative plan for flood control on the creek using its own paid[10] and unpaid experts. The coalition designed a multi-objective stream corridor management plan that challenged the traditional, "take it or leave it" flood control plan presented by the county flood control district. After a hearing to review both plans, the county board of supervisors chose the traditional flood control plan. However, after environmental concerns were raised by the coalition about the traditional plan—the disturbance of endangered species habitat for one—the plan was unable to meet certain regulations and was not approved.

Because of these difficulties, in 1985, the county board of supervisors finally put together

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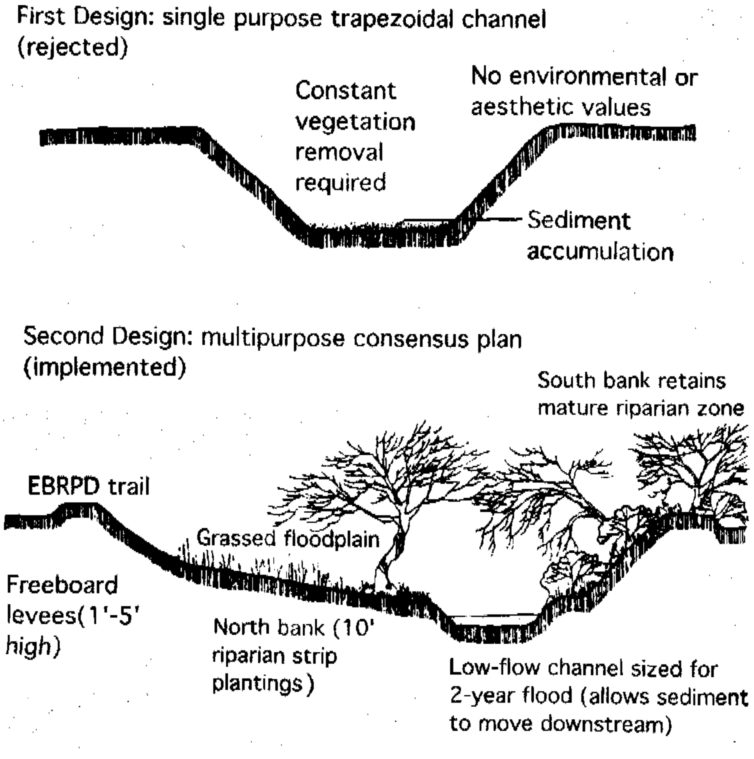
[10] The coalition received funding from two private foundations, an environmental non-profit organization, the East Bay Regional Park District, and the Coastal Conservancy to hire its own experts.

a team charged with creating an acceptable design. This team, made up of members from the previous citizen-based coalition, the U.S. Fish and Wildlife Service, the California State Lands Commission, the California Department of Fish and Game, the East Bay Regional Park District, Congressman George Miller and other local politicians, as well as the Corps and the flood control district, met as often as once a week over the next year, and, in 1986, arrived at a Consensus Plan.

The Consensus Plan, which was implemented over the next four years, used the concepts of natural channel geometry to provide flood control for most of the North Richmond section of the creek, instead of the standard concrete and riprap channels of the traditional plan.[11] The plan used 10- to 15-foot wide, meandering, low-flow channels designed to carry the creek's mean flows (see Figure 24-5), and wide floodplains between set-back levees on which flows can spread, lose velocity, and deposit sediment (Riley 1989). Riparian vegetation remained on both sides of the low-flow channels, to shade the channels and prevent the overgrowth of rushes and other vegetation that could obstruct flows.

By preserving the riparian habitat, creating a trail on the creek's northside set-back levee, and involving the community, the project has led to additional, recreational, aesthetic, economic, and educational opportunities in North Richmond. A Richmond youth group, CYCLE (Community Youth Council for Leadership and Education), has worked on the creek since the restoration first began, planting and maintaining trees, removing debris, and monitoring water quality in the creek. CYCLE was recently

Figure 24-5
Designs For Wildcat Creek Flood Control Project



First Design: single purpose trapezoidal channel (rejected)

Second Design: multipurpose consensus plan (implemented)

Source: Ann Riley, Waterways Restoration Institute

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[11] At the insistence of the Corps and the local flood control district, a section of the creek that flows beneath the railroad tracks was designed as a more traditional flood control channel.

appointed to the U.S. EPA's National Stream Monitoring Committee: up to 20 teenagers take samples of the creek's water each week and analyze them at EPA labs for hazardous wastes and other pollutants (Jones 1997–1998). In addition to what they learn about the creek's ecology, the students receive stipends for their work on the creek when grant money is available (Jones 1997–1998).

The increased focus on the creek in the community as a result of the flood control/restoration project and the trail and educational signage has encouraged broad use of the creek as an educational tool. At least three elementary schools in Richmond and San Pablo have instituted creek ecology programs using Wildcat Creek as an "outdoor lab" (Ho 1997–1998). As part of the "Creek Keepers" program sponsored by the San Francisco Estuary Project, students from Richmond High School are employed to monitor the creek's water quality after school and during the summers throughout their high school years. As part of Richmond High's Teacher Cadets program, the students design elementary school-level lesson plans in science, math, English, music, and art, using Wildcat Creek as the focus (Ely 1995). They then use those lesson plans to teach third and fourth graders at Dover Elementary School in San Pablo.

Lana Martarella, who heads the Teacher Cadets program, says specializing in Wildcat Creek has not only helped give her students ideas for future careers but empowered them to take personal responsibility for their local environments and to become community activists (Ely 1995). Students and community members have been able to see how "their" section of Wildcat Creek connects to the upper watershed in the regional parks (which many of them had never seen before) (see Figure 24-4) on tours co-sponsored by the Urban Creeks Council and the city of San Pablo (Ho 1997–1998).

Cost

The Consensus Plan that was ultimately implemented to restore/provide flood control on Wildcat Creek saved federal dollars because it satisfied multiple objectives—park development, fisheries enhancement, recreational benefits, and wildlife habitat—which attracted multiple funding sources at the state and local levels, including fish and game agencies and park districts (Riley 1989) (see Table 24-2).

Table 24-2
Costs and Funding Sources For Wildcat Creek Restoration

Agency	Funds	Purpose
Army Corps	$793,000	For implementing the Consensus Plan
California Coastal Conservancy	$800,000	To acquire and enhance land in the riparian zone and to plan and conduct restoration of the salt marsh
California Department of Water Resources, Urban Stream Restoration Program	$100,000	For the project generally, based on its design innovations, citizen participation, and educational opportunities (Riley 1989). Some of these funds were used to employ CYCLE youth to monitor and maintain the restoration.
California State Lands Commission	$240,000	To purchase transitional habitat, preserving the entrance of Wildcat Creek into San Pablo Bay salt marsh
East Bay Regional Park District	$793,000	To develop a regional trail
East Bay Regional Park District	$19,000	To enhance creekside habitat near Verde School (see Figure 24-6)

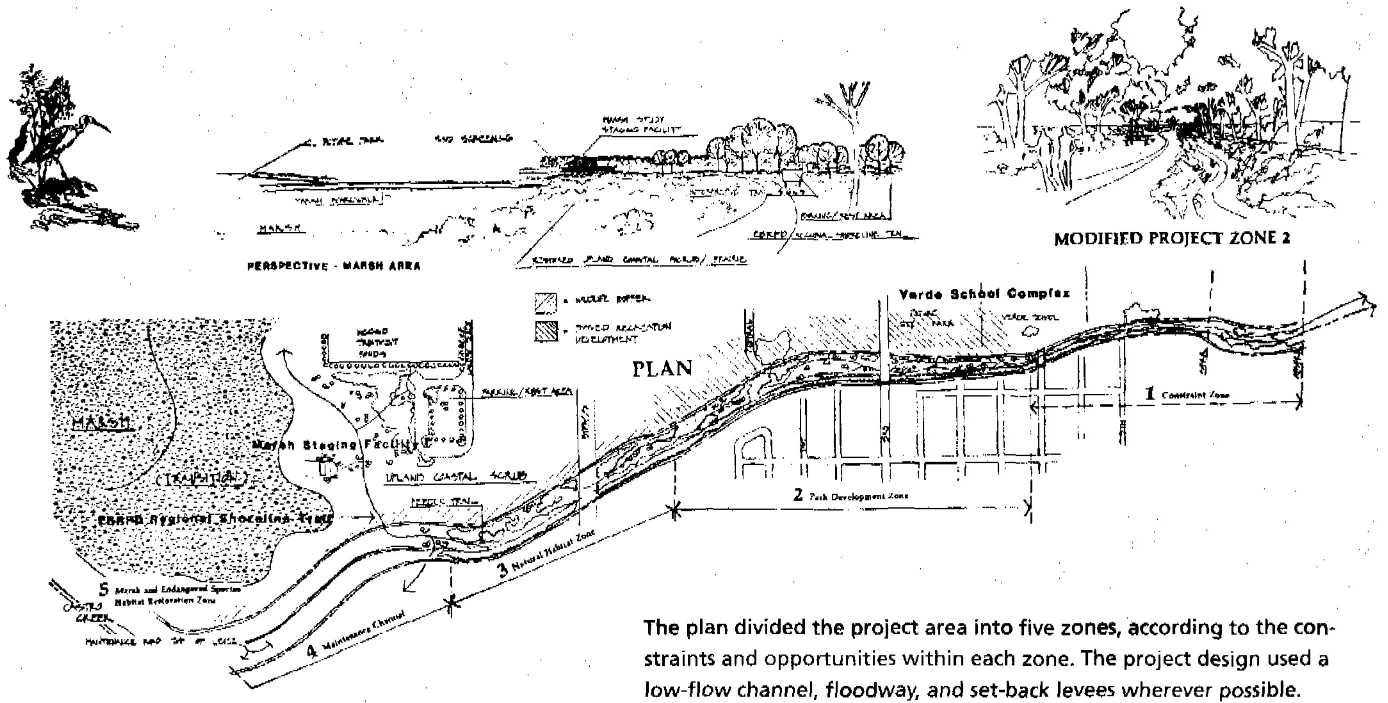
Source: Riley 1989

Evaluation of Success

Today, the community of North Richmond no longer experiences problems with flooding (Riley 1998), due to the restoration of approximately 4,000 linear feet of stream.[12] Despite the heavy winter rains of 1995, 1997, and 1998, the more natural flood control project performed well, with heavy flows inundating the floodplain between the creek and the set-back levees as planned. Wildcat Creek and its rare and valuable riparian habitat did not become a concrete channel. The Consensus Plan's low-flow channels have also prevented the sedimentation of Wildcat Marsh hydrologists predicted would occur with a traditional flood control channel (Riley 1989). As part of the restoration, the construction of a regional trail system was implemented, connecting North Richmond to Wildcat Marsh. Eventually, the trail will continue to the creek's upper watershed in Wildcat and Tilden Regional Parks (see Figure 24-4). Educational, interpretive signs and an observation platform were installed in Wildcat Marsh and along the trail near Verde Elementary School, where the creek is used as an outdoor classroom.

A measure of the restoration's success in providing habitat can be found in the fact that steelhead trout have returned to the creek for the first time in almost a century. This past winter, volunteers from the East Bay Conservation Corps, the non-profit Waterways Restoration Institute, and the Contra Costa Flood Control Department joined forces to remove grates covering a fish ladder (on the more traditional-style flood control channel constructed near the railroad tracks), which were causing debris and sediment to impede fish migration. Steelhead should now be able to migrate upstream to better spawning grounds in the regional parks (Riley 1998).

Figure 24-6
The Modified Flood Control Plan For Wildcat Creek



The plan divided the project area into five zones, according to the constraints and opportunities within each zone. The project design used a low-flow channel, floodway, and set-back levees wherever possible.

Source: Ann Riley

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[12] A later restoration, further upstream in Alvarado Park, restored approximately 1,500 additional linear feet of stream.

The Contra Costa Flood Control District now endorses a team approach for handling flood control controversies—a huge shift in policy and approach (Riley 1998). This new, more consensus-based philosophy has started to carry over to other projects in Contra Costa County (whose flood control district has a history of culverting and channelizing creeks). And, based partly on the success of Wildcat Creek, the Corps has begun using non-structural flood control measures in various projects around the country (Riley 1998). The new voter-approved floodplain restoration/flood control project on the Napa River was inspired by the Wildcat project as well (Cuff and Simerman 1998).

The community continues to remain involved in decisions about Wildcat Creek. The Wildcat Creek Watershed Council, which meets regularly to discuss and resolve creek-related issues and to give advice on the water-quality monitoring project, includes members of the original design team, a diverse array of neighbors, agency personnel, and members of local, non-profit "friends of creeks" groups.

As in the case of San Luis Obispo, the initial restoration on Wildcat Creek inspired additional projects. The city of San Pablo is planning to restore between 250–300 linear feet of Wildcat Creek (upstream from the North Richmond flood control project) in a planned pocket park[13] within a minority community that currently experiences flooding. The project, funded by a $75,000 DWR grant, will increase the creek's channel capacity and restore the floodplain and the riparian corridor (Goetting 1998); San Pablo also received a $50,000 federal grant to help create the park. Using San Luis Obispo as a model, San Pablo has built pedestrian bridges across the creek in its downtown area and is purchasing rights-of-way from private owners in an effort to link the stretch of Wildcat Creek that runs through the downtown to Wildcat Marsh and the restored North Richmond section on the west and to the regional parks in the hills to the east (see Figure 24-4).

In addition to providing local benefits, the Wildcat Creek restoration has become a national model for non-structural flood control and citizen-based decision-making on flood control issues that is used by the Corps and the Federal Interagency Floodplain Management Task Force.

Strawberry Creek: Berkeley

Probably one of the most valuable forms of urban stream restoration is creating habitat where none exists or restoring some of what once existed. In addition to providing habitat, bringing creeks back above ground can improve water quality, with creek beds and

The California Department of Water Resources Urban Stream Restoration Program began in 1985 "when a coalition of local water management districts, neighborhood organizations, sport fishing, environmental groups, service organizations, and city and county governments sponsored the creation of a new urban stream restoration and flood control program." The program's objectives are "to assist communities in reducing damages from stream bank and watershed instability and floods while restoring the environmental and aesthetic values of streams, and to encourage stewardship and maintenance of streams by the community." The program provides grants on an annual cycle for on-site stream restoration work, design of restoration and flood damage reduction plans, organizing volunteer maintenance and monitoring projects, and acquisition of green belts along streams (DWR, *Urban Stream Restoration Program*, 1991).

Since 1986, over 160 projects have been funded through the Urban Streams Restoration program, at a cost of $5 million (Denzler 1997). However, not enough funding is allocated to it, funding that would enable larger-scale projects that could compete with the better-funded, more traditional, structural type flood control projects (Schemmerling 1997). As of late 1998, the program had been given no funding.

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[13] In addition to reducing flood problems in this area, the city wants to create a small park, since its current park-to-resident ratio is only 14 acres of park for 26,000 residents while the city's general plan calls for 52 acres of open space and the county recommends twice as much (Brown 1996).

riparian vegetation filtering out sediment and other pollutants that would ultimately flow to bays and oceans.

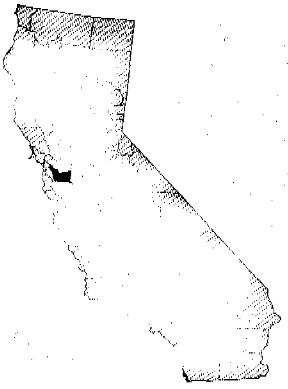
In 1983, a long-culverted section of Strawberry Creek was brought above ground in the Berkeley flatlands, as part of the city's efforts to transform a four-acre former railroad freight yard into a park.

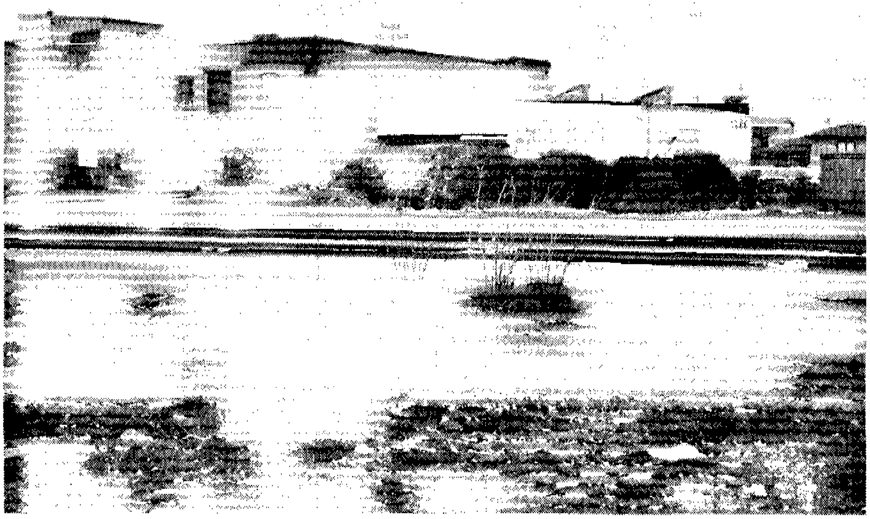
For less than 10 percent of the $580,000 allotted to the park creation, landscape architect Douglas Wolfe unearthed and restored the 200 feet of creek that ran through this blighted area beneath the ground in a culvert (Schemmerling 1998).

In the late 1800s, railroad tracks crossed the creek on a wooden trestle. But in 1904, the railroad decided to "improve" the crossing by putting the creek into a concrete culvert and filling the ravine with dirt (Wolfe 1988). In 1948 the railroad abandoned the freight yard, and in 1974 the city of Berkeley acquired the land. When the city took out the tracks in 1978, it began discussing the possibility of transforming the area into a park. But it took an innovative landscape architect, citizen support, and a creek-loving member on the parks commission to convince city officials (who were afraid that small children would drown in the creek or that the creek would attract rats) that bringing the creek back to life was worthwhile. After a strong show of support from area residents and well-known environmentalist David Brower, the parks and recreation commission voted unanimously to open the creek.

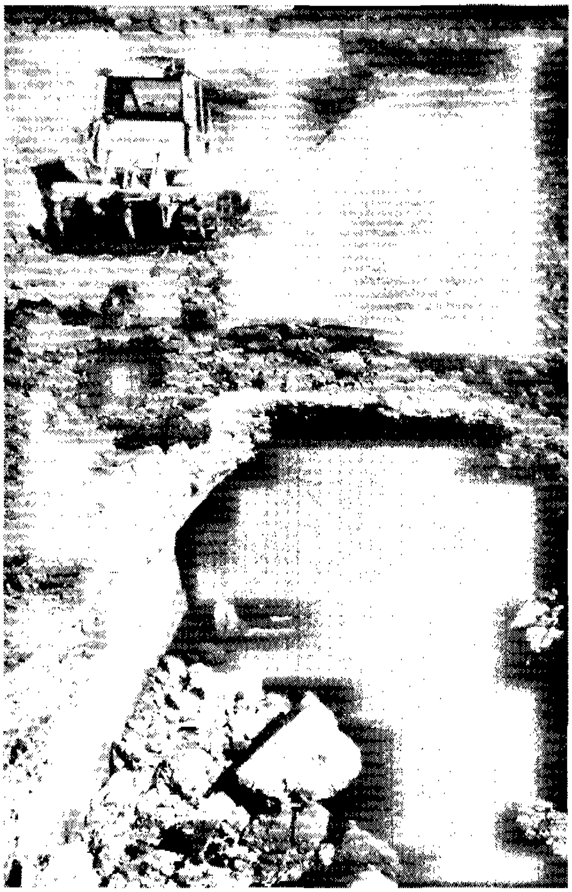
Despite approval from the parks commission, however, Wolfe was told to drop the creek from the project if the entire project could not be completed within the $650,000 allotted. As it turned out, he was able to restore the creek for less than 10 percent of the total budget (Powell 1991), and the entire project took only six months to complete. Like the San Luis Obispo restoration, cement left over from the demolition of the freight yard was used to create walkways near the creek and—along with native plants—to stabilize the creek's banks. Soil from the excavation of the creek was used to create small hilly areas in the park, adding aesthetic interest, and to rebuild the recreational area after the hardtop surface of the freight yard was removed. Drainage swales in the open space area, planted with native riparian vegetation, carry runoff to the creek as an alternative to underground drains and catch basins, and offer habitat.

Completed in 1984, Strawberry Creek Park is very popular with nearby residents and is frequented by a



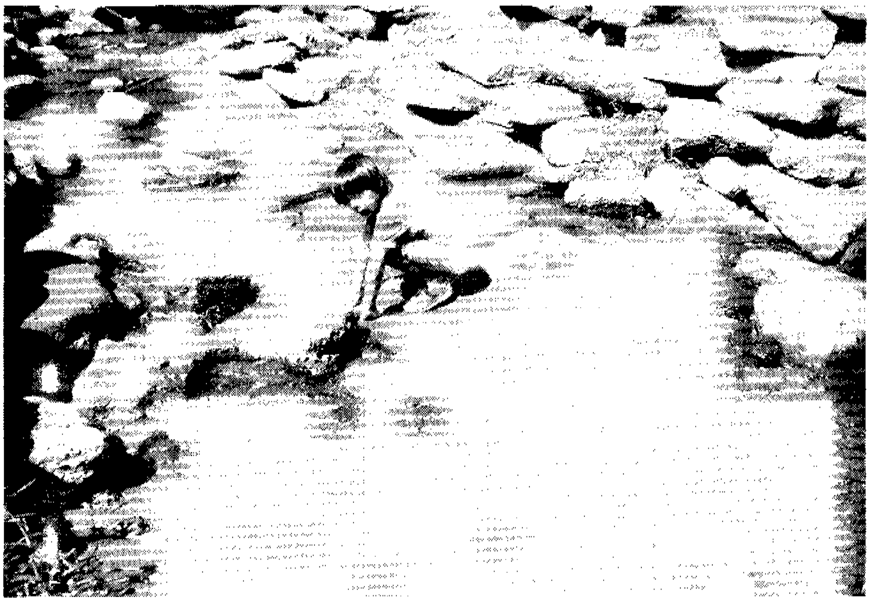


Strawberry Creek "before" (Photo courtesy of Wolfe Mason Associates)



Unearthing the creek (Photo courtesy of Wolfe Mason Associates)

A drainage swale offers habitat—and a place to rest (Photo by author)



Strawberry Creek Park immediately "after": "No sooner had we brought the creek back above ground than kids were there, playing in the water," says Carole Schemmerling with the Urban Creeks Council. (Photo courtesy of Wolfe Mason Associates)

diversity of birds and other wildlife. The park includes a huge, open green space, as well as a recreational area with swings and play equipment. The multiple uses seem to work well together, and a former eyesore has become an amenity for this urban neighborhood (Powell 1991).

The native tree, shrub, and ground cover species, which were chosen for their tenacity and drought tolerance, have, since 1983, grown into a lush riparian strip running through the middle of the park.

The Berkeley Youth Authority, housed in a building bordering the park, employs local teenagers to maintain the park and the native riparian vegetation. The teenagers recently planted an organic garden adjoining the park and earn money selling the plants at a local ecology center and farmers' markets. Partially in response to the success of Strawberry Creek Park, Berkeley is now studying the feasibility of daylighting a stretch of Strawberry Creek that runs through its downtown (Burt 1997).

Cost

Compared to some restoration projects, the cost of the creek restoration in Strawberry Creek Park—approximately $50,000—was minimal since land did not have to be acquired, with the railroad donating the right-of-way and old freight yard to the city. Reusing the concrete for new walkways also kept costs down. The primary cost in most "daylighting" projects is that of the heavy equipment needed to dig up buried creeks, and the cost of hauling away excavated soil, pipe, and cement or asphalt (Goetting 1997). In this case, the soil was reused on the site to create small hills in the park's open space area (Powell 1991) and to help create the recreational area (Schemmerling 1998).

Other Projects

The section of Strawberry Creek that runs through the central UC Berkeley campus (approximately 2,000 linear feet) was restored in 1987 (see Figure 24-7).

An initial six-month study of the creek's water quality (funded by a $15,000 grant from the chancellor's office) found elevated concentrations of nitrates and fecal coliform bacteria, as well as lead, zinc, and mercury in the creek's bottom sediments (Charbonneau and Resh 1992). An extensive sanitary engineering investigation was undertaken by the campus Environmental Health and Safety office, which revealed a number of cross-connections between sanitary sewer lines and storm drain

Strawberry Creek Park today (Photo by author)

lines (which flow into the creek) as well as deteriorating sewer lines whose contents were leaching into adjacent storm drains. Some direct discharges into the creek from a number of old campus buildings (constructed before modern building and health codes were in place) were also discovered.

To address the findings of the study, an interdisciplinary faculty and staff advisory committee was formed to oversee the proposed restoration. Staff from the Environmental Health and Safety office and campus facilities and planning departments were included on the committee, as were representatives from the city of Berkeley, and the U.S. Department of Energy's Lawrence Berkeley Laboratory. The goal of the committee was to restore the ecological integrity of the creek throughout the Berkeley campus. Campus deferred-maintenance funds of close to $500,000 were used to rehabilitate sewers, eliminate cross-connections, and reroute sewer discharges to the sanitary sewer system. By the spring of 1989, the worst problems had been corrected (Charbonneau and Resh 1992). Additional smaller and less-costly projects were undertaken as well: to prevent runoff of various pollutants into the creek, garbage bin wash-down areas were changed, and abandoned pipes along the creek were sealed or removed; back-flushing practices at a large swimming pool on the campus were changed to prevent chlorinated water from entering the storm drain system and the creek;

The **Waterways Restoration Institute** (which worked on the Wildcat Creek Consensus Plan and continues to work on additional Wildcat restoration projects) has performed restorations on many waterways both in the Bay Area and throughout the country. One of its goals is to create national models for stream restoration.

The **Urban Creeks Council** acts as an umbrella organization for citizen-based groups interested in stream restoration. It helps local watershed groups get started, offers referrals and reference materials, and helps local communities obtain grant funding.

Wolfe Mason Associates is a landscape architecture firm that has designed and performed many creek restoration projects, including the original Strawberry Creek Park project, the Root Park revitalization and creek restoration project in San Leandro, and the Blackberry Creek project at Thousand Oaks School in Berkeley, among others.

and floating oil-spill/debris control booms were installed where the creek enters the central campus from the city's urban northside district.

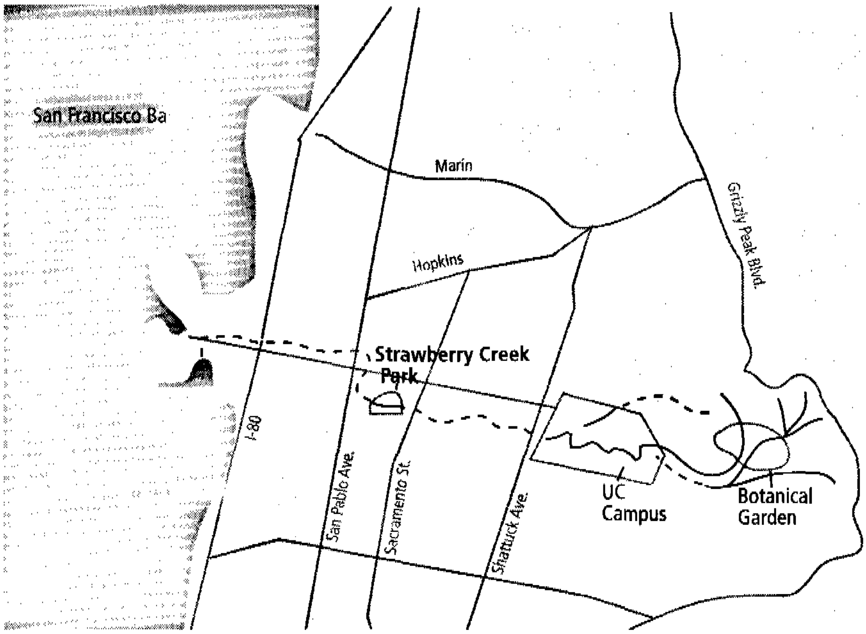
An eroding creek bank that was beginning to undercut an adjacent automobile bridge was stabilized, with the help of student volunteers, by installing a redwood "cribwall" and native plants. By the time the redwood logs rot (in about 75 years), the vegetation will have taken over the structural stabilization function (Charbonneau and Resh 1992). Erosion control activities were also undertaken, with several gullies in the headwater canyons of the north and south forks of the creek being regraded, stabilized, and revegetated. Water clarity has improved substantially on the campus, with decreases in total suspended solids and turbidity, and nutrient and fecal coliform concentrations (Charbonneau and Resh 1992). Water quality in the creek on the central campus pre-restoration (1986) was considered "poor,"[14] but after restoration (in 1991) was upgraded to "good" (Charbonneau and Resh 1992) (see Table 24-3). In 1989, native fish—three-spined sticklebacks—were reintroduced into the creek and continue to spawn there today (Maranzana 1998). Other species of native fish have been reintroduced as well, and in 1991, snowy egrets were seen foraging for fish in the creek for the first time in decades (Charbonneau and Resh 1992).

Cost

The restoration on the Berkeley campus was facilitated by the support of the administration, with funding from the Environmental Health and Safety office and facilities' deferred-maintenance budgets of $500,000, and through cooperative agreements with state agencies, which allowed water quality monitoring to be done at far less than the usual cost (Charbonneau and Resh 1992). Like the Strawberry Creek Park project and some of the San Luis Obispo projects, this restoration had the advantage of taking place on land already owned by the parties

Figure 24-7

Areas Where Strawberry Creek Can be Seen Above Ground



Source: Adapted from **Strawberry Creek, A Walking Tour of Campus Natural History;** ***UC Berkeley, Office of Environmental Health and Safety***

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[14] Based on the Family Biotic Index scores for macroinvertebrates. Aquatic macroinvertebrates are the group of organisms most widely used in water quality monitoring programs.

undertaking the restoration, and therefore did not involve the high costs of land acquisition.

Evaluation of Success

Strawberry Creek Park is an oasis in a very urban setting. The park and creek project turned blighted, unused land into an attractive multiple-use resource that is well used by residents of the area and wildlife. The project has won three awards for innovative design, including the 1995 American Society of Landscape Architects merit award, the 1990 California Cities award, and the 1983 California Parks and Recreation Society's Environmental Planning Award (First Place, Neighborhood Parks Category).

The successful restoration of Strawberry Creek inspired local creek advocates to undertake a series of "daylighting" projects, including the 1991 daylighting of a section of Blackberry Creek that runs through the grounds at Thousand Oaks School, (funded through a DWR Urban Streams Restoration Program grant of $144,000 to the Berkeley Unified School District and the Thousand Oaks PTA), and the 1994 daylighting of a city-block-size section of Codornices Creek in the Berkeley flatlands. The Urban Creeks Council, the city of Berkeley, and Wolfe Mason Associates worked together to design the Blackberry restoration, which restored a portion of the area's natural habitat while improving drainage and flooding problems on the school site (Mason 1998). The restored creek is the focus of several educational programs at Thousand Oaks School; neighbors and nearby businesses also enjoy the creek as an amenity. The project won a 1996 Certificate of Recognition for Outstanding Landscape Design from the Berkeley Architectural Heritage Association as well as the 1997 American Society of Landscape Architects Award for Restoration and Preservation. Codornices Creek was restored through the collaborative efforts of the Urban Creeks Council, the Waterways Restoration Institute, and Wolfe Mason Associates (three Berkeley non-profits active in creek restoration). That restoration was funded by a $23,000 DWR grant and $5,000 each from the cities of Albany and Berkeley. The East Bay Conservation Corps—and over 300 volunteers—performed much of the hands-on work.

Table 24-3

Strawberry Creek Macroinvertebrate Survey Data

Macroinvertebrate Group	Family	Pre-Restoration (1986)	Post-Restoration (1991)
Ephemeroptera	Baetidae	x	xxx
	Heptageniidae		xx
	Leptophlebiidae		x
Odonata	Coenagrionidae	xxx	xxx
Plecoptera	Nemouridae		x
Hemiptera	Corixadae		x
	Gerridae		x
	Velliidae	x	
Megaloptera	Sialidae	x	x
Trichoptera	Hydropsychidae	xx	xxx
	Hydroptilidae		xxx
	Lepidostomatidae		xxx
	Odontoceridae		x
	Sericostomatidae		x
Coleoptera	Dryoptidae		x
	Dytiscidae	x	
	Elmidae		x
Diptera	Chironomidae	xxx	xxx
	Empididae		x
	Simuliidae		xxx
Acarina			x
Gastropoda	Physidae	x	xx
Pelecypoda	Sphaeridae		xxx
Oligochaeta	Lumbricidae	xxx	xxx
	Tubificidae	xxx	xxx
Turbellaria	Planariidae	x	
Number of families		11	23
Family Biotic Index		7.4	4.9
(Water quality category)		Poor	Good

Survey based on macroinvertebrates collected from the South Fork on the central campus. Number of "x"'s refers to frequency of occurrence: x=found in a single sample; xx=found in more than one but in less than the majority of samples; xxx=found in the majority of samples.

Source: Charbonneau and Resh 1992

One of the nearby businesses has established an outdoor eating area near the creek. Other restorations on Cordornices Creek on private and university-owned land, co-sponsored by the Urban Creeks Council and the city, adjoin the initial project, bringing the total length of Codornices Creek restored in this urban area to 550 linear feet. The Waterways Restoration Institute and the Urban Creeks Council have proposed additional restoration projects to the city of Berkeley in the flatlands, which would create an almost continuous linear riparian strip along Codornices Creek throughout the city (Schemmerling 1998; Goetting 1998).

On the UC Berkeley campus, over 1,500 students in 50 different classes use the creek as an educational tool each year. The educational benefits of the restored creek extend to the general public as well: a creekside trail was installed in the UC Botanical Garden in the upper canyon of the creek's south fork, and the garden sponsored a public symposium on the creek and the restoration project. Other educational efforts have been undertaken by the city in conjunction with the university, including an informational mailing to northside residents, and the stenciling of storm drains (to prevent dumping into them), both on and off campus. As a result, any pollution in the creek observed by residents is quickly reported (Charbonneau and Resh 1992).

Conclusions/Lessons Learned

The three case studies in this story are representative of a growing number of stream restoration projects. In each case, an initial restoration project sparked interest in additional projects that led to further environmental, social, and other benefits. In each case, it took a key person or a group of people who recognized the values of these long-forgotten waterways and the benefits they offer (whether social, environmental, or economic) to implement projects to protect or enhance these natural resources. Without motivated citizens and decision-makers, these projects probably wouldn't have taken place.

As the cases in this story show, the costs of restoration greatly increase when land acquisition, building relocation, and demolition are involved. In any benefit-cost analysis performed, however, the costs and the many benefits of restoration, for which an exact dollar amount cannot always be measured, should be compared to the long-term costs of maintaining structurally engineered projects, which are usually very high, and to the environmental impacts from those projects (Schemmerling 1998). Where restoration simply involves revegetating and stabilizing eroding banks using volunteer labor, restoration costs can be very low.

In all of these examples, the restoration projects led to an increased awareness and involvement on the part of community residents in their local environments. Although none of the projects was designed to restore a pristine natural environment (which would be impossible), each project has either provided habitat where none existed (for almost a century in the case of Strawberry Creek), saved the complete destruction of existing habitat (Wildcat Creek), or led to additional restoration projects designed to increase the amount of or improve the quality of natural habitat (San Luis Obispo Creek).

One of the key elements to the success of each project was the involvement of all interested parties early in the process. The Wildcat project experienced temporary delays when one key party—the local school district—was inadvertently left out of the process (Riley 1989). Researchers on the Strawberry Creek project on the Berkeley campus found that making changes in a complex institutional setting was difficult but not impossible. The project's conservation goal—as well as public awareness and support for the restoration—seemed to help change long-standing attitudes and practices and win support for the project on the part of campus administrators. The creation of an interdisciplinary advisory committee both increased support for and widened the benefits from the project.

The success of urban stream restoration projects is magnified when projects transform blighted, unused land into multiple-use areas that provide habitat where little or none existed, and recreational and educational opportunities. Although the geographic scale of these projects tends to be limited, particularly since in many cases all that is left are city-block-sized opportunities (Riley 1997), the projects' multiple benefits greatly outweigh limitations of physical size. While most of these projects received funding from multiple sources—at the state, federal, and local levels—better funding particularly at the state level could help expand their scale. Although most of these projects received some DWR funding, DWR's Urban Streams Restoration Program budget cannot compete with the billions of dollars spent on the state's "subventions" program, which subsidizes up to 70 percent of traditional flood control projects (Riley 1998; Denzler 1998). As of late 1998, *no* funding had been allocated to this program. Nonetheless, despite funding limitations, the examples in this story show how one small initial project often inspires many additional projects that can greatly expand the amount of stream and wildlife corridor that is restored or preserved. Urban stream restoration (or perhaps any riparian restoration) cannot restore pristine ecosystems. But it offers a way of lessening the damaging effects of a highly urbanized society on the natural—including the human—environment.

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References

Bank of America. 1995. "Beyond Sprawl: New Patterns of Growth To Fit The New California." San Francisco, CA.

Brown, D. 1996. "San Pablo thinks small to expand park space." *West County Times*. December 27.

Burt, C. 1997. "Creek May Move Above Ground." *Oakland Tribune*. December 28.

California Department of Fish and Game. 1993. *Restoring Central Valley Streams; A Plan for Action*. Sacramento, CA. November.

California Department of Water Resources. 1991. *Urban Stream Restoration Program* brochure. Sacramento, CA.

Charbonneau, R. and V. Resh. 1992. "Strawberry Creek on the University of California Berkeley Campus: A case history of urban stream restoration." *Aquatic Conservation: Marine and Freshwater Ecosystems* 2:293-307.

Cuff, D. and J. Simerman. 1998. "Napa to tame river by letting it run free." *West County Times*. March 5.

Denzler, S. 1997–1998. California Department of Water Resources. Sacramento, CA. Personal communications.

Dury, J. 1995. "Biography of an Urban Creek," *Terrain*. Berkeley, CA: Berkeley Ecology Center. October.

Ely, E. 1995. "Urban Kids Monitor Creek." *Volunteer Monitor* 7:2. San Francisco, CA. Fall.

FIFMTF (Federal Interagency Floodplain Management Task Force). 1996. "Protecting Floodplain Resources, A Guidebook for Communities," 2nd Ed. Washington, DC. June.

Freitas, D. 1997. Contra Costa County Clean Water Program. Martinez, CA. Personal communications.

Goetting, D. 1997–1998. Waterways Restoration Institute. Berkeley, CA. Personal communications.

Haltiner, J. 1997. "Urban Stream Restoration: An Alternative to Traditional Flood Control Design." *Creeks Speak* 7:4. Bay Area Citizens for Creek Restoration c/o Aquatic Outreach Institute. Richmond, CA.

Havlik, N. 1997–1998. City of San Luis Obispo. Personal communications.

Ho, A. 1997–1998. City of San Pablo. Personal Communications.

Jones, L.M. 1997–1998. CYCLE. (Community Youth Council for Leadership and Education). Richmond, CA. Personal communications.

Kaplan, R. and S. Kaplan. 1989. *The Experience of Nature/A Psychological Perspective.* Cambridge, MA: Cambridge University Press.

Keller, E.A. and E.K. Hoffman. 1977. "Urban Streams: Sensual Blight or Amenity?" *Journal of Soil and Water Conservation* 32:237-240.

Kondolf, G.M. and E. Micheli. 1995. "Evaluating Stream Restoration Projects." *Environmental Management* 19(1):1-15.

Maranzana, S. 1998. UC Berkeley Environmental Health and Safety Office. Berkeley, CA. Personal communications.

Mason, G. 1998. Wolfe Mason Associates. Oakland, CA. Written materials.

Otahal, C. 1997–1998. Coyote Creek Riparian Station. San Jose, CA. Personal and written communications.

Pollock, S. 1991. "The Solace of Urban Creeks." *Pacific Discovery*. San Francisco, CA: California Academy of Sciences. Winter.

Powell, K. 1991. "The Free Creek Movement." *Landscape Architecture* 81(1). January.

Platt, R., R. Rowntree, and P. Muick. 1994. *The Ecological City/Preserving and Restoring Urban Biodiversity*. Amherst, MA: University of Massachusetts Press.

Richard, C. 1993. *Guide to East Bay Creeks.* Oakland, CA: The Oakland Museum.

Riley, A. 1989. "Overcoming Federal Water Policies/The Wildcat-San Pablo Creeks Case." *Environment* 31(10): 12-31.

Riley, A. 1997–1998. Waterways Restoration Institute. Berkeley, CA. Personal communications.

Riley, A. 1998. *Restoring Streams in Cities/ A Guide for Planners, Policymakers, and Citizens.* Washington, DC and Covelo, CA: Island Press.

RHJV (Riparian Habitat Joint Venture) undated brochure. California Department of Fish and Game, Wildlife Management Division, Sacramento, CA.

Schemmerling, C. 1997–1998. Urban Creeks Council. Berkeley, CA. Personal communications.

Schwartz, K. 1997–1998. San Luis Obispo, CA. Personal and written communications.

Stark, B. 1997–1998. Land Conservancy of San Luis Obispo County. San Luis Obispo, CA. Personal communications.

Steere, J. 1994. "Greening our Bay Cities/Creek Restoration Flows Into New Channels." Sierra Club *Yodeler*. May.

Struve, M. 1997. City Engineer. El Cerrito, CA. Personal communications.

Wolfe, D. 1988. In J.R. Rieger and B.K. Williams (Eds.) "Recreating a 'Natural' Riparian Environment, or Getting the Creek Out of the Culvert." *Proceedings of the 2nd Native Plant Revegetation Symposium.* San Diego, CA. Society for Ecological Restoration and Management. Madison, WI.

Chapter 25

Finding Mono Basin Replacement Water: Mono Lake Committee and Los Angeles Department of Water and Power

Anna Steding

Introduction

The plea to save Mono Lake—one of the oldest and most unique lakes in North America (Wiens et al. 1993)—became a familiar sight on California bumpers in the early 1980s. Forty years of diversions from Mono Lake tributaries by the Los Angeles Department of Water and Power (LADWP) had decreased the elevation of the lake and increased the salinity of the water, with grave consequences for animal (including human) and plant species. Thankfully, the plea was heeded, and the process of restoring the water resources of Mono Lake and its tributaries has begun.

The court battles are the most well known part of the Mono Lake saga. Many Californians are familiar with the fact that the Public Trust Doctrine took on an expanded meaning in *National Audubon Society v. Superior Court* (33 Cal.3d 419, 1983) and that sections of the Fish and Game Code were enforced in *CalTrout I* and *CalTrout II* (*CalTrout v. State Water Resources Control Board,* 207 Cal.App.3d 585, 1989; and *CalTrout v. Superior Court*, 218 Cal.App.3d 187, 1990). Further, many environmentalists supported the amendment of LADWP's licenses in 1994 by the California State Water Resources Control Board to allow for greater flow into Mono Lake.

Yet these legal victories are merely one side of the story. With amended licenses, LADWP would necessarily take less water from the Mono Basin. How would it make up for the loss? Additional supplies from the Owens Valley or the San Francisco Bay-Delta were one possibility. However, the Mono Lake Committee (MLC) recognized the importance of avoiding the potentially redirected impacts to these environmentally sensitive areas, and working closely with LADWP to fund alternative projects by the water agency, sought other "replacement water" for Mono Lake supplies. All told, the MLC-LADWP replacement water effort led to funding for recycling and conservation of 50,450 acre-feet per year. With additional funding from LADWP and elsewhere, these recycling and conservation programs will ultimately yield as much as 88,100 acre-feet per year by 2015—enough to make up for lost Mono Basin supplies.

Background

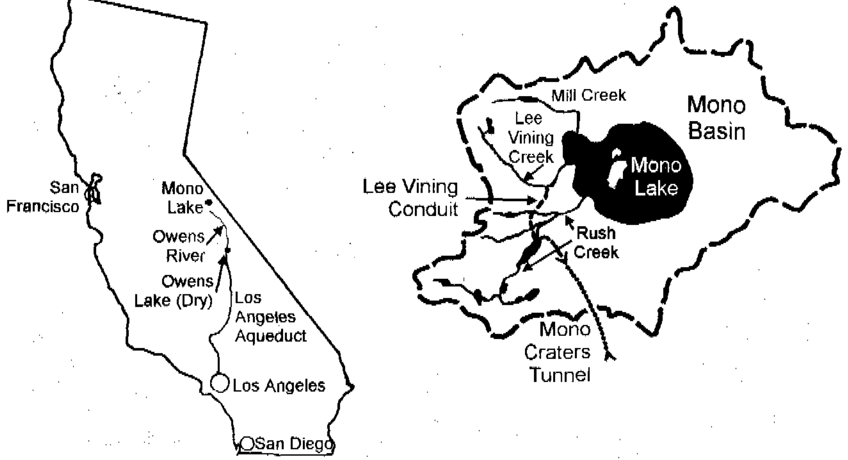
Mono Basin Hydrology and Ecosystem

Located in eastern California (see Figure 25-1), Mono Lake obtains most of its water supply from Sierra Nevada snowpack runoff. It is a closed hydrologic system—i.e., it has no surface outlet and acts as a groundwater sink—and thus is very sensitive to changes in inflow and evaporation (Wiens et al. 1993). A simple trophic web depends on this delicate hydrologic balance. Phytoplankton are grazed by brine shrimp, which provide food for eared grebes, California gulls, and other bird species. Algae are eaten by brine flies, which in turn support snowy plovers, among other birds. For some of these species, Mono Lake is critical habitat. For example, approximately 95 percent of the state's California gull population and 25 percent of the total California gull population nests at the lake (*National Audubon Society v. Superior Court,* 33 Cal.3d 419, 1983).

Origin of Problem

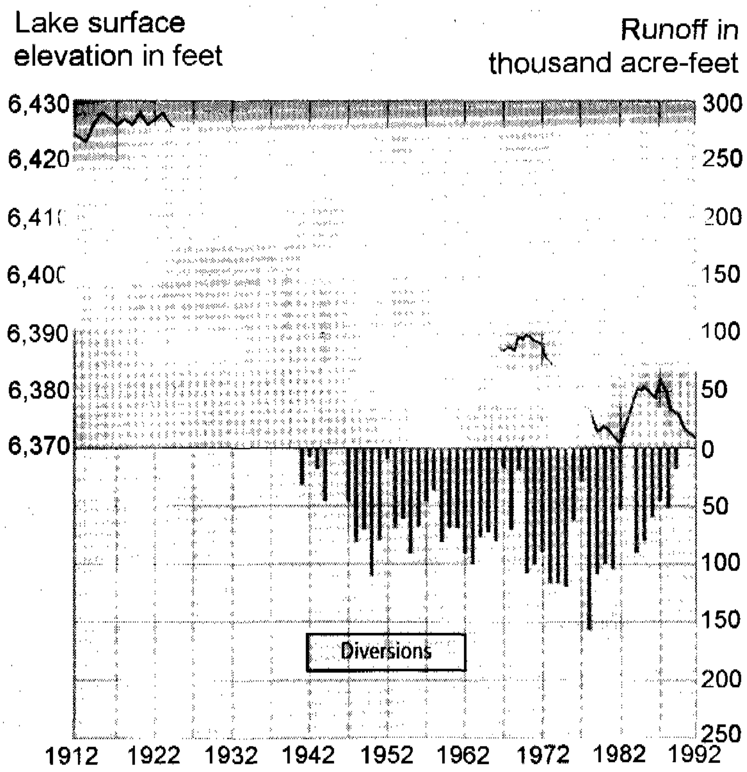
Since the turn of the century the city of Los Angeles has been in pursuit of reliable water supplies. After tapping the water of Owens

Figure 25-1
Mono Lake and Basin



Source: Hart 1996

Figure 25-2
Mono Lake Diversions, Streamflow, and Lake Level



Note: Read left scale for lake level, right scale for streamflow and export volumes. Streamflow includes not only the four diverted streams but also Mill Creek and lesser streams whose water was never diverted from the Mono Basin.

Source: Hart 1996

Valley[1] in 1913, Los Angeles turned to Mono Basin where it purchased riparian rights to the lake and its tributary creeks. In 1940, the Los Angeles Department of Water and Power applied to the state for permits to appropriate the waters of four creeks: Lee Vining, Walker, Parker, and Rush. Since LADWP sought the water for domestic use[2] the state overlooked claims that the diversions would lower the surface level of Mono Lake and diminish its commercial, recreational and scenic values (*National Audubon Society v. Superior Court* and Hart 1996) and approved the application. Diversions began in 1941 upon completion of the northern extension of the Los Angeles Aqueduct and averaged 57,067 acre-feet per year (afy) until 1970, but increased to 99,580 afy between 1970 and 1980 after the second Los Angeles Aqueduct was completed (LADWP 1995).

As a result of LADWP diversions, water inflow to Mono Lake decreased, causing the lake level and volume to drop, salinity to increase, shoreline flats to be uncovered, tufa towers[3] to be exposed, inflowing streambeds to be incised, and islands to be connected to the shore (see Table 25-1 and Figure 25-2). Changes in the physical environment affected, in turn, the viability of animal species. The most dramatic of these effects was the death of 95 percent of hatched California gull chicks in 1981 as a result of the emergence of a land bridge that allowed coyotes and other predators easy access to the gull nests on the islands (*National Audubon Society v. Superior Court*).

Mono Lake Committee

The poor health of the Mono ecosystem caught the attention of a number of student scientists who formed the Mono Lake Committee

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[1] For an account of the Owens Valley story, see Reisner 1986, Hundley 1992, or Hart 1996.

[2] Section 106 of the California Water Code declares that it "be the established policy of [California] that the use of water for domestic purposes is the highest use of water and that the next highest use is for irrigation."

[3] Tufa towers are composed of several forms of calcium carbonate, or lime. Water from springs that emerge under the lake is high in calcium and, upon mixing with the carbonate-rich lake water, causes lime to precipitate and the tufa towers to grow (Hart 1996).

Table 25-1
Status of Mono Lake Health at Start of LADWP Diversions and Forty Years Later

	Status	
Indicator	**1941**	**1981**
Runoff to Lake	130,000 acre-feet per year[a]	80,000 acre-feet per year[b]
Lake Level	6,417 feet	6,372 feet[c]
Lake Volume	4.5 million acre-feet	2.2 million acre-feet
Lake Salinity	50 parts per thousand	100 parts per thousand

Notes: (a) Approximate average runoff, as read from Figure 25-2, from 1912 to 1941.
(b) Approximate average runoff, as read from Figure 25-2, from 1942 to 1981. Average runoff between 1970 and 1990 was closer to 60,000 acre-feet per year.
(c) Represents the lowest lake level in 1,000 years (Wiens et al. 1993).
Source: Wiens et al. 1993 and Hart 1996

Table 25-2
SWRCB Regulation of LADWP Mono Diversions in 1994 Decision

Lake Level (feet)	Diversions Allowed (afy)	Amount of Water "Lost" by LADWP (afy)[a]
< 6,377	None	85,000
≥ 6,377 and < 6,380	4,500	81,500
≥ 6,380 and < 6,391	16,000	69,000
≥ 6,391[b]	All water in excess of amount needed for fishery protection[c]	55,000

Notes: (a) Based on average diversion of 85,000 afy between 1970 and 1990 (Hart 1996).
(b) SWRCB (1994) predicts that this lake level will be reached in 2024.
(c) LADWP (1995) estimates this "excess" water to be 30,000 afy.
Source: SWRCB 1994

(MLC) in 1978. Since then the MLC—the force behind the movement to save Mono Lake—has dedicated itself to the following goals:

- Protecting and restoring the Mono Basin ecosystem;
- Educating the public about Mono Lake and the impacts on the environment of excessive water use; and
- Promoting cooperative solutions that protect Mono Lake and meet real water needs without transferring environmental problems to other areas (MLC 1997).

To achieve these goals the MLC has employed the tools of litigation, legislation, cooperation, and public support. While cooperation and public support are the most important for the story we tell here, neither would have been possible without litigation and legislation.

Litigation and Legislation

The first step the MLC took toward protecting Mono Lake was into the courtroom. In 1979, the MLC, in conjunction with National Audubon Society, Friends of the Earth, and four Mono Basin landowners, filed suit to enjoin LADWP diversions from Mono Lake tributaries. This suit ultimately led to the landmark 1983 "public trust" decision, although many other legal steps were taken before LADWP's diver-

Table 25-3
Summary of Key Mono Lake Litigation and Legislation

Case/Statute	Year	Decision/Significance
Mono Lake Tufa State Reserve	1981	Established to protect shorelands exposed due to the decline of Mono Lake
National Audubon Society v. Superior Court, 33 Cal.3d 419	1983	Court found that: Public Trust Doctrine applies to tributaries of Mono Lake; public trust values broadly stated include scenic views, air quality, and wildlife habitat; SWRCB has affirmative duty to uphold public trust and can amend water appropriation licenses to do so; and LADWP permits were granted without consideration of public trust values and therefore need to be reconsidered.
Mono Lake Basin National Forest Scenic Area	1984	Established, as first National Scenic Area, to protect unique ecological and cultural resources of Mono Lake Basin
Environmental Water Act, AB 444 (State)	**1989**	**Established a $60 million fund of investment capital to help LADWP build water recycling and conservation facilities**
CalTrout v. State Water Resources Control Board (CalTrout I), 207 Cal.App.3d 585	1989	Court ruled that SWRCB must bring LADWP's licenses into compliance with California Fish and Game Code §§5937 & 5946 which states that owners of dams must allow sufficient water below dam to keep fish in good condition.
CalTrout v. Superior Court (CalTrout II), 218 Cal. App.3d 187	1990	Court ruled again that SWRCB must bring LADWP's licenses into compliance with California Fish and Game Code §§5937 & 5946 (SWRCB had not acted as ordered) and that historic fisheries on all four tributaries must be restored.
El Dorado County, Superior Court Coordinated Proceeding Nos. 2284 and 2288	1989–1991	Court entered a preliminary injunction requiring sufficient inflow into Mono—set at 55,000 acre-feet per year—to keep lake at 6,377 feet (entered in 1989 and renewed in 1991); also set interim flows for tributaries and ordered LADWP to "help re-establish the conditions that benefited the fisheries prior to 1941" (1990).
Western Water Bill, HR 429 Title 16 (Federal)	**1992**	**Authorized a 25 percent cost share with Los Angeles area water agencies to develop 120,000 acre-feet of recycled water supplies to help protect Mono Lake and Santa Monica Bay**
State Water Resources Control Board Decision (SWRCB) D-1631	1994	SWRCB amended LADWP's licenses to comply with Fish and Game Code and protect public trust values at Mono Lake (see Table 25-2); SWRCB also ordered LADWP to develop plans to restore waterfowl and stream habitat damaged as a result of diversions, and to pay implementation costs associated with restoration.

*Note: Entries in **bold** will be discussed in this case study.*
Sources: California State Lands Commission (CSLC) 1993, SWRCB 1994, MLC 1997, and Davis 1997

sion licenses[4] were amended in 1994 (see Table 25-3). This amendment, made by the State Water Resources Control Board (SWRCB), decreased the amount of water that LADWP could divert from the Mono Lake tributary creeks. SWRCB based its decision on a desire to protect the public trust resources of the lake by insuring that it reached an optimum level of 6,392 feet (SWRCB 1994). Thus, the amount of water available for diversion by LADWP depends on how close the actual lake level is to the optimum lake level (see Table 25-2).

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[4] While LADWP had initially applied for permits, those permits became licenses upon completion of the second Los Angeles Aqueduct (i.e. upon evidence of due diligence). The *licenses* were amended in 1994 (see Table 25-2).

Equally as important as the legal victories, and more relevant to this story, were the legislative feats (shown in bold in Table 25-3) that provided public support and public funds for the effort to find replacement water for Mono Basin supplies.

The Water Replacement Program

Goals and Philosophy

The MLC set an explicit goal at the outset of its effort to "save" Mono Lake to assist LADWP in securing funding for "as much replacement water as necessary" (Davis 1997). Although the MLC aimed toward securing a replacement supply of 70,000 afy, it knew that the exact amount of replacement water would depend on how the SWRCB modified LADWP's licenses.

The MLC opted to undertake the replacement water effort, rather than focus solely on an environmental victory for Mono Lake, for two reasons. First, LADWP had expressed its intention to make up for the lost Mono water by taking additional supplies from Owens Valley (through the Los Angeles Aqueduct) or the San Francisco Bay–Delta (through the Metropolitan Water District of Southern California). Taking more water from either of these sources would possibly result in a redirection of adverse environmental impacts. In other words, a victory for Mono Lake could mean damage to another environmental resource. To prevent "redirected impacts," the MLC needed to work with LADWP to find other sources. Second, the MLC felt that LADWP had a legitimate claim to "adequate, reliable water resources" just as Mono Lake did (Davis 1997). As LADWP points out, "the Mono Basin supply represents a $100 million investment in facilities constructed in good faith under laws which granted [Los Angeles] water rights permits to begin diversions in 1941" (LADWP 1989).

Thus, the MLC approached the problem from "both ends of the aqueduct."[5] At the Mono Lake end, the MLC viewed obtaining more water for Mono Lake as a way to restore environmental quality, restore habitat and natural processes, and comply with the Clean Water Act, Clean Air Act, Endangered Species Act, and other environmental regulations. At the Los Angeles end, the MLC strove to accomplish the following goals:

- Strengthen Los Angeles's economy by developing locally controlled, drought proof supplies;
- Improve Los Angeles's environment by reducing the amount of effluent running into Santa Monica Bay; and
- Involve and support community and business groups throughout Los Angeles (Davis 1997).

Players and Process

The MLC began its water replacement program in earnest in the late 1980s. In 1987, it commissioned a study by the Environmental Defense Fund (EDF) to locate Mono Basin export water replacements. Driven by its interest in water marketing, EDF identified two small irrigation districts willing to implement conservation improvements—thereby growing the same crops with less water—in exchange for transferring the saved water to LADWP (Hart 1996). Thus, with a potential source identified, the MLC turned to the question of funding.

An answer came first from the California Legislature. There, Assemblyman Bill Baker (R-Danville) authored AB 1442, which promised to "eliminate a twenty-year-old debt between the state water contractors and the state of California" (Reifsnider 1989) and provide funding for solutions to water-related problems around the state. Working with Baker, Phil Isenberg (D-Sacramento) was able to push a bond act, AB 444, through the Legislature in 1989. AB 444, codified as section 12929 of the California Water Code, established an Environmental Water Fund of $60 million[6] to develop replace-

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[5] **This phrase comes from the Mono Lake Committee's materials on the World Wide Web at http://www.monolake.org.**

[6] Funding would be made available by appropriating $1 million to the Environmental Water Fund in the 1990–91 fiscal year, and $8 million each year between fiscal years 1991–92 and 1998–99, inclusive (California Water Code §12929.12).

ment supplies for permanent protection of Mono Lake. Funding would be made available upon request by LADWP and approval by MLC. The focus of possible replacement water sources was then expanded from water markets to include conservation and recycling projects.[7]

The Environmental Water Fund remained untapped for six years, resulting in its gradual diminution. Negotiations between the MLC and LADWP aimed at defining an appropriate project were frustrated again and again. In fact, instead of negotiating with the MLC, LADWP opted to focus on continued litigation and to maintain maximum Mono Basin water rights.

LADWP intended to maximize the diversions allowed to the city by getting the courts, and ultimately the SWRCB, to set the target lake level as low as possible. LADWP calculated that a lake level of 6,386 feet would translate into a replacement cost of $700 million over 25 years, based on a cost of $27 million to replace the 70,000 afy that would be lost. At a lake level of 6,375 feet, LADWP estimated that replacement water would cost $400 million over 25 years. Thus, according to its calculations, LADWP stood to gain $300 million by fighting in court, but only $60 million by settling and accepting AB 444 money (Katz 1992). This may have indeed been the case, except for the fact that the El Dorado Superior Court had required that LADWP allow 55,000 afy of flow into Mono Lake starting in 1989 (Schlichting 1992a). This was 55,000 afy that would likely be irrecoverable through further litigation, making it difficult for LADWP to recover all of the 70,000 afy. In other words, LADWP had already lost a portion of the $27 million needed to replace Mono Basin water annually. The MLC sought to convince LADWP that they might as well take the remaining AB 444 funds.

In 1992, more funds for Mono Lake replacement water came from the federal government with the help of testimony by MLC staff. HR 429, authored by Congressman George Miller (D-California) and Senator Bill Bradley (R-New Jersey), was a broad-based bill designed to "overhaul water policy in California's Central Valley . . . authorize major water projects and establish new precedents for water conservation and wildlife protection throughout the West" (Schlichting 1993). Title 16, a small part of the omnibus bill, authorized a 25 percent federal cost share with water agencies throughout the 13 western states to develop water-recycling projects. LADWP, as well as West Basin Municipal Water District, would use Title 16 funds to develop recycling projects to help protect both Mono Lake and Santa Monica Bay. The water savings from these projects would ultimately amount to over 100,000 afy.

Meanwhile, AB 444 funds had diminished considerably. Because LADWP and the MLC missed the filing deadlines, $2 million were taken from the fund in 1991, followed by $12 million in 1992 for other government needs (Schlichting 1992a). LADWP continued to be reluctant to plan, design, and build water-recycling projects. Finally, with the encouragement of the office of the mayor of Los Angeles, Governor Wilson's office, and, in particular, Los Angeles City Councilwoman Ruth Galanter, LADWP initiated funding discussions with the MLC. In late 1993, LADWP accepted the remaining $36 million of AB 444 funds for four water-recycling projects that would amount to 40,950 afy. In exchange, it promised that any water developed with these funds would be credited to Mono Lake.

An additional source of funding—one not generated by the MLC, but nonetheless important to the story—came through Metropolitan Water District of Southern California's (MWD) Local Projects Program. Under this program, LADWP would be able to receive a rebate of up to $250 for every acre-foot recycled, provided that its water-recycling project(s) would cost more than MWD's treated water rates and would reduce potable water needs (LADWP 1995). LADWP has used this funding for the Sepulveda Basin Irrigation Project (1,200 afy), which is expected to be operational by 1999. LADWP did not take MWD funding for the East Valley Project since the costs to LADWP are not substantially larger than the MWD water rate.

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[7] A project eligible for AB 444 funds might be a "water or power conservation project, a wastewater reclamation project, a conjunctive use program, a groundwater recharge project, the enlargement of existing water or power facilities owned by the city of Los Angeles, electric power production facilities, or a water marketing program" (California Water Code §12929.22).

Table 25-4

Mono Replacement Supplies[a]

Project	Year On-Line	Current Production (acre-feet)	Future Annual Production (acre-feet)			
			2000	2005	2010	2015
Water Conservation						
ULFT Program	1990	25,000	25,000	25,000	25,000	25,000
Water Recycling						
East Valley	1999	0	11,600	21,600	35,100	40,100
Sepulveda Basin	1999	0	1,200	1,900	1,900	3,000
Terminal Island	~1999	0	5,500	9,000	16,000	17,000
Westside[b]	1996	250	1,850	1,850	1,850	3,000
Total		**25,250**	**45,150**	**59,350**	**79,850**	**88,100**

Notes (a) The AB 444 and HR 429 funds have supported the production of 50,450 afy through the projects above: 4,500 afy for the ULFT program and 45,950 afy for the recycling programs.

(b) This refers only to the amount of the water produced by the West Basin Water Reuse project that is being used by the City of Los Angeles.

Sources: LADWP 1995, Davis 1997, and Gewe 1997

They reasoned that there would be little subsidy to LADWP, and, in fact, if MWD were to support the East Valley Project, it might justify a reduction in the amount of water delivered to LADWP from MWD during a drought event (Gewe 1998).

Results

Using AB 444, HR 429, and MWD funds, as well as its own, LADWP developed water-recycling and conservation projects that will ultimately amount to 88,100 afy of replacement water (see Table 25-4). Of this total, 50,450 afy (57 percent), are funded by AB 444 and HR 429 described above. The balance of the funding will come from LADWP itself and other sources.

The conservation program connected with the Mono Lake replacement effort is part of a larger water conservation program that grew out of California's 1987 to 1992 drought. Of interest here is the ultra-low-flow toilet (ULFT) rebate program, inaugurated in 1990 in collaboration with the MLC, which involved a rebate from LADWP for toilet purchase and installation in homes by community members. This program had two positive effects: water conservation and community building. To date, more than 750,000 ULFTs have been installed, for an estimated water savings of 25,000 afy (see *Community-Agency Partnerships,* Chapter 5). AB 444 provided partial funding for replacing about 140,000 toilets, with an estimated annual savings of about 4,500 afy.

The water-recycling projects are currently producing only 250 afy, but will ultimately provide more than 63,000 afy. The Sepulveda Basin Project will provide 3,000 afy of tertiary-treated recycled water for golf courses, recreational facilities, and wildlife parks (LADWP 1995 and MWD 1996). The East Valley Project is under construction and will supply 40,100 afy for groundwater recharge, industrial cooling towers, and landscape irrigation (MLC 1995 and Gewe 1997). The Terminal Island[8] Project, still in the planning phase, will produce 17,000 afy by the year 2015 and water from the Westside extension of the West Basin Project will generate 3,000 afy (LADWP 1995). Reaching the ultimate projections for the East Valley Project and the Terminal Island Project is dependent on funding being available for future phases. Ultimate capacity of the East Valley Project will

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[8] The Terminal Island Project was conceived in response to a cease and desist order issued by the Regional Water Quality Board to the city of Los Angeles to eliminate discharges into the Los Angeles Harbor (Gewe 1997).

Table 25-5
Costs Associated with Mono Lake Replacement Water

Project	Capital Cost ($ million)	Marginal Cost ($/af)[a]
Water Conservation		
ULFT Rebate	55[b]	290
Water Recycling		
East Valley	55	550
Sepulveda Basin	8	320
Westside	8	710
Terminal Island	—	N/A
Cost of Mono Supplies	—	100-500[c]
Cost of MWD Water	—	344-426

Notes: *(a) Based on capitalized cost and annual operation and maintenance costs in 1994 dollars. The costs for the recycling projects are planning numbers and may vary substantially depending on actual capacity developed and future regulatory actions.*

(b) Refers to total (not capital) costs to date.

(c) Lower estimate refers to cost during wet years; upper estimate refers to cost during dry years.

Source: LADWP 1995

also require a relaxation of current health standards regarding the percentage of recycled water allowed for groundwater recharge. Nevertheless, LADWP is counting on these recycling projects to reduce future drought and emergency interruptions in imported supplies (Gewe 1998).

It should be noted that the West Basin Water-Recycling Project as a whole will deliver 100,000 afy to many water customers in the Los Angeles area (see *Use of Recycled Water in Urban Settings,* Chapter 12). Although this supply is technically not Mono Lake replacement water, since it will be used to service agencies other than LADWP, the MLC played a part (through HR 429) in making federal funding possible for the project, as well as other water-recycling projects throughout the 13 western states.

As noted earlier, LADWP will be "losing" approximately 70,000 afy of supplies between now and 2024, or the time at which the Mono Lake level is predicted to reach 6,391 feet (see Table 25-2). Once this "protection level" is reached and LADWP is able to expand its diversions to 30,000 afy, then it will be "losing" 55,000 afy. At that point, water recycling and conservation measures will be more than compensating for "lost" Mono Basin water.

Costs

There are two categories of costs associated with diversion of water from Mono Basin. The first category includes "private" costs, or those that are paid for by LADWP, which include the costs to construct the diversion works and the operation and maintenance costs. The second category includes "social" costs, or costs that are not paid by LADWP but nevertheless accrue to society at large. These include the costs of environmental destruction, such as the destruction of habitat, species viability, and water quality. The real cost of diverting water from Mono Basin for use in Los Angeles consists of both private and social costs. The social costs of diverting water from the Mono Basin are higher than the social costs associated with water-recycling projects since recycling projects cause very little, if any, environmental damage. Since social costs are difficult to quantify, the numbers discussed below only refer to private costs.

Apart from the time and energy of MLC and LADWP staff, the major cost considerations in securing Mono Basin replacement supplies are the capital and operation and maintenance costs for the conservation and recycling projects themselves. As shown in Table 25-5, the cost of replacement supplies varies, with ULFT rebates being the least expensive. The cost of Mono Lake water is generally the lowest of all LADWP sources. The cost can, however, be as much as $500 per acre-foot in dry years because of the fixed costs associated with operating and maintaining the Los Angeles Aqueduct regardless of how much water it delivers (LADWP 1995). In dry years the cost of replacement supplies compares favorably with the cost of Mono Basin supplies. Further, the cost of what LADWP originally expressed as its alternative supply for lost Mono Basin water—water from MWD—ranges from $344 to $426 per acre-foot, thus also comparing favorably to at least the water conservation and Sepulveda Basin Project.

Evaluation of Success

The replacement water program developed through the cooperation of MLC and LADWP has allowed for a durable, sound solution to the need for more water in Mono Lake tributaries and a reliable supply for Los Angeles. Since the water recycling facilities have required significant commitment through capital expenditure, these projects promise to be part of the water supply scheme in Los Angeles for the foreseeable future. The conservation program, with its extensive community infrastructure, is also likely to be durable and may form the basis for a larger conservation effort. These durable solutions are environmentally affordable since they have prevented a redirection of impacts, and therefore do not burden the San Francisco Bay–Delta, the Owens River, or any other environmentally sensitive system. The solution is also financially affordable, as it apportions the costs of recycling among general taxpayers (through AB 444 and HR 429 funds), as well as LADWP ratepayers. Since many residents of California, not to mention the country, benefit from the preservation of a healthy Mono Lake, this spreading of costs is particularly appropriate.

By expanding the ability of LADWP to meet its water needs locally, and decreasing dependence on supplies imported through the Los Angeles Aqueduct, the program has resulted in a more sustainable use of water. Mono Basin's basic environmental needs, as determined in the 1994 SWRCB decision, will be met, and water quality in the lake will improve. In Los Angeles, more efficient water use has resulted in part from the ULFT rebate program, and per capita use has decreased from approximately 176 gallons per capita per day in 1980 to 150 gallons per capita per day in 1994 (LADWP 1995). This means less need for imported water and less waste. Further, once the Terminal Island Recycling Project is on-line, LADWP will be able to recover a fraction of the city of Los Angeles's 625,000 afy of wastewater (LADWP 1995). For both of these reasons, LADWP enjoys a more "drought-resistant" supply.

It is possible that without the water replacement agreement between the MLC and LADWP, LADWP would have appealed the 1994 SWRCB decision to modify its water rights (Davis 1997). By getting elected officials at all levels of government involved, the MLC has helped settle this water dispute in a more time- and cost-efficient manner than any available through the courts. Thus, interagency coordination between the state legislature, federal legislature, U.S. Bureau of Reclamation, MWD, and DWR has necessarily been an important component of the program. In addition to collaboration with government agencies, the MLC has also worked with community groups such as the Mothers of East Los Angeles and the Korean Neighborhood Association, thereby involving local community stakeholders in seeking solutions.

Conclusions/Lessons Learned

The MLC replacement water case may serve as a model for the solution of other environmental water problems. Among the many points to take away from this case are the following:

- Litigation, even when necessary, may not be sufficient.
- Water problems must be viewed from all perspectives and all needs must be considered (i.e. urban water needs should not be considered to the exclusion of environmental water needs and vice versa).
- Focusing on collaborative solutions, rather than assigning blame and responsibility,

makes for a more certain outcome.
- Funding alternative water sources needs to happen simultaneously with altering fundamental viewpoints.

Litigation, although an important part of resolving many environmental conflicts, may not be sufficient for solving water problems. In this case, the replacement water program would not have been possible without the series of wins on the court battleground. However, the outcome of the protracted court battles could have resulted in bad news for Delta water resources, and may not have necessarily led to more efficient use of water in Los Angeles.

The story of water and Mono is not just about the tufa towers and the California gulls; it is also about Los Angeleños. Residents of Southern California, just like residents elsewhere in the state, are entitled to a reliable water supply. They are also entitled to information about how sustainably their water purveyor is managing the resource, and about what they themselves can do to improve the efficiency of water use both in their own homes and in the region as a whole. They should understand the implications of living in a vast semi-arid region for the fragile ecosystems of the southern Sierra. But they should not bear the burden of a one-sided solution to the Mono Lake problem.

It could be argued that, since LADWP was the entity that inflicted harm on Mono Lake's environmental resources, it should pay for its own way out of the mess. It was partly because the MLC did not take this viewpoint, and because it focused instead on finding a solution at "both ends of the aqueduct" and a diversity of funds to support this solution, that the dispute at Mono Lake has moved closer to resolution.

Finally, many water purveyors continue to think that the only supply available to them must be "developed," "new," or imported. Without knowing that recycling and conservation can be equally, if not more cost effective while providing a secure water supply, these purveyors are ignoring what may be their best long-term options. The experience of Mono Lake and the efforts of the MLC may help them see a broader set of possible futures.

Contacts

Martha Davis, Mono Lake Committee
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References

California State Lands Commission (CSLC). 1993. *California's Rivers: A Public Trust Report*. Sacramento, CA.

California State Water Resources Control Board (SWRCB). 1994. *Mono Lake Basin Water Right Decision 1631*. State of California, Water Resources Control Board. Sacramento, CA.

Davis, M. 1997. Faxed communication. August 3.

Hart, J. 1996. *Storm Over Mono: The Mono Lake Battle and the California Water Future*. Berkeley, CA: University of California Press.

Hundley, N., Jr. 1992. *The Great Thirst: Californians and Water, 1770s-1990s*. Berkeley, CA: University of California Press.

Los Angeles Department of Water and Power (LADWP). 1989. Brochure on Mono Lake. Los Angeles, CA.

Los Angeles Department of Water and Power (LADWP). 1995. *Urban Water Management Plan for the City of Los Angeles*. Los Angeles, CA.

Metropolitan Water District of Southern California (MWD). 1995. *The Regional Urban Water Management Plan for the Metropolitan Water District of Southern California*. Los Angeles, CA.

Metropolitan Water District of Southern California (MWD). 1996. *Local Resources Program: Recycled Water and Groundwater Recovery Projects, Status Report*. Los Angeles, CA.

Mono Lake Committee (MLC). 1997. Mono Lake Committee Web site: *http://www.monolake.org.*

MLC. 1995. "Money Flowing for Reclaimed Water." *Mono Lake Committee Newsletter.* Summer.

Reifsnider, B. 1989. "Sacramento's Odd Couple: Mono Backers Isenberg and Baker." *Mono Lake Committee Newsletter.*

Reisner, M. 1986. *Cadillac Desert: The American West and Its Disappearing Water.* New York, NY: Penguin.

Schlichting, B. 1992a. "AB 444 Funds: Going, Going, Going ... ?" *Mono Lake Committee Newsletter.*

Schlichting, B. 1992b. "Letter Reviews Faulty Logic of DWP's Position." Mono Lake Committee Newsletter.

Schlichting, B. 1993. "Landmark Bill Singles Out Mono Lake." *Mono Lake Committee Newsletter.* Winter.

Wiens, J.A., D. T. Patten, and D. B. Botkin. 1993. "Assessing Ecological Impact Assessment: Lessons from Mono Lake, CA." *Ecological Applications.* 3(4):595-609.

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Improving Water Management through Groundwater Banking: Bakersfield 2800 Acre Recharge Facility and Semitropic Groundwater Banking Program

Arlene K. Wong

Introduction

"Conjunctive use" refers to the water-management practice of coordinating the use of surface water and groundwater to improve the overall reliability of water supply. In general, when surface water supplies are plentiful, they are used by water customers or for recharging groundwater. Groundwater is then used during dry periods when surface water is less available. Surface water can recharge groundwater basins through both natural and artificial means. Natural or incidental recharge results from percolation into the basin from natural waterways (fed by rainfall or snowmelt) and from excess water applied for crop irrigation. Artificial recharge replicates and promotes natural processes by capturing and retaining water in surface impoundments (dams, dikes, and spreading grounds) to allow water to percolate into the underlying basin. Another form of artificial recharge is direct injection of water into the basin through wells. An additional form of recharge is "in-lieu" recharge, which refers to the groundwater that remains in the basin when groundwater users rely on surface water instead of pumping from aquifers. Whether physical or in-lieu recharge methods are used, groundwater stored in the basin can be used at a later time.

In the past few years, "groundwater banking" has come to refer to the practice of recharging specific amounts of water in a groundwater basin that can later be withdrawn and used by the entity that deposited the water. It differs from the more general description of conjunctive use because the water deposited is attributed to specific banking participants and may be imported from non-local sources. Likewise, withdrawals must be in amounts specific to the amount deposited and available and can be used outside of the basin in which the deposits were made. In effect, water banking uses groundwater basins for storage purposes, and offers water users, including those who do not overlie a groundwater basin, another tool for managing their water supplies. It offers participants the opportunity to store water during wet years to provide for more reliable dry-year supplies. It also could allow for another storage option to smooth out the use of surface supplies that have been further constrained by operational requirements intended to improve endangered and threatened fisheries. Operational requirements have impacted surface supplies in terms of the timing and amount of deliveries. Such constraints have made it increasingly important for water users to be able to store water during periods when diversions are allowed. This case study reviews two innovative and successful water banking programs that have led to better coordination and use of limited water supplies and effective cooperation among users with different interests.

As a storage alternative, water banking has several advantages over surface reservoirs. Groundwater storage is generally considered less environmentally damaging than dam or reservoir construction, and significant evaporative losses can occur with surface storage. Water stored underground does not evaporate, although evaporative losses can occur as the water is being transferred to underground storage. Also, stored groundwater may not always be 100 percent recoverable. In general, water banking has lower capital costs than dam and reservoir construction, though banking projects can require extensive distribution systems, construction for spreading grounds, and wells for injection as well as withdrawal. Spreading operations can be complex, requiring land, and sometimes changes in land use. Annual operation and maintenance costs may be higher than conventional surface storage, particularly when considering the recovery costs of pumping during dry years.

Water-Banking Issues

Water banking requires certain physical characteristics in terms of the groundwater basin, surface water availability, and access to transport, as well as the institutional factors related to the management and use of the basin, surface water availability, and transportation facilities. Ideal natural characteristics for conjunctive use and water banking include the following:

- Aquifers with accessible storage: unconfined, with adequate de-watered storage space at relatively shallow depth;
- Aquifers that are easy to fill: overlying area with good percolation and space for recharge facilities;
- Aquifers that are easy to pump: high-yielding wells with minimal pumping drawdown; and
- Areas that minimize negative impacts: no risk of subsidence, liquefaction, or water quality degradation as water levels change; lack of direct hydraulic connection with perennial streams that would induce recharge from others' supplies.

(Brown 1994)

If in-lieu recharge is used instead of spreading, then overlying irrigation or other groundwater use activity that allows for the exchange of surface water in lieu of pumping is necessary.

Additionally, sources of surface water and transportation and distribution facilities to both receive and distribute the banked water are needed. Banking requires that participants have access to surplus water when it is available and the ability to transport it to the banking facility. Banking projects must also provide for a method of transporting extracted water to banking participants. Projects utilizing in-lieu recharge must have sufficient distribution systems to support the necessary conjunctive use. Construction of such facilities can be very costly. Aside from the physical infrastructure necessary, the transfer and transport of water also have institutional requirements: parties must have or acquire the right to the surplus water and negotiate use of transportation facilities if they belong to others. Extractions may involve additional transfer implications since the water extracted is not necessarily the same water that was stored, and the stored water may be involved in subsequent transfers or sales. These exchanges require developing the institutional agreements and infrastructure necessary to account for and guarantee a secured right to the banked water for all participants in the project.

An additional concern pertains to the perceptions and cooperation of local landowners. Overlying landowners, whether participating in the project or not, have concerns about impacts on groundwater resources. While recharge may have positive benefits of temporarily raising the water table and reducing pumping costs, withdrawals will have the opposite effect, drawing down the water table and possibly resulting in subsidence or water quality degradation. Furthermore, landowners are extremely sensitive about mining their own resources to export water to another region. This is a particularly relevant issue for basins that are relatively full, since an aggressive conjunctive use or banking program would require first dewatering the basin to provide sufficient storage space for future surface water recharge.

The Example of Kern County

Kern County offers an example of an area that has implemented water-banking programs as an important water supply management tool to better meet local needs. Located at the southern end of the San Joaquin Valley, the county is the third most productive agricultural county in the nation (KCWA 1996). With over 800,000 acres of irrigated farmlands, the county relies on both surface and groundwater sources to meet its agricultural and urban demands. Kern County has 11 groundwater basins with varying degrees of groundwater availability. The largest of these is the basin underlying the San Joaquin Valley portion of the county. About 700,000 acres of irrigated farmland overlie the useable groundwater basin (KCWA 1996). Surface water supplies include local supplies from the Kern River, minor streams, and imported supplies from the Central Valley Project (CVP) and State Water Project (SWP) via the Friant-Kern Canal and California Aqueduct respectively. Six districts in the county receive CVP water, and the Kern County Water Agency contracts with the SWP and in turn sub-contracts this water to its 15 member agencies. Groundwater supplies about 39 percent of total water demand annually, and surface sources contribute the rest—Kern River (21 percent), SWP (22 percent), and CVP (10 percent), and other local sources (8 percent)—for an annual total use[1] of about 3,612,400 acre-feet (KCWA 1998).

A number of factors make Kern County's San Joaquin Valley area a prime area for water-banking programs. The natural attributes of its basin provide for good percolation of surface waters, and heavy reliance on groundwater throughout the years has resulted in substantial dewatered storage.[2] A 1983 study estimated that dewatered storage capacity equaled or exceeded 11 million acre-feet (KCWA 1983). Portions of the aquifer lie under highly absorptive areas offering good percolation for recharge of the basin. The county also has extensive and flexible options for moving water around via the Kern River, the Friant-Kern Canal, Califor-

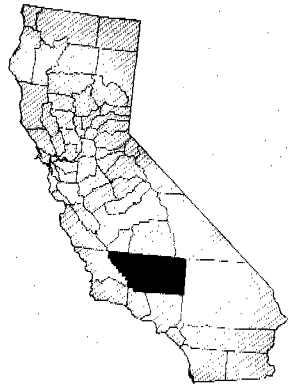
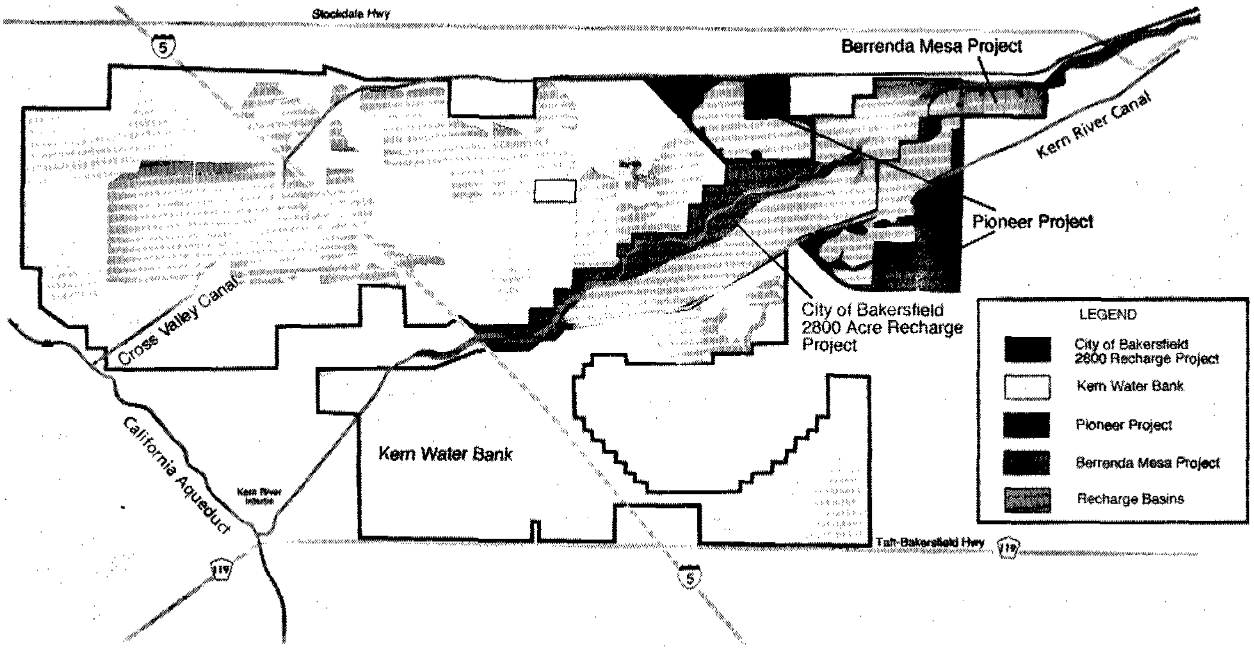


Figure 26-1

Kern Fan Area Groundwater Recharge Facilities[a]



[a] The figure presents the major groundwater banking and recharge facilities in the Kern Fan area. It does not include all banking projects in the county, such as the Arvin Edison and Semitropic projects.

Source: Adapted from KCWA 1997

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[1] Including water used for groundwater recharge.

[2] Groundwater overdraft continues to be a problem. Subsidence from groundwater overdraft has occurred in numerous places throughout the valley, resulting in permanent loss of basin storage capacity. Surface imports were deemed essential to preserve the groundwater supplies and have reduced long-term overdraft from 800,000 acre-feet annually (in the 1960s to early 1970s) to 250,000 acre-feet per year (average from 1970 to 1995) (Fryer 1998).

nia Aqueduct, and the Cross Valley Canal. A distribution network of canals and pipelines serves much of the irrigated acreage.

Kern County's banking programs grew out of the various groundwater recharge or replenishment programs that districts have undertaken. Direct recharge takes place in unlined canals, portions of the Kern River channel, and constructed spreading ponds. Recharge programs were implemented to take advantage of excess water available during wet periods to address overdraft issues. Groundwater banking evolved to specifically account for water recharged, stored, and recovered and to allow for export and use outside the basin. These programs were variously motivated by the ability to utilize groundwater storage to manage erratic surface water supplies; the area's need to meet water needs during drought years when the SWP cannot meet contracted amounts; and the opportunity to develop a funding mechanism to expand conjunctive use activities. The earliest programs began in the late 1970s and early 1980s. The city of Bakersfield developed 1,430 acres of spreading ponds within its 2800 Acre Recharge Facility; Kern County Water Agency developed 240 acres of recharge ponds on lands along the Kern River for the Berrenda Mesa Water District, as well as recharge operations in a portion of the Kern River channel. The early 1990s saw the development of still more banking programs: the Kern Water Bank, Kern County Water Agency's "Pioneer Property," and programs in the Arvin Edison and Semitropic Water Districts. Semitropic's program primarily uses in-lieu recharge to "bank" the water. The others operate spreading ponds to recharge banked water and collectively represent about 25,000 acres of recharge facilities, largely along the Kern River (KCWA 1997) (see Figure 26-1). Through 1995, over 1.7 million acre-feet have been recharged and over 243,000 acre-feet have been recovered (KCWA 1998). In addition, about 382,000 acre-feet of stored water have been involved in sales, in which the right to extract the water has been purchased from the banking participant by another entity; however, this right has not yet been exercised, and the water remains in the basin.

The programs initially focused on local water districts and kept water withdrawals within the county boundaries. Recently, however, banking programs have sought banking partners outside of the county. Both Arvin Edison and Semitropic have now signed long-term contracts with Metropolitan Water District; Semitropic has agreements with Santa Clara Valley Water District, Alameda County Water District, and Zone 7 Water Agency; and the SWP stores water in several Kern County projects. For the most part, participants bank their excess supplies from Kern River rights, SWP or CVP contracts, and excess flood waters from any of these sources. With a growing number of programs and participants, accounting for banked water can be very complex. Surface water is often physically banked and recovered at whichever facility has the spreading capacity available and/or provides the easiest (and therefore least expensive) transport. Credits and debits against the various programs are worked out to account for the water.

Banking programs are not without controversy. As previously mentioned, spreading facilities can require major changes in land use. The Kern Water Bank faced numerous environmental issues regarding the facility's impact on wildlife habitat when the fallowed farmland identified for the project subsequently became home to several endangered species. Keeping track of imports and exports has also raised concerns. Banking programs raise issues about who owns what water, how best to import and export water out of a basin, how to measure and reduce impacts on groundwater basins, as well as concerns about the hydrologic links between surface and groundwater supplies. The Arvin Edison project will store CVP water purchased by Metropolitan Water District during "wet" years. During its approval, some groups opposed the transfer, arguing that water purchased by MWD should instead be available for environmental needs along the San Joaquin River or to other districts within the region.

Because a groundwater bank is operated based on the idea that the water recharged is intended for extraction, its recharge and extraction operations do not address the issue of accumulated overdraft in a basin. Banking can, in fact, compete with recharge efforts aimed at reducing accumulated overdraft by creating a competing use for surplus waters that once went towards overdraft correction. Thus, institutional arrangements and agreements are an important part of protecting existing recharge programs for addressing overdraft and ensuring that banking programs do not create a perverse incentive to export stored water out of the basin to the detriment of attempts to correct accumulated overdraft.

With appropriate institutional controls, banking programs can support overdraft correction programs. For example, in the case of Kern County, the banking projects have expanded the number of spreading facilities and increased the county's absorptive capacity for recharge. This has allowed agencies to expand their overdraft correction programs by contracting with banking facilities for recharge. By agreement, banking projects place a higher priority on recharging water for overdraft correction. Thus, local floodwaters are first recharged into basins for overdraft correction purposes, and only after those targets are reached can water be recharged for banking purposes. Banking programs can also require that a percentage of water banked must remain in the basin for overdraft correction.

The cases that follow offer two examples of banking programs that have been established in Kern County. The Bakersfield 2800 Acre Recharge Facility was the first such banking project in the county and is a prime example of a local banking project that has successfully allowed participants to better manage surface supplies by taking advantage of groundwater storage. The Semitropic program distinguishes itself from Bakersfield by relying on in-lieu recharge rather than physically banking the water, and by seeking partners in urban centers outside the county. Groundwater banking has allowed Semitropic to expand its ability to serve its farmers with surface water and therefore take greater advantage of conjunctive use potential to manage resources.

The Projects

Bakersfield 2800 Acre Recharge Facility

Introduction

The city of Bakersfield's 2800 Acre Recharge Facility serves the city and three other agencies (Olcese Water District, Buena Vista Water Storage District, and Kern County Water Agency), and has banked over one million acre-feet of water from 1978 to 1997. It has physically returned over 182,000 acre-feet for use by banking participants, and another 158,000 acre-feet have been transferred, sold, or exchanged with participants outside the banking project. Operating for two decades, the project allows the city to better manage its highly variable Kern River supplies, and offers banking participants a method for storing surface supplies for later use during dry periods. The banking project has also provided a way for water users that do not overlie the groundwater basin to gain access to groundwater supplies when surface supplies are scarce. The project was possible because the city was able to take advantage of the natural and human-made attributes of the area, which were conducive to a banking program, the growing sophistication of groundwater banking throughout the county, and the efforts to coordinate the various projects.

Background

The city of Bakersfield is the largest metropolitan area in Kern County with a population of 235,000.[3] In 1997, annual water demand was about 120,000 acre-feet. The city relies on groundwater for 80 percent of its supply while surface water provides the balance. The surface water is contracted from KCWA's Improvement District 4, which operates a water-treatment plant. In 1976, the city purchased a substantial portion of Kern River water rights from Tenneco West Inc. At the time, the city did not need the water for its own use, but purchased it in anticipation of future needs. The city

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[3] This includes several unincorporated areas within the city's service area.

entered into long-term contracts[4] with five local irrigation districts for 80,000 acre-feet of the acquired rights. Annual Kern River flows are highly variable. Even with the operation of Isabella Dam (completed in 1957), the Kern River has had a low of 221,267 acre-feet in 1990 and a high of 2,491,313 acre-feet in 1983. The city's water rights provide for an annual average of 140,000 acre-feet, but the river flows are rarely average. In many years there is no flow in the river past Bakersfield due to upstream canal diversions (COB 1986). Along with the water rights, the city acquired about 2,800 acres of land in and along the Kern River channel. These lands offered the city prime recharge areas for a banking project that would allow it to store and better manage the variable Kern River supplies just purchased.

Project Description

Facilities

The recharge facility is located about eight miles west of Highway 99 along the Kern River channel. The property is approximately six miles long and lies on both sides of the Kern River, next to the city's Kern River Canal. Prior to construction of the recharge facility, the land primarily served to capture river overflow; thus, developing the spreading grounds did not involve a major change in land use. Construction was done in three major phases, and headgates, river levees, and earthworks were installed to shape the basins on both sides of the river. By 1978, the city began spreading water in a single basin, and by 1986 11 basins were completed. The last two basins required the most earthwork and were completed in 1997 when budgets allowed. All told, the construction includes 13 basins covering approximately 1,430 acres; headgates; river, interbasin, and perimeter levees; diversion works; and 19 extraction wells.

Recharge ponds at 2800 Acre Recharge Facility (Photo courtesy of City of Bakersfield)

Banking operations

The facilities are well located to permit easy water "deposits" and "withdrawals." Water can be delivered to the spreading basins from the Kern River channel, Kern River Canal, Pioneer Canal, and the Cross Valley Canal. In addition to its own banking activities, the city of Bakersfield agreed to long-term contracts with three other agencies, the Hacienda/Olcese Water District, Buena Vista Water Storage District, and Kern County Water Agency. The banked water includes Kern River supplies to which participants have rights, surplus water from the SWP and CVP available for purchase or within existing contracts, and floodwater from either of the three sources.

The city of Bakersfield has first priority to spread its Kern River water in the 2800 Acre Recharge Facility. Next, per contractual agreements, the Olcese Water District, Buena Vista Water Storage District, and Kern County Water Agency are respectively allowed to spread their waters. Extraction is handled in the same priority order. Banking participants pay the city $3 per acre-foot spread and another $3 per acre-foot extracted, plus a nominal fee for annual operations, maintenance, and facilities improvements. Six percent of water banked is deemed transportation and recharge losses.

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[4] Contracts expire in the year 2012 and stipulate that at that time the city can take back water as needed for its own purposes.

Table 26-1

Summary Banking, Extraction, and Storage at 2800 Acre Recharge Facility, 1977–1997

Quantities in acre-feet

	Banking					**Extraction**[a]					**Storage**[b]
Year	**City of Bakersfield**	**Olcese Water District**	**Buena Vista Water Storage District**	**Kern County Water Agency**	**Total Banking**	**City of Bakersfield**	**Olcese Water Water Storage District**	**Buena Vista Water Storage District**	**Kern County Water Agency**	**Total Extractions**	**Groundwater Storage (end of year)**
1977	0	0	0	0	0	0	0	0	0	0	0
1978	104,587	24,328	6,056	0	134,971	0	0	0	0	0	134,971
1979	4,505	0	9,913	0	14,418	0	0	0	0	0	149,389
1980	68,804	52,604	0	0	121,408	0	0	0	0	0	270,797
1981	2,603	4,465	0	44,912	51,980	0	0	0	0	0	322,777
1982	37,913	14,266	24,465	0	76,644	0	0	0	0	0	399,421
1983	113,380	0	0	0	113,380	0	0	0	0	0	512,801
1984	16,058	0	0	0	16,058	472	0	0	0	472	528,387
1985	402	0	0	15,055	15,457	1,615	0	0	0	1,615	542,229
1986	64,168	56,197	10,000	22,766	153,131	0	0	0	0	0	695,360
1987	109	0	0	7,379	7,488	656	0	656	0	1,312	701,536
1988	0	0	0	0	0	1,932	0	1,786	0	3,718	697,818
1989	0	0	0	0	0	2,859	873	3,138	1,086	7,956	689,862
1990	0	0	0	0	0	23,318	1,400	2,242	0	26,960	662,902
1991	0	0	0	0	0	13,028	1,400	4,410	33,316	52,154	610,748
1992	0	0	0	0	0	23,816	0	4,004	28,331	56,151	554,597
1993	32	0	7,849	125,944	133,825	0	0	0	0	0	688,422
1994	0	0	0	18,726	18,726	8,311	1,160	0	18,416	27,887	679,261
1995	13,089	6,028	20,000	73,337	112,454	1,297	0	0	752	2,049	789,666
1996	300	1,694	20,000	16,612	38,606	1,781	0	0	74	1,855	826,417
1997	16,635	10,000	0	875	27,510	14	0	0	0	14	853,913
Total	442,585	169,582	98,283	325,606	**1,036,056**	79,099	4,833	16,236	81,975	**182,143**	

[a] *Extractions include physical extractions (well production) only and not paper transfers to external participants. Internal transfers between participants are not included.*

[b] *Groundwater Storage indicates the banked water available for extraction but does not include paper transfers (158,041acre-feet total), which should also be deducted from groundwater storage. This value does not currently reflect spreading losses which, starting in 1998, will be recorded as six percent of water banked.*

Source: City of Bakersfield 1998

Extraction is limited by the use and capacity of the wells. Water is pumped and transported to the appropriate facility, with energy and transportation costs paid for by banking participants.

The banked water can be extracted and transported for direct use, sold, or exchanged, with the stipulation that extracted water must be used in the San Joaquin Valley portion of Kern County for irrigation, light commercial and industrial, and municipal or domestic purposes, unless otherwise specified. Located upstream of the facility, the city of Bakersfield often sells its banked water to users downstream, or exchanges it for water from other sources. Two newly constructed wells now allow Bakersfield to pump banked water directly for municipal and industrial uses within the city. Olcese is also upstream of the facility and exchanges its water to downstream users for Kern River supplies. KCWA can pump its banked water into the Cross Valley Canal for transport to the Aqueduct or up towards the metropolitan Bakersfield area for potable treatment in the Henry C. Garnett Water Treatment Plant.

In addition to physical extraction of the water, banked water can also be involved in a "paper" transfer or sale. Paper transfers include internal transfers between the banking participants where banked water is moved from one participant's 2800 Acre account to another's. External transfers involve the transfer of banked water from banking participants to non-banking entities. Often, exercising "rights" to the water will not necessarily involve the physical extraction of the water from the 2800 Acre Recharge Facility, but instead the withdrawal will be credited against the 2800 Acre account and the water extracted elsewhere. For example, KCWA may transfer some of its 2800 Acre water to a district looking to purchase banked water. When the district chooses to exercise its right to its banked water (during the next drought for example), it may in fact be delivered from another location, but will count against the 2800 Acre account. Thus, water involved in a paper transfer designates that it will likely be extracted, though it may not be physically taken from the facility, nor will extraction necessarily take place at the time of the transfer.

Capital costs associated with the construction of the facility were about $2 million. Legal, engineering, and environmental assessment costs added another $1 million. The city's Water Resources Department paid all capital costs from its own capital budget funded by operating revenues. Fees charged to banking partners cover the annual operation and maintenance costs for the project and are expected to repay the capital costs over time.

Evaluation of Success

Meeting service demands

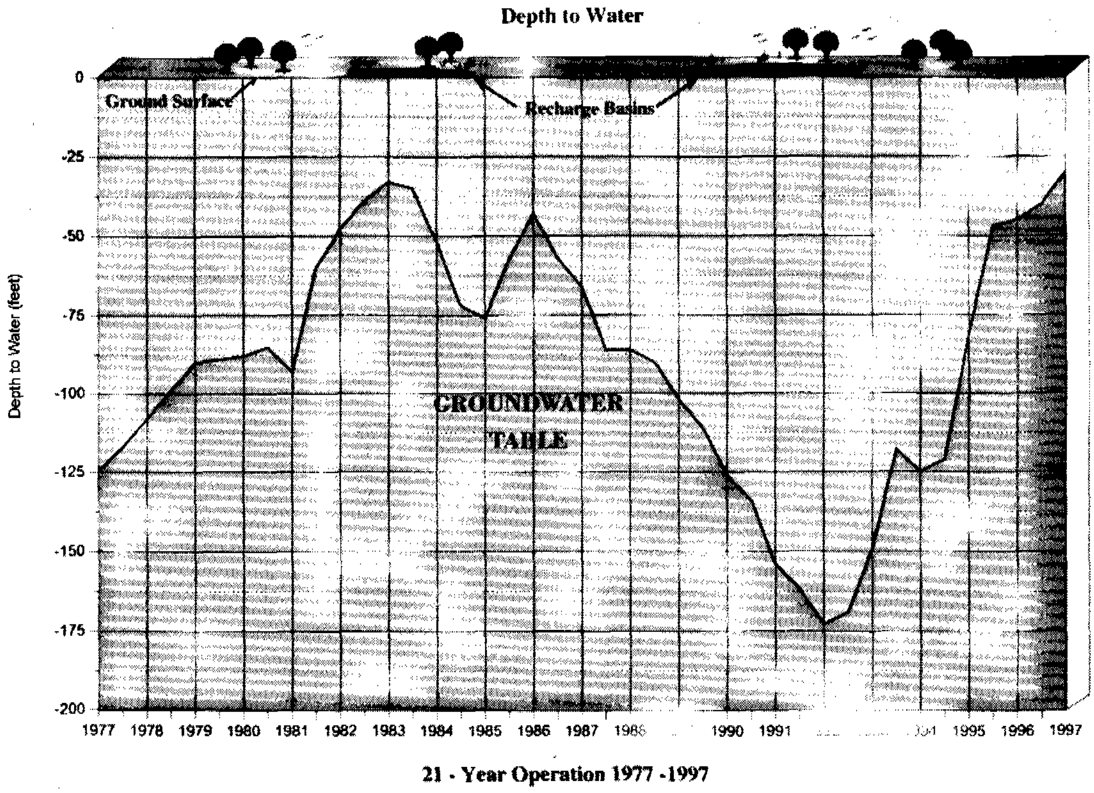
Since its inception, the 2800 Acre Recharge Facility has banked over one million acre-feet, and extracted 182,143 acre-feet through 1997 (Table 26-1). "Paper" transfers account for an additional 158,041 acre-feet that result in a reduction in groundwater storage, leaving 695,872 acre-feet available for extraction, sale, or transfer. About half of the water banked was Kern River water. Reviewing the pattern of recharge and extraction in Table 26-1 shows that the banking program is operating as expected. Water is recharged in "wet" years when heavy snowpacks in the Sierra result in high Kern River flows and surplus deliveries from the SWP and CVP. In 1986 the program had a peak recharge amount of 153,131 acre-feet, and, more recently, during the wet season of 1995, it recharged over 112,000 acre-feet. Water is then extracted during dry periods, when surface supplies are less available. During the 1987–1992 drought, all banking participants took advantage of stored groundwater supplies. Well water production from the facility peaked during the drought in 1991 and 1992 with 52,154 and 56,151 acre-feet pumped respectively.

In addition to providing participants with a method for storing Kern River and other surplus supplies, banking facilities and operations have a valuable role to play in utilizing flood waters and assisting with flood control. Banking recharge operations during flood release periods serve to minimize downstream flooding problems while maximizing recharge of water on the Kern River fan for local benefit. For example, in 1995, Kern River was 199 percent above normal runoff (April–July), and the Friant Water User Authority required flood releases from the Friant-Kern Canal into the Kern River channel where it could be utilized for banking.

The basin's absorptive capacity is 450 acre-feet per day on average. On only two occasions (in 1983 and 1986) has the facility had to "pass through" water during times of particularly heavy runoff. Otherwise, the facility has been

Figure 26-2

City of Bakersfield 2800 Acre Recharge Facility Depth to Water Table, 1977–1997



Source: City of Bakersfield

able to operate in concert with other facilities (banking and transport) to meet the needs of its banking participants' recharge and extraction demands.

Impacts on groundwater levels

In 1982, the city established a groundwater-monitoring program to measure groundwater levels in the project area. As expected, groundwater levels increased with banking recharge activities. The average depth of water in the observation wells throughout the facility has risen substantially during recharge periods. In 1982 and 1983, both wet years, groundwater levels rose 12 and 11 feet respectively. Such increases in the water table reduce lift costs for overlying and neighboring groundwater users.

Conversely, during dry years, water table levels drop. The 1987–1992 drought saw a large increase in groundwater pumping throughout the basin, as well as by the facility. Water levels plummeted 150 feet in some places. Wells on the facility "sucked air" when water levels fell drastically, and pump intakes were lowered to "chase down" the water.[5] Florn Core, Bakersfield's Water Resources Director, commented that the development of banking projects on the neighboring properties have perhaps increased the ability to coordinate and control extractions to prevent the extreme drawdowns seen in 1991 and 1992. The Pioneer Operating

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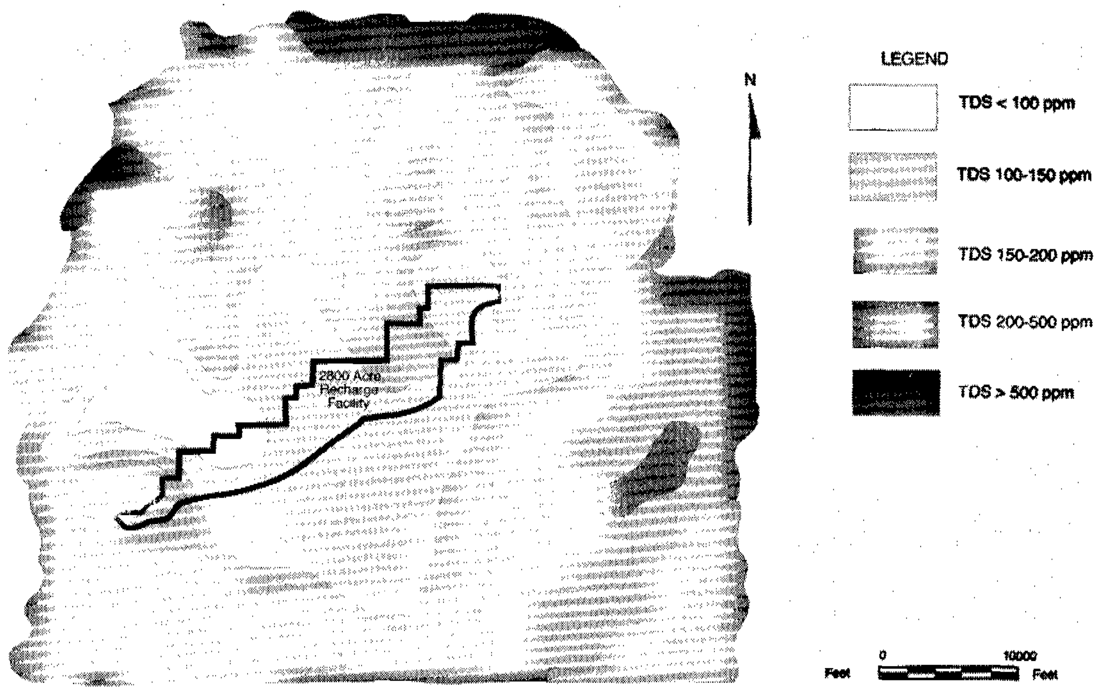
[5] Lengthening the column pipe to lower the pump bowl can cost about $12,500. The additional energy costs for pumping the increased lift amounted to about $6.50 to $10.00 per acre-foot (Core 1998).

Figure 26-3

City of Bakersfield 2800 Acre Recharge Facility Groundwater Quality, 1979–1981



Source: Adapted from City of Bakersfield, 1986

Agreement established in 1997 involves all the major banking programs in the county, and contains agreements to control the spacing of extraction wells and coordinate extraction practices, to minimize impacts on neighboring landowners. The Kern Fan Monitoring Committee also monitors groundwater levels and water quality for this same purpose.

Impacts on water quality

When high quality water is recharged into a basin, it has the potential of improving groundwater quality relative to the water surrounding it. Water from the Kern River and Friant-Kern Canal is of very high quality, averaging 30 to 80 parts per million of total dissolved solids (ppm TDS) (cited in COB 1986). Water from the SWP averages about 300 ppm TDS. Groundwater quality measurements taken from 1979 to 1981 along the Kern River channel show that water in the area upstream of the 2800 Acre Recharge Facility contains 150 to 300 ppm TDS; in the vicinity of the project, groundwater is 120 to 150 ppm TDS; downstream of the project salinity increases to 300 to 400 ppm; and north of the project, groundwater was sampled at 600 ppm (cited in COB 1986). Thus, the recharge area is an area of good quality groundwater surrounded by lesser quality groundwater. Water recharged for banking would not be expected to have a negative impact on groundwater quality, and could, in fact, have a positive localized effect. During the 1987–1992 drought, water quality levels showed little degradation overall. The severe drawdowns, however, did change groundwater flow patterns, and poorer quality water plumes did migrate towards several city wells. These wells were shut down or placed on stand-by for a short period as poorer quality waters migrated through the area. Again, monitoring programs proved important for detecting such impacts and determining if long-term problems existed.

Habitat benefits

The 2800 Acre Recharge Facility lies on lands that had been used, for several decades, for absorbing river overflow to prevent flooding of adjacent farmlands. Prior to that, the property was used for industry (oil fields), agriculture, and grazing. The property supports three habitat types—riparian, freshwater marsh, and Valley Mesquite-saltbush (COB 1986). The recharge facility brought more water to the property, and recontoured its landscape with earthen levees and spreading ponds. Some levees were treated with a gravel, all-weather road top. When the spreading ponds were designed, particular efforts were made to preserve the San Joaquin Valley saltbush, one the few remaining stands of this native vegetation and important habitat for a number of federal- and state-protected species—the San Joaquin antelope squirrel, the valley race of kit fox, the giant kangaroo rat, and the blunt-nosed leopard lizard. Levees were designed around the saltbush in some places, or levee elevations were lowered to prevent the drowning of trees and to increase open space. When the ponds are full, there are about 100 acres of undisturbed habitat. The city also passed an ordinance in 1983 to preserve the area as open space, banning further development.

The increased water within the property has enhanced riparian and marsh habitat. When filled, the basins provide feeding sites for birds, including federally-protected raptors such as the northern harrier (or marsh hawk). Over 40 species of birds can be found on the property. The kit fox, giant kangaroo rat, and blunt-nosed leopard lizard have all been seen on the property, which requires that the city take steps to minimize any adverse impacts from the facility. Biological surveys must be done before significant maintenance work is begun, to avoid impacting protected species.

The natural vegetation has provided the facility with unexpected benefits. The vegetation has actually improved soil conditions for absorption on the ponds. The city has found that allowing the vegetation to prosper, rather than clearing it, allows for more efficient percolation and saves money on maintenance (Core 1998).

Semitropic Groundwater Banking Program

Introduction

A water-banking program in the Semitropic Water Storage District has been in operation since 1990. Banking partners pay $90 per acre-foot to store SWP water and $40 per acre-foot (plus the energy costs) to withdraw it. The surface water furnished by banking partners is used by the District's farmers in lieu of pumping groundwater. The groundwater left in the basin is credited as stored water for the banking partners. Semitropic has already signed agreements with Metropolitan Water District, Santa Clara Valley Water District, Alameda County Water District, and Zone 7 Water Agency for 800,000 acre-feet of storage. More than 450,000 acre-feet have already been banked. Ultimately, up to one million acre-feet of water could be stored.

This project has provided Semitropic Water Storage District with a financial mechanism to expand its ability to deliver surface water to District farmers, bringing more of the District under conjunctive-use management. Farmers are provided with an additional source of water, improving reliability and stabilizing costs, and the District can expand its in-lieu recharge program to better service customers and purchase surplus waters for overdraft correction. The District's banking program is also one of the first long-term banking agreements between an agricultural district and urban water agencies.

Background

Semitropic Water Storage District, in Wasco, California, ("the District") was formed in 1958 and is comprised of 223,000 acres in the western San Joaquin Valley in Kern County, about 28 miles northwest of Bakersfield. The District is composed almost entirely of agricultural users and serves about 136,000 acres of irrigated land.

The District has an arid climate: precipitation in the region averages about four inches per year, and much of the recharge of the basin takes place through percolation of applied water (irrigation) and subsurface flows into the basin. Though some limited artificial recharge takes place in spreading ponds, percolation rates are not high and the District primarily relies on "in-lieu" recharge to replenish basin supplies. Prior to receiving SWP water in 1973, the District relied entirely on groundwater. Farmers paid to drill their own private wells and the energy costs of pumping the water. There are approximately 1,200 private wells district-wide. During this period, groundwater levels dropped considerably, as pumping exceeded recharge. With the advent of the State Water Project (SWP), surface water could be provided at rates competitive with the cost of groundwater pumping, so pumping decreased. The SWP delivered a firm amount of surface water to over 42,000 acres, about 30 percent of the District's acreage.[6] Subsequently, an additional 26,700 acres were connected to the surface water distribution system, which is now able to receive surface water to replace pumping when local or SWP water is available. Over 50 percent of the District, however, still relies exclusively on groundwater supplies.

While SWP imports slowed the groundwater overdraft, they did not completely eliminate it. In fact, the 1987–1992 drought saw groundwater levels decline rapidly. Since 1986, groundwater levels in parts of the basin have dropped between seven and eight feet annually (Boschman 1998). One result of overdraft in the basin was the creation of two million-acre feet of storage space beneath the District (Semitropic Water Storage District 1996).

Water banking offered a way to take advantage of the available underground storage, raise the groundwater table, and offer greater reliability in providing water, particularly during drought periods, by improving groundwater supplies. It also provides the District with the financial means to meet and expand infrastructure needs. In the late 1980s and early 1990s, Semitropic began searching for partners for a water-banking program. In principle, the plan was simple. Already tied into the SWP, Semitropic was well-positioned to receive water from other contractors during years in which supplies were adequate or ample. Semitropic's farmers would then use the surface water sent for storage in lieu of groundwater, which would then be considered "banked" or stored on behalf of banking partners to withdraw when needed. To evaluate the potential of this plan, the District spent about $1 million in studies and environmental impact reports.

In 1990, Semitropic initiated a demonstration program with the state to store 92,000 acre-feet. Water was stored via in-lieu recharge as described above. When the state wanted to "withdraw" the water, Semitropic agreed to provide the state with water from its SWP entitlement (an "entitlement exchange")—the water it normally received from the SWP. However, in 1991, in the worst year of the drought when the state would naturally want its banked water, Semitropic received no water from the SWP[7] and therefore could not produce the water when the state needed it. The one-year demonstration program made it clear that a water-banking program would have to guarantee return of water on demand and could not rely solely on entitlement exchanges. The new water-banking program was premised on developing that guarantee.

Banking Program Facilities

Canals
- Over 20 miles of improvement, including concrete canal lining
- 35 percent increase in capacity

Pipelines
- 85 miles in length
- 12 to 84 inches in diameter

Pump Stations
- Up to 5,400 hp

Power Generation
- 850 kW hydroelectric

Source: Semitropic Water Storage District

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[6] As previously mentioned, SWP may not always provide full allocations. Groundwater is used during those periods when surface supplies fall short (during dry years or during peak irrigation periods when surface operational constraints limit deliveries).

[7] During the 1987–1992 drought, agricultural contractors saw their water deliveries from the SWP reduced by 25 to 100 percent.

Goals of Program

District goals in pursuing water banking were as follows:

- Correct overdraft with new facilities to provide for increased in-lieu recharge.
- Reduce groundwater pumping lifts.
- Increase operational flexibility through increased reliability of both surface and groundwater sources.

Additional benefits of water banking would include stabilizing the cost of water for farmers; providing opportunities for other California entities to better manage their SWP water and other supplies; and offering an environmentally sound alternative for creating storage.

Project Description

Facility development

Semitropic Water Storage District's distribution facilities take water directly from the California Aqueduct. Semitropic's proximity to the aqueduct allowed it to design facilities that could physically return water to the aqueduct from the basin for outside agencies that stored water in Semitropic. The District also has its own energy program, which included plans for a hydroelectric facility. Thus, the 78-inch pipeline built to return stored water from the District to the aqueduct could also be used to run a turbine to generate energy.

The cost to develop the surface water distribution, groundwater pumping, and return conveyance facilities was estimated at $134 million. Distribution of surface water would have to be expanded to increase system capacity for more effective conjunctive use and in-lieu recharge. Plans call for bringing at least an additional 23,159 acres (about 16 percent) of the District into a conjunctive use improvement area, by providing distribution lines so that farmers can receive surface water in years when extra water is available.

Program operation

The program dedicates one million acre-feet for storage by banking partners. Expanded surface water distribution facilities will allow a minimum of 91,000 acre-feet to be stored each year. This could increase to as much as 315,000 acre-feet per year depending on the District's use of facilities for taking their own imported water. Banking partners are charged a 10 percent distribution and aquifer loss as water is delivered to the program. Banked water is returned by either SWP entitlement exchange or by actually pumping stored water back into the California Aqueduct. The minimum guaranteed for return from the program is 90,000 acre-feet annually, not including any entitlement exchange. If Semitropic were to commit its full allocation to returning water, it could commit an additional 223,000 acre-feet in a year.[8] Each participant is entitled to a percentage share of the guaranteed return depending on its level of participation.

Wells within Semitropic currently produce water that meets DWR's water quality standards for returning water to the California Aqueduct. The current average is 300 ppm TDS. Semitropic wells have measured TDS levels ranging from less than 100 ppm to 1,000 ppm. Should future water quality standards change significantly, or if Semitropic cannot meet water quality standards with well water, water may be returned to banking participants by alternative methods, such as purchases of alternative supplies or treatment of groundwater to acceptable standards. Additional costs of any such methods will be borne by the banking participants.

Partnering agreements: identifying benefits and allaying fears

Urban agencies proved to be natural banking partners. Agencies such as Metropolitan Water District (MWD) and Santa Clara Valley Water District were searching for banking programs that offered them a method of storing excess

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[8] Of course, SWP allocations will vary from year to year, and since payback is likely to be in a dry year, when SWP deliveries are lower, it is unlikely that such a maximum could be achieved.

surface waters during normal and wet years for use in critically dry periods. This offered the agencies a method for improving the management of their existing sources to allow for increased reliability during dry periods.

Partners required that the District demonstrate that the program was structurally, operationally, and institutionally feasible. The geological conditions of the basin and the design of the facilities had to be capable of conveying, recharging, returning, and storing water. The District had to demonstrate the ability to convey or exchange the water supplies to and from the program during the times of the year when water must be moved. The development of the pumpback option in addition to entitlement exchange was a key factor in providing the necessary guarantees of delivery on demand. And, finally, the agencies regulating the conveyance and place of use of water supplies (i.e. DWR and the SWP) had to approve. As part of this, the program needed to assure that rights to the water were legally secure. The District, in fact, agreed to hold the water in trust for the banking partners.

Educating the district about the benefits

Some district landowners feared a repetition of what happed in the Owens Valley, where local water rights were sold to Southern California users, whose exports subsequently devastated the basin. Although the conditions were not similar, pumping water for delivery to MWD raised eyebrows, and it was important to educate local participants. Semitropic was banking surplus water from other agencies' SWP and CVP[9] entitlement rather than transferring any of its own water. A complete explanation of the banking agreement was enough to put most landowners' fears to rest. Surface water would be offered by the District at rates discounted compared to the costs of pumping. This offered farmers a financial incentive and a second source of water, increasing reliability and reducing costs. They also realized a cost savings when water tables rose and reduced lift costs.

Ultimately, one of the biggest benefits to the District was the development of expanded distribution facilities the District could not otherwise afford. Greater use of surface water by farmers has been constrained by the District's ability to expand distribution to new areas. The banking program is a valuable way to develop new facilities that the District can use when the banking partners are not storing or withdrawing water. Thus, the District can increase its own program of conjunctive use and in-lieu recharge by providing more of its users with imported water when such water can be purchased.

Costs and financing

MWD advanced Semitropic $1.35 million in early 1995 to begin design and construction of the banking facilities. Semitropic has repaid MWD through reductions in storage payments. The remaining financing is designed as a pay-as-you-go policy with four different options.[10] All four options are essentially equivalent in terms of cash flow for Semitropic. Partners contract for storage space and are required to pay for a portion of the capital costs represented by their participation in the program. In other words, if a banking partner desires to bank 100,000 af, or a 10 percent share, it is expected to pay 10 percent of the capital costs, or $13.4 million. Capital costs must be paid up front or within 10 years.

For the banking partners, participation in Semitropic's program is estimated at $175 per acre-foot. This reflects $90 per acre-foot for storage, $40 per acre-foot for withdrawal, and about $45 per acre-foot for Semitropic's pumping costs. Total costs must also account for

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[9] In addition to banking SWP water, both the Santa Clara Valley Water District and Zone 7 Water Agency have indicated that they may opt to bank surplus CVP water held in San Luis Reservoir.

[10] Each option provides a distinct procedure for a banking partner to manage its financial contribution while purchasing storage rights.

Table 26-2
Summary of Banking, Extraction, and Storage for Semitropic Banking Program, 1993–1998

	Banking[a]						Extraction						Storage
Year	SWP	MWD	SCVWD	ACWD	Zone 7	Total Banking	SWP	MWD	SCVWD	ACWD	Zone 7	Total Extractions	(end of year)
1990	91,663					91,663	0					0	91,663
1991	0					0	0					0	91,663
1992	0					0	41,499					41,499	50,164
1993	0	45,377	0	0	0	45,377	0	0	0	0	0	0	95,541
1994	0	0	0	0	0	0	0	0	0	0	0	0	95,541
1995	0	45,000	0	0	0	45,000	0	0	0	0	0	0	140,541
1996	0	85,500	40,500	5,580	0	131,580	0	0	0	0	0	0	272,121
1997	0	112,500	31,500	9,000	0	153,000	10,033	0	0	0	0	10,033	415,088
1998[b]	0	35,550	28,800	5,085	4,365	73,800	0	0	0	0	0	0	488,888
Total	91,663	323,927	100,800	19,665	4,365	**540,420**	51,532	0	0	0	0	**51,532**	

[a] Banked amounts reflect the assessment of a 10 percent distribution loss.
[b] Projected figures.
Source: Semitropic Water District 1998

annual operation and maintenance fees[11] charged by Semitropic, frequency of "puts" and takes, and conveyance charges by the SWP to actually transport the banked water to the participant's own facilities. For example, Santa Clara Valley Water District (SCVWD) estimated that its participation at the 350,000 acre-foot level would cost between $195 and $300 per acre-foot. SCVWD compared the cost of banking with the cost of providing alternative supplies during a drought period. Banking compared favorably with the cost of purchases from the State Drought Water Bank in 1991 ($225 per acre-foot) and with the marginal cost of additional supplies during that period ($313 per acre-foot) (SCVWD memo 1997).

Semitropic continues to finance the needed improvements as agreements are executed and partners pay for storage. Other than the monies generated by the banking program itself, no District money is spent on the program.

Neighboring district concerns

Neighboring districts expressed concern about possible program impacts on their groundwater sources and pumping activities. Semitropic developed a Memorandum of Understanding with its five neighboring districts regarding the operation and monitoring of the program. A monitoring task force was formed to ensure that Semitropic's activities do not disrupt groundwater sources in other districts. Generally, data are collected annually to monitor groundwater levels and water quality. A triennial report is expected to be released in 1998.

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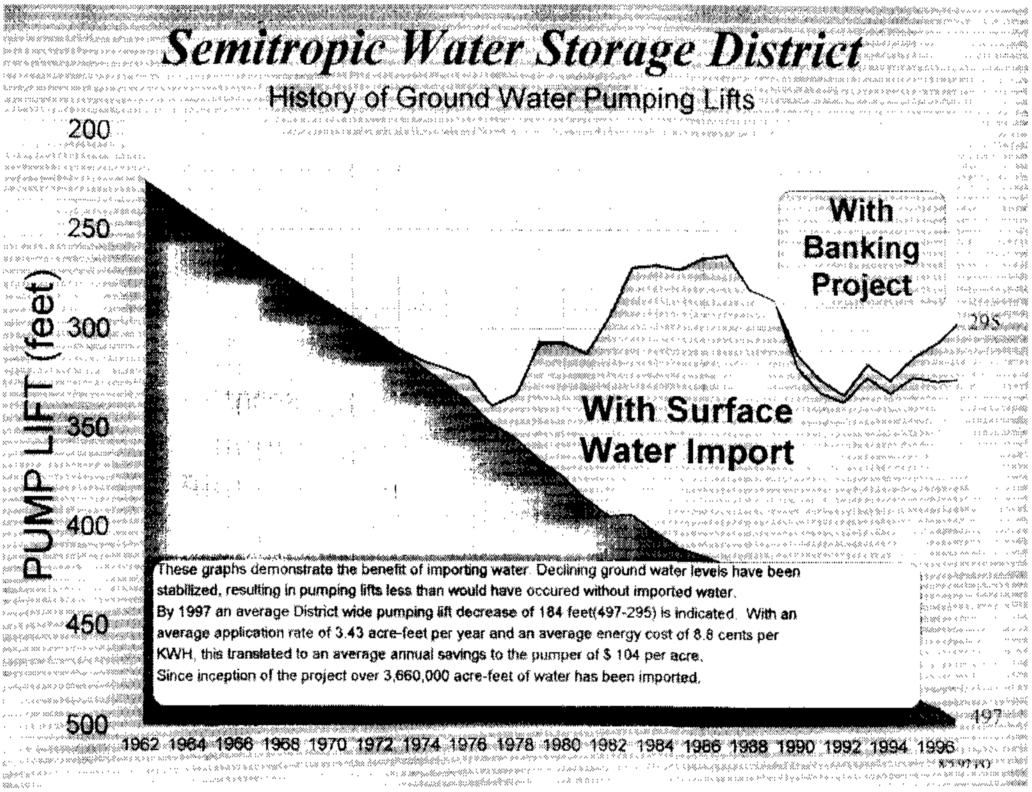
[11] The annual operations and maintenace fee is charged per acre-foot based upon the partner's fully vested permanent storage capacity (vested when capital costs are paid).

Figure 26-4
Semitropic Water Storage District History of Groundwater Pumping Lifts, 1962–1996



These graphs demonstrate the benefit of importing water. Declining ground water levels have been stabilized, resulting in pumping lifts less than would have occured without imported water.
By 1997 an average District wide pumping lift decrease of 184 feet(497-295) is indicated. With an average application rate of 3.43 acre-feet per year and an average energy cost of 8.8 cents per KWH, this translated to an average annual savings to the pumper of $ 104 per acre.
Since inception of the project over 3,660,000 acre-feet of water has been imported.

Source: Semitropic Water Storage District 1997

Evaluation of Success

To date, the program has four banking partners—Metropolitan Water District, Santa Clara Valley Water District, Alameda County Water District, and Zone 7 Water Agency.[12] Together, these partners have signed agreements to store 800,000 acre-feet. Semitropic continues to look for additional partners to participate in using the remaining 200,000 acre-feet of available storage.

Over 400,000 acre-feet have been banked and about $40 million spent on developing additional delivery capacity, well capacity for withdrawal, and the pumping plant to return water to the partners.

The project offers both economic and noneconomic benefits to Semitropic Water Storage District and participating partners. On the economic side, the program is structured to provide revenue to the District for improvements to facilities and expansion of surface water deliveries. It also allows the District to stabilize the cost of water for farmers at rates competitive with groundwater pumping. Rates for all should go down, as surface water is discounted to compete with groundwater costs, which are expected to decrease due to shorter lifts as the water table rises. Figure 26-4 shows the reduction in pump lifts given the implementation of both surface imports from the SWP and the banking project. Partners gain an economical alternative for increasing dry-year reliability by storing water

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[12] The State Water Project was involved in the demonstration program, but has chosen not to sign a long-term contract for additional storage. However, it retains a priority position in withdrawing the water it has already stored.

for use during critically dry periods.

Non-economic benefits include reduction of annual overdraft as a result of decreased pumping in the short-term. In the long-term, accumulated overdraft can be better addressed through expanded surface water facilities that allow for greater conjunctive use and in-lieu recharge. Underground storage could also offer Semitropic's banking partners a cheaper and more environmentally sound alternative to additional surface storage. The banking program and expanded surface delivery facilities allow both banking partners and Semitropic to better manage their water supplies and increase reliability for users.

The next real test for the program will come when partners need to withdraw the banked water. Program performance in delivering banked water, as well as impacts of the withdrawals on the basin, can then be evaluated.

Conclusions/Lessons Learned

In recent years, the number of water banking projects has grown, as districts seek to take advantage of groundwater storage options where they can, and to improve ways of managing scarce supplies. Groundwater banking offers a valuable supply-side management tool. It provides operators with additional storage flexibility necessary to smooth out supplies given the variability of surface flows (local, state, and federal). It has proven an economic alternative for providing drought water supplies, and agencies such as MWD and Santa Clara Valley Water District have begun to look for viable groundwater banking projects outside their own service areas.

In areas geographically suited for banking, the biggest challenges for program managers continue to be costs for facilities (whether for the land for spreading and/or distribution facilities), identifying water supplies for storage, and related institutional issues. As surface supplies continue to be stretched, groundwater banking represents yet another competing use for "excess" water, whether that water is storm water or contracted water. The program's ability to transport the water out of a basin also raises issues related to water transfers and water rights. Successful projects are able to provide infrastructure and operations that offer participants a reliable way to bank and extract water when needed, which is most often linked to adequate distribution systems and the ability to pump back groundwater rather than relying solely on entitlement exchanges. Projects must also establish institutional agreements that provide for secure rights to stored water.

Groundwater banking, like any conjunctive use strategy, cuts to the heart of the links between surface and groundwater, and basin impacts such as water quality, recharge and migration of groundwater, and groundwater levels. In addition to the supply benefits that accrue to the banking participants, there are broader basin impacts as well. Neighboring groundwater users are impacted by changes in the water table level and potential changes in groundwater quality. Thus, banking programs are best implemented as part of a larger groundwater management or monitoring program, however formal or informal. They require that program managers gather vital information on water quality and water table levels, which are necessary to monitor long-term impacts on groundwater storage. Banking programs also require that program managers coordinate activities with other groundwater and surface water users. In addition to supply benefits, banking programs provide a management tool to help a district better coordinate groundwater and surface water activities to improve basin conditions.

Contacts

Will Boschman, District Engineer and Manager, Semitropic Water Storage District
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Lloyd Fryer, Kern County Water Agency

References

Anderson, T. 1997. Santa Clara Valley Water District. San Jose, CA. Personal communications.

Boschman, W. 1997. Semitropic Water Storage District. Wasco, CA. Personal communications.

Brookhart, B. 1996. "California Urban and Agricultural Water Districts Develop Storage Program." *The Bakersfield Californian.*

Brown, L. 1993. *Conjunctive Use: Problems and Advantages.* Proceeding of the 19th Biennial Ground Water Conference, J.J. DeVries, J. Woled, editors. Water Resources Center Report No. 84. University of California, Davis.

COB (City of Bakersfield). 1986. Report entitled "2800 Acre Groundwater Recharge Project."

Core, F. 1998. City of Bakersfield. Personal communications.

Fryer, L. 1998. Kern County Water Agency. Bakersfield, CA. Personal communications.

Harding, R. L. 1995. *Metropolitan Water District and the Semitropic Water District Ground Water Storage and Exchange Program.* Proceedings of the 20th Biennial Ground Water Conference, J.J. DeVries, J. Woled, editors. Water Resources Center Report No. 88. University of California, Davis.

Haslebacher, T. 1998. Kern County Water Agency. Bakersfield, CA. Personal communications.

Iger, R. 1997. "Groundwater Banking in Kern County." Presented to American Water Resources Association 1997 Annual Meeting. Kern County Water Agency.

Kern County Water Agency (KCWA). 1997. "California Water Commission Tour of the Kern Fan Area Groundwater Recharge and Recovery Facilities" handout. Bakersfield, CA.

KCWA. 1996. *Water Supply Report 1994.* Bakersfield, CA.

KCWA. 1998. *Water Supply Report 1995.* Bakersfield, CA.

KCWA. 1983. *Report on Investigation of Optimization and Enhancement of the Water Supplies of Kern County.* Prepared by Associated Engineering Consultants. Bakersfield, CA.

Water Education Foundation. 1993. "Layperson's Guide to Ground Water." Sacramento, CA.

Semitropic Water Storage District. 1996. Materials developed as part of an application for the Association of California Water Agencies' Clair A. Hill Award Program. Wasco, CA.

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Comprehensive Groundwater Management: Orange County Water District and West and Central Basins

Arlene K. Wong

Introduction to Groundwater Management in California

While surface water supplies get much of the attention, California's hidden resource is its extensive groundwater basins. The California Department of Water Resources (DWR) estimates that these basins contain about 850 million acre-feet (maf) of water, though far less than half is considered usable because of quality considerations and the costs of extraction (DWR 1994a). In a year with average rainfall, DWR estimates that approximately 20 percent of the water used in California, 15 million acre-feet, is groundwater (DWR 1994a). Any given region may rely on groundwater for 20 to 90 percent of its water supply (DWR 1994a). During times of drought, groundwater use increases dramatically. During the 1987–1992 drought, groundwater use accounted for at least 60 percent of overall water use (WEF 1993).

The Legal Structures

Most western states have some institutional control over groundwater, establishing permit systems and regulating extractions to protect the resource. California has firmly resisted state regulation of groundwater and remains one of only two western states (the other is Texas) without statewide controls. Unlike surface water, groundwater use does not require a permit. Generally, the right to use groundwater is treated as a property right[1] of the overlying landowner, and as such is largely unregulated. As competition for water increased in the state, conflicts arose between groundwater and surface users alike,[2] and an imperfect and piecemeal body of law and court rulings developed.

Overlying rights were determined to be correlative, that is, shared proportionally among the landowners. Later court decisions established that groundwater could be appropriated, pumped, and transported to areas that do not overlie the aquifer after the needs of the overlying property owners are met—that is, "surplus" water could be appropriated. Part of the difficulty with such rights is actually defining and quantifying surplus. Prescriptive rights refer to cases where an appropriator established continuous and open use of nonsurplus water (for a specified period), using water in such a way that harmed the overlying right holders. After such period, the appropriator could secure prescriptive rights to the water despite the over-use of the resource. In most cases, groundwater rights—overlying, appropriative, or prescriptive—are not defined or quantified until extractions threaten another's use or the basin supply, and affected parties have brought suit to determine rights and limit extractions.

Groundwater Management Institutions

For the most part, groundwater management has usually been undertaken when basin supplies were deemed to be in grave jeopardy due to overpumping, degraded water quality, or surface diversions adversely impacting groundwater. Having resisted state control, California groundwater management has been left to individual property owners or local agencies. Many

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[1] Individuals do not own the water itself, rather, they acquire usufructary rights—a right to use the water.

[2] As noted in the sidebar on Groundwater Basics, surface and groundwater are not independent, and surface water diversions can affect groundwater supplies and vice-versa.

of the earliest management institutions were established through adjudication of pumping rights, special legislation, or actions by local water agencies. More recently, with increasing concerns about groundwater transfers and exports, as well as the ever-present talk about the need for state control, localities have undertaken management programs in advance of facing critical basin conditions.

In court adjudication, a party or parties may bring suit to determine groundwater rights of users and limit extractions. The court must determine who the extractors are and how much each has the right to extract. The court also assigns a watermaster who ensures that the basin is managed in accordance with the court's ruling. Court adjudication of groundwater rights has been brought about in basins experiencing severe overdraft problems. Often suits are brought by users themselves, attempting to better balance basin use. More recently, the State Water Resources Control Board has intervened in a number of coastal basins to protect the basin resources from salt water intrusion. There are 16 adjudicated groundwater basins in California; all but three of these are in Southern California (Table 27-1).

In addition to management ruled by the court, the California State Legislature has enacted statutes establishing groundwater management districts or agencies, authorizing them to enact ordinances to regulate the amount of groundwater that is extracted or limit its place of use within the district. It also authorizes finance mechanisms such as pump taxes, bonds, or other assessments to support management activities. Today, there are 10 such agencies or districts, though not all are considered very effective at actively managing the basin (DWR website). Two additional districts, Orange County Water District and Santa Clara Valley Water District, can levy pump taxes but have no statutory authority to regulate groundwater extractions directly. The California Water Code also provides statutory authority for some districts or local agencies to impose forms of groundwater management such as conservation of storm waters for spreading, or protecting basin water quality. Some agencies have chosen to do so; many others have not.

Groundwater Basics

What is groundwater?

Unlike images of large underground rivers or pools of water, groundwater is water that accumulates in highly porous materials such as sand and gravel found in alluvial deposits buried below the land surface, or pores and fractures in hard rocks. Groundwater aquifers are large deposits of such waterbearing materials and can extend for hundreds of miles. Size and capacity are determined by the aquifer's geologic structure. The porosity of the subsurface material generally determines the relative amount of water an aquifer can hold, and the permeability of the material determines the speed with which water moves through the aquifer. *A groundwater basin consists of one or more aquifers bounded by non-waterbearing material* such as bedrock or an underground displacement of rock such as a fault or divide.

How is groundwater recharged and extracted?

Water enters a groundwater basin by either percolating through the soil and overlying sediments in the aquifer or from subterranean movement of water from one aquifer to another across a subterranean fault. Percolating water can come from precipitation on the surface, from streams or other bodies of water passing over permeable materials, or from water applied to the surface by humans, such as through irrigation. Such activities are considered natural or incidental recharge or replenishment of the basin. Artificial recharge takes place when people replicate and promote natural processes by capturing and retaining water in surface impoundments (dams, dikes, spreading grounds) to allow water to percolate into the underlying basin. Another form of artificial recharge is direct injection of water into the basin through wells. Yet another term that has grown common in recent years is "in-lieu recharge." Rather than referring to water intentionally added to a basin, in-lieu recharge refers to groundwater left in the basin when surface water is used in its place. A farmer who irrigates his lands with surface water instead of pumping groundwater might be credited with in-lieu recharge for the amount he agrees not to pump.

Water exits a basin through both natural and artificial means. Groundwater naturally flows from higher elevations to lower elevations and may move from basin to basin and eventually reach the sea. Nearer the surface, groundwater may join surface water where streams have carved channels into the bedrock or a fault boundary of the basin. A third natural exit is artesian springs, where groundwater confined under pressure between two layers of relatively impermeable materials actually breaks through the top layer to flow to the surface. Artificial extraction commonly takes place through wells and pumps.

Groundwater Problems

To maintain groundwater levels and flows, basins rely on a balance between replenishment and extraction. The two overriding problems groundwater basins face are overdraft and contamination.

Overdraft occurs when the amount of water removed from a basin exceeds the amount of water being replenished. Safe or sustainable yield refers to the amount of groundwater that can be safely extracted without causing overdraft. Natural patterns of wet and dry years commonly result in periods of overdrafting and refilling of a basin. However, long periods of overdraft can cause severe problems. Years of overpumping can deplete the resource, lower the water table, and increase the costs of pumping. When water is removed from the waterbearing material and not replaced, soils can become compacted and storage space permanently lost. This is known as land subsidence.

Contamination of a basin can be a problem when subsidence occurs and minerals from soils mingle with groundwater. In coastal basins, lowering the water table may allow seawater to intrude into an aquifer and mix with the fresh water. Contamination can also occur from surface activities that either contaminate the surface water that percolates into the basin or the soils through which the water percolates.

Table 27-1
Adjudicated Groundwater Basins in California

Basin	County	Filed in Court	Final Decision
Scott River Valley	Siskiyou	1970	1980
Santa Paula Basin	Ventura	1991	1996
Central Basin	Los Angeles	1962	1965
West Coast Basin	Los Angeles	1946	1961
Upper Los Angeles River Area	Los Angeles	1955	1979
Raymond Basin	Los Angeles	1937	1944
Main San Gabriel Basin	Los Angeles	1968	1973
Puente	Los Angeles	1985	1985
Cummings Valley Basin	Kern	1972	1972
Tehachapi Basin	Kern	1973	1973
Lower, Middle & Upper Mojave River Valley Basins	San Bernardino	1990	1996
Warren Valley Basin	San Bernardino	1976	1977
Chino Basin	San Bernardino and Riverside	1978	1978
San Bernardino Basin	San Bernardino and Riverside	1963	1969
Santa Margarita Watershed	San Diego and Riverside	1951	1966

Note: Cucamonga Basin in San Bernardino is operated as part of Chino Basin.
Source: DWR 1996

Table 27-2
Groundwater Management Districts or Agencies in California

Agency	County	Legislation Enacted
Willow Creek Groundwater Management Agency	Lassen	1993
Honey Lake Valley Groundwater Management District	Lassen	1989
Long Valley Groundwater Management District	Lassen and Sierra	1980
Sierra Valley Groundwater Management District	Sierra	1980
Mendocino City Community Services District	Mendocino	1987 (groundwater authority enacted)
Mono County Tri-Valley Groundwater Management District	Mono	1989
Pájaro Valley Water Management Agency	Santa Cruz	1984
Ojai Groundwater Management Agency	Ventura	1991
Fox Canyon Groundwater Management Agency	Ventura	1982
Monterey Peninsula Water Management District	Monterey	1947
Orange County Water District	Orange	1933
Santa Clara Valley Water District	Santa Clara	1951

Source: DWR 1996

A fourth form of groundwater management was added with the passage of AB 3030 in 1993. It allows existing local agencies overlying any groundwater basin to develop groundwater management plans. Plans adopted by water districts must include public hearings and consider protests to adoption of the plan.[3] The Water Code provides the agency with the authority of a water replenishment district to fix and administer fees and assessments for management purposes. It also allows for limitation of extractions if the agency can show that existing programs have proven insufficient to lessen the demand for groundwater and the basin is in jeopardy. Some 30 agencies have adopted groundwater management plans in accordance with AB 3030, though many are primarily monitoring programs. At least 98 more agencies have begun the process of preparing a plan for adoption (DWR website 1997).

In 1995, the California Supreme Court declined to review a lower court decision (*Baldwin vs. Tehama County*) that holds that state law does not regulate the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater. This introduced a fifth option for management that cities and counties have begun to exercise. In *Tehama*, the county passed an ordinance requiring a permit to export groundwater beyond county boundaries. To receive a permit, an exporter must show that the transfer of groundwater will not negatively impact the basin. Imperial, San Benito, San Diego, San Joaquin, Butte, and Davis counties have also recently adopted groundwater ordinances.

Selection of Cases

There are those that feel that many of the management districts that have formed in recent years have yet to adequately regulate groundwater use to improve management and protection of basins. Some feel that some form of state control is necessary, while others believe that the best forms of management have been produced locally. The following cases provide two different models of successful groundwater management. One offers an examination of a basin where groundwater extractions have been adjudicated, and therefore limited, and the multiple agencies that were created to address the basin problems. The other offers the case of a non-adjudicated basin where groundwater pumping is not limited and a supply-side strategy is pursued.

Orange County Water District

Introduction

Orange County Water District (OCWD, or the District) was established in 1933 by a special act of the California Legislature. It covers an area of more than 350 square miles in the northern half of Orange County. Since its creation, OCWD has adopted several management strategies to protect the groundwater supply. The early years were focused on maintaining adequate Santa Ana River flows into the basin, largely accomplished through litigation. When natural replenishment was determined to be insufficient, the District implemented a pump tax and funded an aggressive replenishment program. The strategy to refill the basin eventually gave way to a combination of seawater barriers to protect the coastal areas and a conjunctive use program to allow users to maximize basin supplies. As strategies changed, certain institutional changes were made, such as the pump tax and the development of the basin production percentage and basin equity assessment. The current groundwater plan continues to build on the conjunctive use program, but includes greater emphasis on making use of recycled water and a focus on basin water quality. Today, the District provides a reliable supply of groundwater to 23 cities and nearly two million county residents. Groundwater supplies approximately 75 percent of water use for the area.

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[3] A majority protest consists of a negative vote by the property owners of more than 50 percent of the assessed value of the land within the service area.

Background

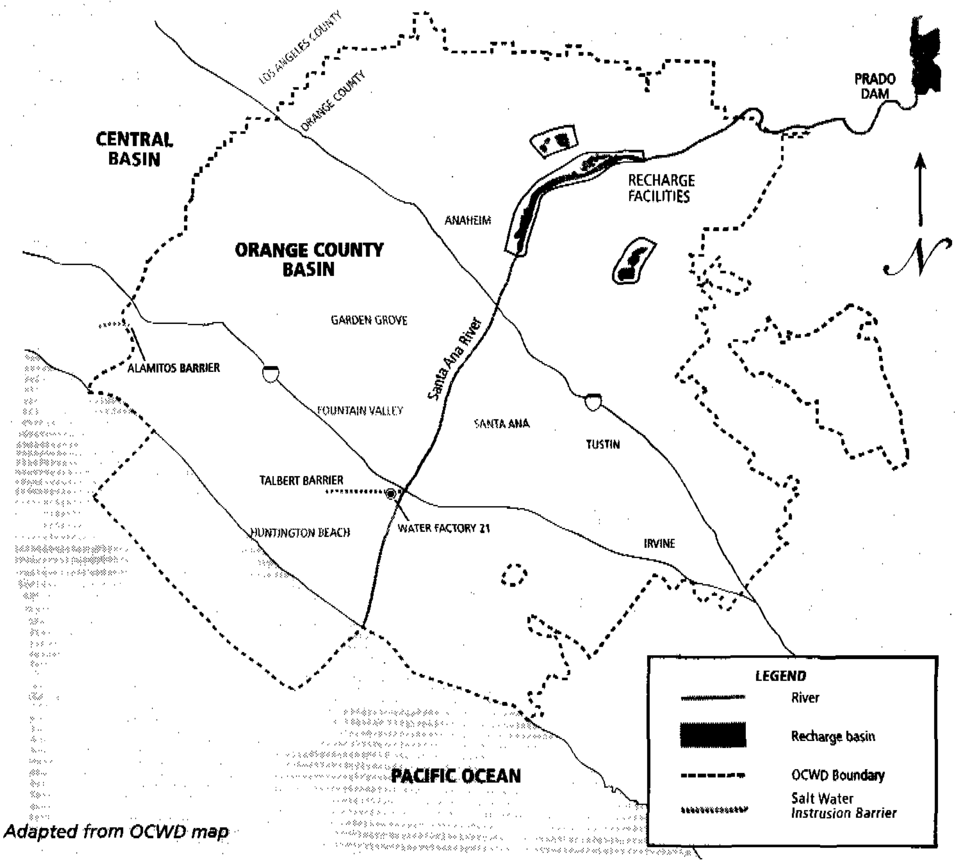
Basin Hydrogeology

The Orange County Basin extends for 300 square miles and contains three major aquifer systems arranged in layers. The lower aquifer system, 2,600 to 4,000 feet deep, contains poor-quality, confined water with a high level of dissolved solids. The middle aquifer system is 1,300 to 2,600 feet deep, and the upper aquifer system extends about 1,500 feet deep. The basin's total storage capacity is about 15 million acre-feet, with 10 percent (or 1.5 million acre-feet) considered usable storage[4] (Blomquist 1992).

The basin's fresh water is physically separated from the Pacific Ocean by a subsurface fault zone known as the Newport-Inglewood Uplift. This division manifests itself on the surface by low hills that extend southeast from Los Angeles County to the southeastern part of Orange County. This barrier has been breached in several areas along the coast, however, where the Santa Ana and San Gabriel Rivers have carved channels through the fault zone. Some gaps have been filled by subsequent underground shifts, but two remain—the Alamitos and Talbert gaps. When the groundwater levels near those gaps drop below sea level, salt water is able to enter the basin.

Recharge of the basin occurs primarily from the percolation of surface waters from the Santa Ana River bed and surrounding recharge spreading areas in the northeastern end of the basin.

Figure 27-1
Orange County Water District



Source: Adapted from OCWD map

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[4] Usable storage is stored water that can be economically extracted or is of adequate water quality for human use.

The Problem

As a coastal basin, Orange County Basin is prone to salt water intrusion problems when water levels are drawn down too low, reversing the flows at the gaps in the fault zone. Located at the downstream end of the Santa Ana watershed, the basin is easily impacted by the diversions of upstream users. These two features, coupled with groundwater demands, first from agriculture and then from cities as the area urbanized, created constant problems with salt water intrusion at the coast, and overdraft depleting the basin.

District Formation

Use of water upstream of the basin seriously diminished the natural flows of the Santa Ana River. In 1932, the Irvine Company, which owned approximately 92,000 acres of farmland in Orange County, filed a lawsuit against upstream water users, to limit their diversions. As the litigation progressed and the number of defendants grew, it became clear that many water users stood to benefit from action taken to limit upstream use. The Irvine Company looked for a better way to share the costs and represent its interests. Upstream defendants in the suit had created the San Bernardino Valley Water Conservation District to represent the interests of all the appropriators in San Bernardino Valley. The Irvine Company looked to do the same.

In 1931, the Orange County Farm Bureau sent a letter to the county's state senator and assemblyman to request help to authorize a special water district to represent county water users and protect the basin resources (Blomquist 1992). In 1933 the Orange County Water District Act was approved. The Act authorized the Orange County Water District (OCWD) to represent the water users and landowners of the District in all litigation involving outsiders (Blomquist 1992). OCWD entered the Irvine litigation as intervener on behalf of the Irvine Company and other Orange County water users.

The Project

District Goals

The legislative act allows the Orange County Water District to "store water within or outside the district; to appropriate and acquire water and water rights within or outside the district; to purchase and import water into the district and to conserve water within or outside the district; to buy, sell, and exchange water; to improve and protect quality of the groundwater supplies; [and] to distribute water in exchange for reducing groundwater extractions" (DWR 1994b). It also granted authority for an annual *ad valorem*[5] general assessment upon all assessable property, excluding personal property.

In exercising its authority, OCWD developed a number of strategies. The District's most recent strategic management plan, established in 1989, includes three major goals, and while the activities have changed over the years, the goals have remained relatively constant:

- Increase basin water supplies, including greater conservation at Prado Dam, optimal utilization of existing recharge facilities, and increased water recycling.
- Protect and enhance water quality, including cleaning up groundwater contamination, and improving Santa Ana River quality.
- Improve management of the basin and the District, including maximizing basin storage and conjunctive use, as well as improving the pumping pattern.

Program History and Description

OCWD was Southern California's first replenishment district (Blomquist 1992). Notably, however, the District was not given the power to regulate or restrict water use by pumpers within its boundaries. The Orange County water community was deeply opposed to adjudication of water rights and committed to the idea of supply-side management and provision of "a water supply adequate to meet demands regardless of growth, development, drought,

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[5] An *ad valorem* tax is assessed against value, e.g. five cents tax against every $100 of assessed value.

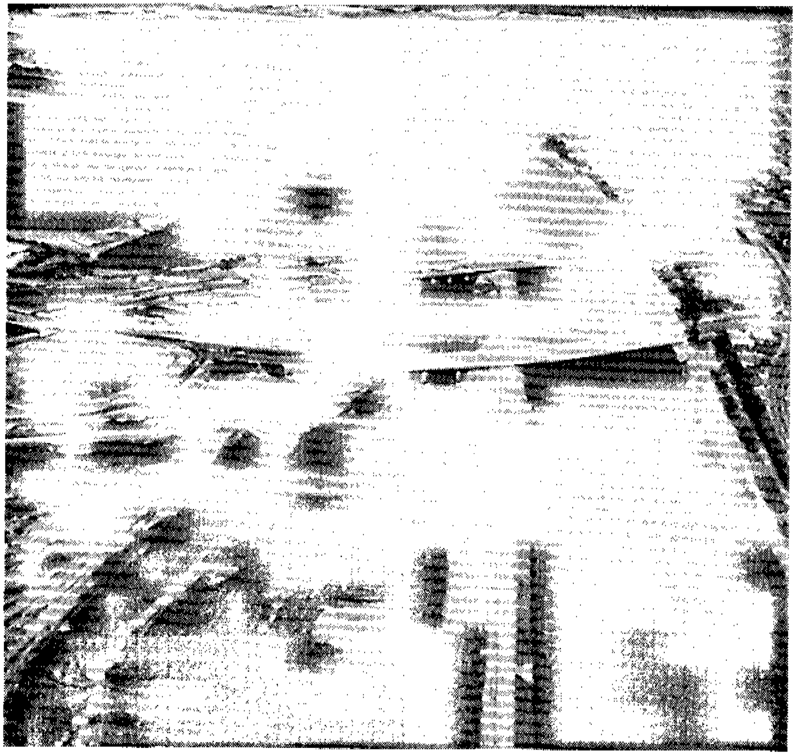
and the like" (Blomquist 1992). There were three focal points for the District's supply-side approach: preservation of flows in the Santa Ana River, basin replenishment activities, and halting the seawater intrusion. In addressing each of these issues, management strategies evolved and institutional arrangements were created.

Litigation and securing Santa Ana River flows

Because natural recharge of the basin is highly dependent on flows from the Santa Ana River, securing adequate flows was a primary concern. Maintaining the flows downstream required the cooperation of the upstream users, which, for the most part, was gained through court litigation. The Irvine litigation was but the first of three suits the District would bring against upstream users to secure flows in the river. This first suit took 10 years to settle. It was primarily aimed at upstream spreading operations that were diverting surface waters for their own recharge operations and reducing river flows downstream. In 1942, the U.S. District Court for the Southern District of California issued a judgment for the Santa Ana River that reduced the amount of water defendants could divert for spreading upstream, specified the spreading locations defendants could use, and placed administrative and monitoring responsibilities on the defendants (Blomquist 1992).

A second suit was brought by OCWD in 1951 against four major upstream appropriators of Santa Ana River flows—the cities of Riverside, San Bernardino, Colton, and Redlands. Again, the District sought to restrict upstream water diversions to maintain flow quantities reaching Orange County. In 1957, a judge ruled that these cities had prescriptive rights to some of the water through their adverse historical use. He established the five-year period prior to the initiation of the lawsuit (1946–1951) for the purpose of determining those prescriptive rights. Each city was then enjoined from taking more than their court-declared right from the watershed.

Despite these earlier rulings, the District once again faced problems with reduced flows in the Santa Ana River as the upstream areas continued to develop, and once again OCWD relied on litigation to secure those rights. This time, the District followed the example set in the San Gabriel River adjudication whereby downstream water users had sued upstream water users to gain a guaranteed flow each year. In 1963, OCWD filed a complaint that began the case of *Orange County Water District v. City of Chino et al.* The complaint requested an adjudication of water rights for every user in the upstream area. Defendants filed 13 cross-complaints naming as cross-defendants essentially all the downstream users (Blomquist 1992). By 1968, OCWD's complaint was dismissed against all defendants except the three major upstream municipal water districts—Chino Basin Municipal Water District, Western Municipal Water District of Riverside County, and the San Bernardino Valley Municipal Water District. Cross-complaints were also dropped. The four water districts negotiated a stipulated judgment similar to the San Gabriel River judgment. The judgment, effective in 1970, established a base-flow of 42,000 acre-feet of useable water per year at Prado Dam, plus all storm flows reaching Prado Flood Control Reservoir.



The Santa Ana River and spreading grounds. (Photo courtesy of OCWD)

This final judgment gave OCWD the security it sought in maintaining the river flows. Ironically, by the 1980s, average flows to Prado Dam were well over the 42,000 acre-feet gained in the settlement. Development of the upper region resulted in an increased volume of wastewater discharged into the river, and today the river's base flow is over 130,000 acre-feet per year. During summer months, it is not uncommon for 90 percent of the river flow to be composed of treated wastewater (OCWD Groundwater Management Plan 1994). This incidental recharge of wastewater into the basin raises water-quality considerations but is not directly regulated as in the case of planned reclaimed water use.[6] Water drawn from the basin must still meet drinking water-quality standards, however, and District water-quality activities are discussed later in this case.

Basin replenishment

Replenishment activities have evolved as basin conditions have changed. Recharge activities are concentrated in the upper basin in and around the Santa Ana River. Completion of the Prado Dam in Santa Ana Canyon in 1941 for flood control purposes provided OCWD with an essential tool to conserve waters and manage releases for maximum recharge downstream. However, even with the improved river flow quantities obtained in the Irvine suit, it was clear that natural replenishment was not sufficient. By 1948, the 250,000 acre-feet pumped each year produced an annual overdraft of approximately 100,000 acre-feet. The average water level in the basin had fallen 15 feet from its previous high, and levels along the coast again fell below sea level (Blomquist 1992).

To supplement recharge, OCWD began an artificial replenishment program in 1948, buying water from Metropolitan Water District through the county's member agencies, primarily the Municipal Water District of Orange County. The water was purchased with property tax revenues by invoking the *ad valorem* tax it was authorized to use. In its first two years, OCWD purchased only about 28,000 acre-feet each year, far less than the 100,000 acre-feet of annual overdraft it needed to overcome.

Additional purchases would have required raising property taxes, something the board was reluctant to do for several reasons (Blomquist 1992). One issue was resentment from landowners who already paid property taxes to support their area's district formation and annexation to MWD,[7] who felt further burdened paying property taxes to OCWD for purchases of yet more MWD water. Also, some property owners overlying the basin were not within OCWD boundaries, but would still get the benefit of basin replenishment. Further, non-pumping property owners would be subsidizing those who did pump.

In light of these concerns, the District sought to redesign their funding mechanism, opting instead for a pump tax. The District's Act was amended in 1953 and the District boundaries enlarged to cover the entire basin so that the pump tax would apply to all pumpers overlying the basin. Amendments also provided for registering wells with OCWD and requiring pumpers to record and submit production data twice a year. Further, the District would provide an annual engineer's report on basin conditions and groundwater production. The tax was set annually at levels required to raise the revenue to purchase the water necessary to match the annual average overdraft over the previous five years, plus one-tenth of accumulated overdraft (Blomquist 1992).

The pump tax allowed the District to support a much more aggressive artificial replenishment program, and for several years the District purchased large amounts of water in an effort to refill the basin as rapidly as possible (Blomquist 1992). Water was stored and released in the Santa Ana spreading grounds. Purchases to refill the basin peaked during the 1960s (see Figure 27-2). The replenishment

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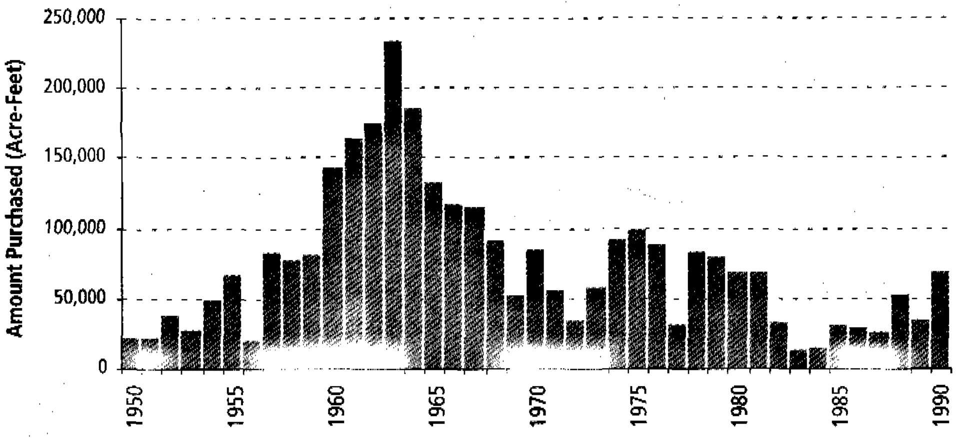
[6] The activities of the Water Replenishment District in the accompanying case offer an example of regulation of planned reclaimed water use for recharge.

[7] Metropolitan Water District (MWD) is the largest wholesale purveyor of water in Southern California. To receive MWD water, an area must first form a water district through a vote of local landowners or registered voters (depending on the type of district), and then the district must request annexation to become a member agency of MWD. Annexation must be approved by MWD's board, whose directors are appointed by its member agencies.

Figure 27-2

Orange County Water District Purchases for Replenishment, 1950–1990



Source: OCWD Annual Reports, cited in Blomquist 1992

program was aided by a decrease in groundwater pumping as more areas in the county annexed to MWD and used imported surface sources. Also, the 1950s and 1960s marked a time of urbanization of agricultural lands, and, at least during the peak of this replenishment effort, the decrease in demand for irrigation water exceeded the increase in demand for urban uses (Blomquist 1992).

The basin reached a historic low point in 1956, with average water levels at 20 feet below sea level and places near the coast at 40 feet below sea level. Salt water had advanced three and one-half miles inland in some places. It is estimated that the accumulated overdraft by 1956 had reached 700,000 acre-feet, or one-half of the usable storage capacity of the basin (OCWD Annual Report 1995). By 1964 the replenishment activities and decreased pumping had restored average water levels in the basin to 24 feet above sea level (Blomquist 1992). Accumulated overdraft had been virtually eliminated. However, basin conditions were such that the water table was rising in the upper basin recharge areas while salt water intrusion continued near the coast.

Maximizing recharge capacity

OCWD again acknowledged the need to readjust their management strategy. The 1965–1966 Annual Report noted: "It now appears certain that spreading in the forebay cannot entirely eliminate seawater intrusion ..." (as quoted in Blomquist 1992). The strategy had now evolved to one of conjunctive use of the basin—that is, it became more important to take advantage of wet years, storing as much water as possible, so that the basin could be used during dry years when surface supplies were more scarce. The District also sought to influence pumping patterns more, both in time and space.

In 1968, the District sought and obtained another amendment to the Act allowing the District to redesign its pump tax. The flat tax was replaced with a tiered system based on a basin production percentage (BPP) agreed upon by the OCWD and the groundwater producers.[8] The BPP is a target percentage of total water production to be made up by groundwater pumping. Each user pays a replenishment assessment for groundwater pumped within the BPP. The replenishment assessment is set at an amount required to finance recharge and basin management operations (approximately

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[8] There are about 65 groundwater producers using groundwater for non-irrigation uses. Fifteen of the producers (water districts and municipalities) account for over 90 percent of the use.

$91 per acre-foot in 1997). Water pumped over the BPP is charged a basin equity assessment (BEA) in addition to the replenishment assessment, for using a greater share of basin resources. The BEA represents the differential cost between pumping groundwater and purchasing imported water (approximately $320 per acre-foot in 1997). BEA funds collected can then be used to pay pumpers to reduce pumping below the BPP, offering them the difference in cost to purchase imported waters instead. OCWD establishes the replenishment assessment, BPP, and BEA each year based on basin conditions and availability of imported water. The BPP is set to maximize productive use of the basin without encouraging overdraft. It applies to anyone pumping more than 25 acre-feet of water per year for non-irrigation use.

Another effort to improve recharge capacity was also undertaken. The District purchased and excavated lands to create new spreading facilities near the Santa Ana River. OCWD was also able to convert nearby gravel pits to spreading basins. This additional recharge capacity improved the District's ability to take advantage of storm runoff that otherwise flowed to the sea. By the early 1980s, OCWD had increased spreading capacity from 50,000 to 200,000 acre-feet for wet years (Blomquist 1992).

Seawater barriers and drought-proof supply

Along with efforts to increase recharge capacity, the District had to develop a more effective means of halting seawater intrusion. Replenishment in the forebay was not helping the coastal areas sufficiently. In the 1960s the District finally turned to barrier projects for the Alamitos and Talbert gaps. The Alamitos Barrier Project[9] was undertaken in cooperation with the Los Angeles County Flood Control District and later, the Water Replenishment District of Southern California (WRD). The barrier straddles the county border and protects both the Central and Orange basins from salt water intrusion. OCWD and WRD share responsibility for acquiring 5,000 to 10,000 acre-feet of water for injection each year. Operations began in 1965.

Seawater intrusion at the Talbert Gap was more extensive and required a larger operation. The Talbert Barrier Project is designed as two-stage barrier. Twenty-three multi-point injection wells create a freshwater barrier to separate the basin from the sea. A series of extraction wells were built between the injection wells and the coast. The extraction wells pull out brackish water moving inland and return it to the ocean through surface channels. It was thought that this would offer a second method to reduce seawater intrusion and reduce the burden on the injection activities.[10] The first units became operational in 1969. Growing concern about the availability of imported water for injection activities convinced OCWD of the value of developing a drought-proof supply using recycled water. Water Factory 21 was built to produce advanced-treated recycled water that is blended with deep well water for injection into the Talbert Barrier Project.

The Current Strategic Plan

OCWD's current strategic plan, introduced in 1989, is based firmly on the foundation of past activities. Plans for increasing local supplies support the District's overall supply-side strategy for conjunctive use, coupled with demand-side signals achieved through the BPP and BEA. Recycled water continues to be an important and growing part of the supply equation. And, finally, water-quality concerns have grown beyond salt water intrusion to encompass other water-quality threats to the basin such as increasing TDS and nitrates.

Expanding Local Supplies

Efforts continue to increase local basin supplies through capital improvements in the spreading grounds that will assist management of flows and increase spreading capacity. With the spreading operations surrounded by development, increased recharge cannot be accom-

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[9] Discussed in further detail in the accompanying case study on the West and Central Basins.

[10] In fact, the injection wells proved sufficient, and the extraction wells were turned off in the early 1980s.

Water Factory 21

In the mid-1960s, OCWD began a pilot-scale reclamation project that developed into the now-famous Water Factory 21. Secondary effluent supplied by the County Sanitation Districts of Orange County is treated to drinking water standards for blending with deep well water and injected into the Talbert seawater barrier wells. The first blended reclaimed water was injected into the barrier in 1976.

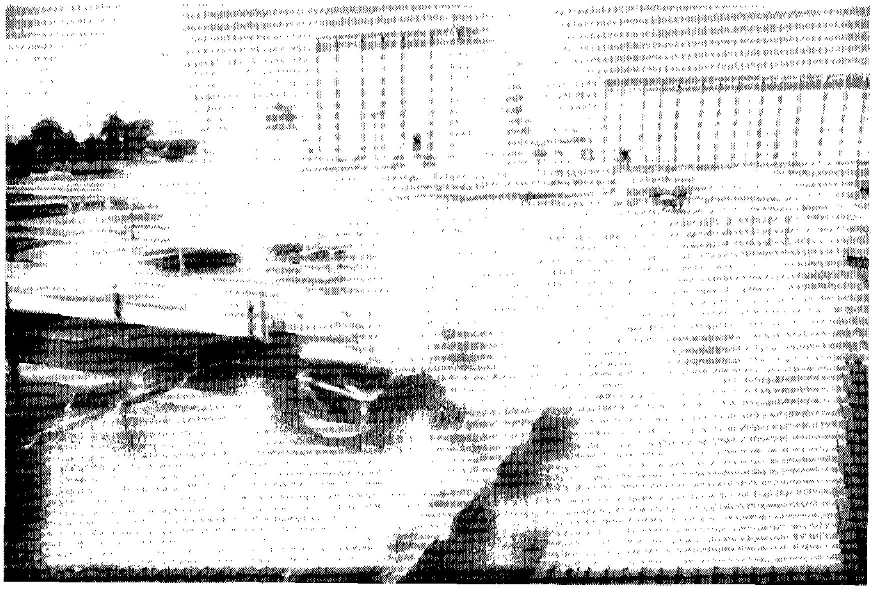
Water Factory 21 produces approximately 15 million gallons per day (mgd) of recycled water, and, when blended with deep well water, produces up to 22.6 mgd for barrier operations. The secondary effluent undergoes chemical clarification, recarbonation, and multi-media filtration. These processes are used to settle out solids, elevate pH levels for disinfection and virus removal, and reduce turbidity. Once the pretreatment is completed, two-thirds of the water is treated by granular activated carbon adsorption (GAC) and one-third is treated using reverse osmosis (RO). GAC is basically composed of layers of coal, silica sand, garnet, and gravel in a column that serves as a filter; each column has 43 tons of granular activated carbon. The purpose of the GAC is to adsorb various dissolved organic compounds from the treated water. Typically, the carbon will remove 70 percent of the total organic carbon. Water from the GAC process is then chlorinated to oxidize ammonia and destroy remaining bacteria and viruses. The RO process is highly effective at removing total dissolved solids (TDS) and reducing other minerals, ammonia, and total organic carbon. Treatment through RO involves passing water through membranes at very high pressures (200-325 pounds-per-square-inch). This process removes 90 percent of TDS. Finally, the GAC and RO water are blended with the deep well water. The final blend is 62 percent reclaimed water and 38 percent groundwater and contains TDS levels at less than 500 milligrams per liter.

Capital and construction costs totaled $20.8 million (actual figures from the mid-1970s). One half was paid by OCWD and the remainder by a combination of grants and loans from the state and federal government. Operating costs (without amortized capital expenses) to produce the blended product at maximum capacity amount to $306 per acre-foot. The advanced-treated water alone is about $470 per acre-foot.

Producing some 10,000 acre-feet of recycled water annually, Water Factory 21 provides OCWD with a drought-proof supply for its seawater barrier injection activities. This reduces local dependency on imported water supplies and reduces the amount of wastewater discharged to the ocean by the amount recycled.

plished economically by physically expanding the spreading areas. The last major land acquisition by the District for its spreading operations was made in 1983. Instead, the District has focused on capital and operational improvements to manage the flow of water through the spreading basins and to improve percolation rates. Of primary importance is the ability to clean the basins of sediments that clog porous surfaces, to promote higher rates of percolation. The District has invested in permanent pumps so that basins can be de-watered rapidly and cleaned more frequently. By 1994, capital improvements had increased recharge capacity to 400,000 acre-feet of water in a year (OCWD Groundwater Management Plan 1994).

The District also continues to improve use of local storm runoff, which requires the capacity to store it for controlled releases through the spreading grounds. Central to conserving more storm waters are agreements with the U.S. Army Corps of Engineers, who operate Prado Dam for flood control purposes. OCWD already owns 2,150 acres of wetlands above the dam for water conservation purposes. The District has negotiated with the Corps for permanent seasonal storage behind the dam. The permanent storage would be increased over a period of several years to offer a storage capacity of 29,000 acre-feet. Environmental regulations require that habitat lost to increased storage



Water Factory 21 (Photo courtesy of OCWD) behind the dam must be mitigated. OCWD will set aside habitat in specified amounts for each incremental increase in storage. The District has already converted 124 acres into habitat for the Least Bell's Vireo (an endangered songbird) and plans to create an additional 278 acres of wildlife habitat as mitigation for the increased storage.

OCWD's commitment to using recycled water as a local source is reflected in its continuing efforts to expand and improve its reclamation activities. OCWD supports a significant amount of research and development in treatment technologies. The goal is to improve treatment performance by using more cost-effective processes. The District also works to expand its use of recycled water. In 1991, OCWD received a permit from the Regional Water Quality Control Board to inject recycled water into the basin without first blending it with fresh water, as is currently done with Factory 21 water. The permit has a number of conditions that still must be satisfied to ensure the removal of viruses, nitrogen, and trace organics, and OCWD is currently conducting studies to show that new technologies will meet the water-quality standards in a cost-effective manner.

The Green Acres Project began delivering recycled water for non-potable uses in October 1991. The project involved building a 7.5 mgd treatment plant to treat secondary wastewater to tertiary levels for non-potable use in landscape irrigation and industrial processes for several cities in the District.[11] The project currently provides approximately 7,000 acre-feet per year (afy), and a recently-completed pipeline extension will deliver an additional 800 afy. Expanded use of recycled water reduces reliance on basin or imported water by substituting for potable water use. The District has plans for a new regional recycling project that will provide up to 100,000 acre-feet of recycled water annually, primarily for recharge.

Protecting and Enhancing Water Quality

More recent water-quality activities focus on protecting the water quality of the basin and improving the water quality of the Santa Ana River flows. Beginning in 1985, OCWD began a water-quality monitoring program. Its system of 110 single-point shallow monitoring wells and 53 multi-point deep wells provides a total of 635 depth-specific sampling points throughout the basin. Systematic sampling allows the District to monitor water-quality levels and identify contaminated areas. Contaminants in the basin are generally salts, nitrates, and volatile organic compounds (VOCs). VOCs are synthetic compounds used in industrial, agricultural, and household applications, and they have reached several wells in the forebay area of the basin. Some of the highly concentrated salt areas are naturally occurring geologic deposits. Other areas, historically used for agriculture, such as Irvine and Tustin, have high concentrations of salts and nitrates, likely the result of fertilizer use.

The best water-quality protections for the basin are achieved through prevention activities. OCWD undertakes general public education activities to make residents aware of links between surface activities and the basin. The District also works closely with regulatory authorities to monitor and identify potential sources of contamination, such as underground storage tanks. However, when contaminated areas are found in the basin, the District takes action to pump and treat the contaminated water, both putting the water to use and removing the contaminants from the basin. It is currently involved in several projects encompassing nitrate treatment, desalters, and VOC treatment throughout the District and in cooperation with pumpers.

The Santa Ana River is the District's single largest water source for basin replenishment. The two most significant water-quality issues are the salts and nitrate content. With the development of Southern California's Inland Empire, the flow into the Santa Ana River is largely composed of effluent from municipal dischargers. Salts build up as the water is diverted and discharged back into the streambed by the numerous upstream users. The high

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[11] Other examples of the development of recycled water projects for urban use are provided in *Using Recycled Water in Urban Settings*, Chapter 12.

amount of nitrate in the river is largely a by-product of the municipal uses and the large dairy operations in the Chino area.

OCWD is actively involved in cooperative management of the Santa Ana watershed.[12] The District is a partner in several desalting projects upstream to reduce the salt content of the river flows. OCWD has also undertaken an extensive Santa Ana River Water Quality and Health study. Begun in 1994, the study will likely take another three years to complete and will assess the quality and health risk potential of using Santa Ana River water for recharge. This comprehensive study will ensure that large-scale recharge with Santa Ana River water and recycled water does not pose a health threat or a negative environmental impact. Findings from the study are certain to influence regulation of recycled water use for large-scale recharge operations.

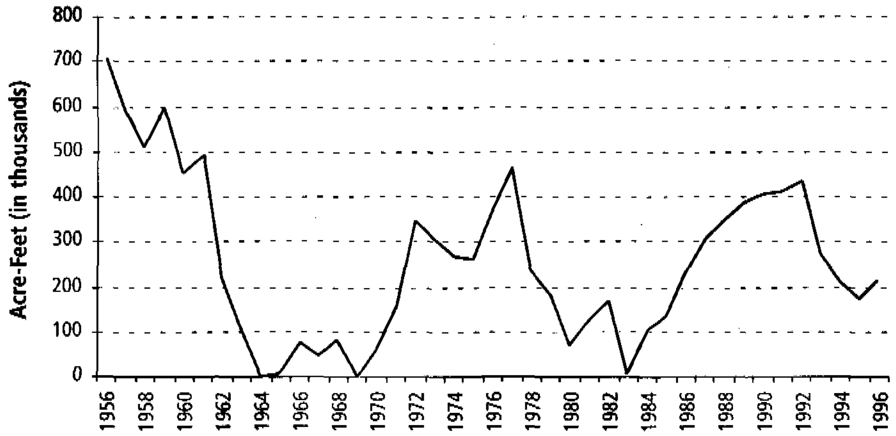
A pilot study in 1992 showed that nitrate levels were reduced dramatically when Santa Ana River flows were diverted through a network of reconstructed wetland ponds on District lands behind the Prado Dam. The studies showed that the ponds had a nitrate removal efficiency of up to 88 percent (OCWD 1994). OCWD has worked to improve the wetland areas to increase their capacity to accept river flows. About half of the Santa Ana River's flow is now diverted through the ponds.

Evaluation of Success

OCWD was first created to represent groundwater users in litigation against upstream diverters. Since then, it has evolved into a district with broad powers to manage the basin and has brought basin use and replenishment into balance without adjudication of rights or limitations on pumping. It has become a leader in reclaimed water use and is an active participant in basin monitoring and clean up.

Increased recharge capacity has allowed the District to implement a conjunctive use strategy of filling the basin during wet periods and increasing use during dry periods. As can be seen in Figure 27-3, since the basin's low point in 1956, the District's strategy has eliminated the accumulated overdraft, and OCWD's conjunctive use strategy has permitted draw-down of supplies in dry periods, with recharge during wet years. The District has weathered two serious droughts—in 1977 and again from 1987–1992—drawing down groundwater supplies during the drought and replenishing sup-

Figure 27-3
Accumulated Overdraft, 1956–1996



Source: OCWD 1996

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[12] A more detailed description of the watershed management activities can be found in *Working for Healthy Urban Watershed Communities*, Chapter 23.

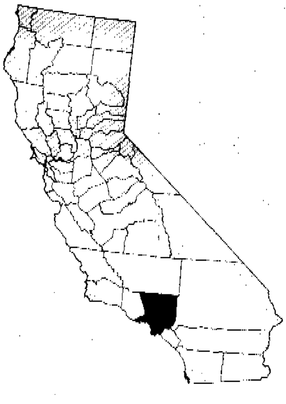
plies thereafter. The ability of the basin to refill to capacity between draw-down periods indicates that drawing down supplies has not resulted in any permanent loss in storage capacity.

When it became clear that upper basin replenishment was not sufficient to stem the salt water intrusion, the District turned to an innovative physical solution, and the seawater intrusion barriers at Alamitos and Talbert have been successful in maintaining a freshwater barrier at the coast. With the facilities now well over 25 years old, the District must plan for capital improvements to the barriers to maintain their effectiveness. They have begun showing signs of wear, such as increased leakage and lower capacity for injection.

Institutionalizing the pump tax was a vital part of the District's success, providing a regular means for funding imported water purchases for injection and replenishment. It had the additional quality of equitably sharing the costs among the groundwater users who benefit.

The need to reliably fund the projects also produced some other innovative financing mechanisms. The development of the basin production percentage and the basin equity assessment added a demand-side management component to the pump tax. The District was now able to signal to pumpers the desired amount of pumping, creating a disincentive to pump above the BPP.

Water recycling was driven by the potential to create a drought-proof supply for injection activities and to reduce dependence on imported supplies. The program has grown from Water Factory 21 (an average of 10,000 acre-feet per year of recycled water) to include the Green Acres Project (7,800 acre-feet per year) and plans for a 100,000 acre-feet regional recycling project.



Central and West Coast Basins

Introduction

The Central and West Coast Basins underlie part of southern Los Angeles County. Groundwater management for the basins is a complex set of activities undertaken by several agencies. Groundwater users organized to create a forum for collective action. Court adjudication of both basins established transferable water rights and pumping limits as well as a watermaster to ensure compliance. The West Basin and Central Basin Municipal Water Districts were formed primarily to acquire and manage supplemental sources to meet the demand for water that exceeded the basin yields. The Water Replenishment District finances the purchase of water for recharge and basin water-quality protection activities, and the Los Angeles County Department of Public Works carries out the recharge operations. Today, the basins provide groundwater for residents and businesses in 43 cities, supplying 40 percent of the water needs of nearly four million people (WRD 1998). The remaining water supply consists of surface deliveries, and more recently, recycled water.

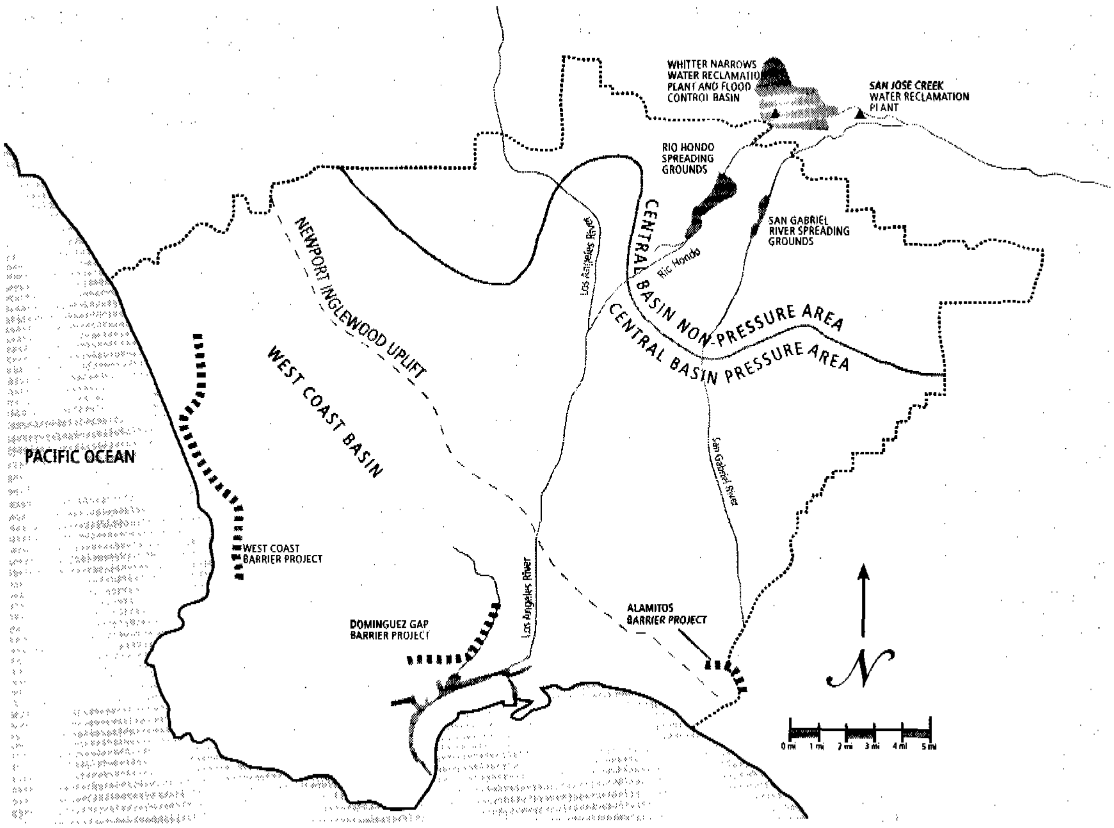
Background

Basin Hydrogeology

The Central and West Coast Basins underlie a 420 square-mile stretch of the Coastal Plain of Los Angeles. The basins are separated by the Newport-Inglewood Fault zone (or Uplift), marked on the surface by low lying hills that run from the city of Long Beach to the Baldwin Hills north of the city of Inglewood. Central Basin underlies a 277 square-mile area northeast of the Newport-Inglewood Uplift, which forms one boundary. At the tip of the basin is the Alamitos Gap, where the San Gabriel River flows into the Pacific Ocean. The basin is crossed by two other surface streams. The Rio Hondo parallels the San Gabriel River, and also enters at Whittier Narrows and runs southwest to join the Los Angeles River about midway in the basin. The Los Angeles River enters the Central Basin through the Los Angeles Narrows and flows south across the basin through the Dominguez Gap to the ocean.

The basin is made up of several shallow aquifers and three large deeper ones. Total groundwater storage is estimated to be over 13 million acre-feet (Blomquist 1992). The basin is divided into a non-pressure and pressure area. The pressure area, covering the southern half of the Central Basin, and including the West

Figure 27-4
Map of the Central and West Coast Basins



Source: Adapted from WRD map

Basin, is covered by an impermeable layer of clay, preventing rainfall and surface flow from recharging the basin. The non-pressure area lies along the northern boundary covering the Los Angeles and Montebello Forebays. The Los Angeles River channel and forebay area have been lined and paved over for development and cannot receive surface recharge. Thus, the basin receives most of its recharge from the percolation of surface and subsurface inflow at the Montebello Forebay, just below Whittier Narrows. Here, the San Gabriel River channel remains unlined, and the county has maintained two offstream spreading grounds along both the San Gabriel and Rio Hondo Rivers.

The West Coast Basin (West Basin) is bounded by the Newport-Inglewood Uplift on the east. The western and southern boundaries are the coasts along the Pacific Ocean and San Pedro Bay respectively. The basin extends for 170 square miles, and storage capacity is estimated at 6.5 million acre-feet (Blomquist 1992).

Given the hydrogeology of the two basins, both the pressure area of the Central Basin and the entire West Coast Basin rely on subsurface flows for recharge. Only in the forebay area of the Central Basin do soil conditions allow for surface recharge. As was the case with Orange County and the spreading operations on the Santa Ana, the basins are highly reliant on the recharge that takes place in the Montebello Forebay area. Further, gaps along the west coast, the Dominguez and Alamitos, allow salt water to intrude inland if basin levels fall below sea level.

The Problem

Both the West and Central Basin regions were initially developed for agriculture. As the region urbanized and populations increased, groundwater overdraft rapidly became a problem. Urbanization not only paved over natural recharge areas, but wastewater was dumped into the ocean rather than used to recharge the basin. By 1950, both basins were experiencing severe overdraft. Water elevations had dropped well below sea level along the coastal regions, and salt water was filling both basins. By the late 1950s, a "front" of salt water had moved two miles inland along the southern coast at the Dominguez and Alamitos gaps, and seawater had intruded one to two miles inland along the Santa Monica Bay. By 1959, the West Coast Basin had an accumulated overdraft of over 800,000 acre-feet, and one-half million acre-feet of salt water had intruded into the basin (Blomquist 1992). The basin was declared "one of the most critically overdrawn ground water sources in southern California" (DWR 1959). In the Central Basin, overdraft totaled about 1 million acre-feet, about 10 percent of the basin's storage capacity, and seawater had begun to flow up the gap at the southern tip of the basin towards the major aquifers (Blomquist 1992).

These problems led to the development of several institutions to deal with the severe groundwater overdraft problem.

The Project

Institutional Goals

In the West and Central Basins, different aspects of groundwater management are addressed by different institutional mechanisms:

- Groundwater users formed formal associations to represent their interests and were an integral part of early efforts to create public agencies to address groundwater needs.
- Courts adjudicated groundwater rights and pumping rates in each basin to limit and monitor groundwater pumping.
- The West Basin and Central Basin Municipal Water Districts were formed primarily to acquire and manage supplemental sources to meet the demand for water that exceeded basin safe yields.
- The Water Replenishment District was created to finance and manage the purchase of water for recharge and water-quality protection activities.
- The Los Angeles County Department of Public Works has responsibility for the actual operation and maintenance of recharge and injection activities.

Together, these different institutions address the issues of preventing groundwater overdraft, protecting the basins from salt water intrusion, resolving other water-quality issues, and improving overall management of the basins' resources.

Program History and Description

Groundwater users organize

Groundwater users in both basins organized early to begin to address the overpumping and resulting overdraft and seawater intrusion problems. The West Basin Water Association (WBWA) was formed in 1946 with 20 charter members representing coastal cities, oil companies, and private water companies. Both membership dues and voting rights were weighted according to groundwater withdrawals. These two factors worked to provide incentives to not over- or understate the amount of water being withdrawn. The Central Basin Water Association (CBWA) was formed in 1950, structured and funded similarly to the West Basin Water Association. The 17 original members of the CBWA accounted for about one-half of the basin's groundwater extractions. The associations offered groundwater users a forum in which to organize and come to consensus about actions to be taken. Both associations played important roles in later establishing water districts to purchase supplemental water, supporting adjudication of the basins, and establishing the replenishment district and other funding mechanisms.

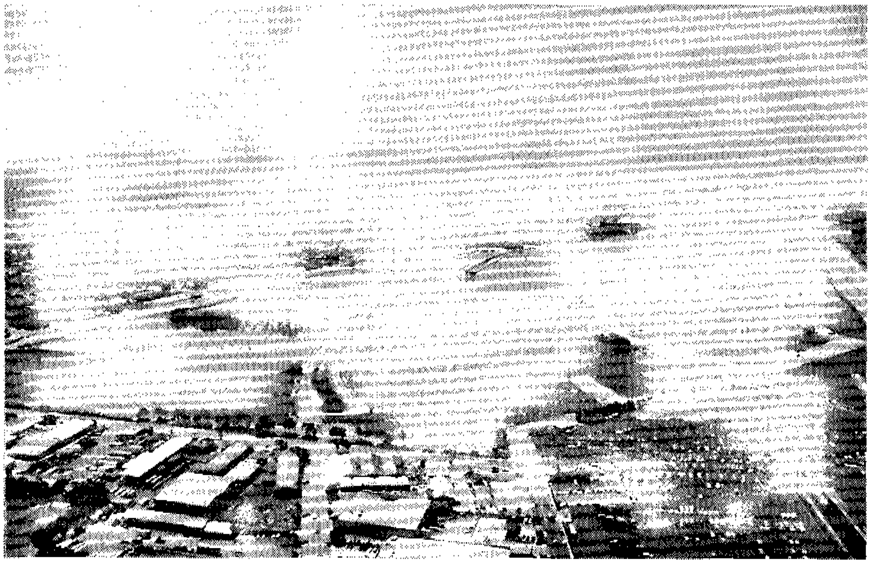
Securing supplemental sources and limiting groundwater extractions

The first strategy undertaken by each basin was an effort to acquire supplemental surface supplies to relieve overdraft. Users in each basin worked to establish water districts to purchase surface water from the Metropolitan Water District (MWD). West Basin Municipal Water District (WBMWD) was formed in 1947 and became an MWD member agency in 1948; Central Basin Municipal Water District received voter approval in 1952 and joined MWD in 1954. This supplemental water supply, while helpful, was not enough to stem overdraft, however, and both basins next turned to court adjudication to limit pumping levels. West Basin adjudication began in 1946 and was concluded in 1961. Central Basin undertook adjudication of its own basin in 1961 and concluded by 1966.

In the West Basin, the California Water Service Company, the Palos Verdes Water Company, and the city of Torrance joined as plaintiffs to file a complaint to seek adjudication and limitation of groundwater rights in the basin. In 1952, a draft referee report by the court found that continuous overdraft in West Basin had begun in 1920 and worsened over the years. The report recommended that groundwater pumping be limited to 30,000 acre-feet per year, with adjustments as basin conditions warranted. This would have required a reduction of pumping levels by two-thirds. The referee report and the dire cutback it recommended motivated the parties to reach their own settlement. By 1954, the parties drafted an interim agreement to reduce pumping by 25 percent. Water rights would be based on prescriptive rights established in 1949. In 1961, a final stipulation was issued by the court after bringing the remaining groundwater producers into the settlement and preventing new pumpers from gaining prescriptive rights. Ninety-nine parties were granted transferable adjudicated rights, and total extractions were limited to 64,468 acre-feet.

Prior to the adjudication of its own basin, the Central Basin engaged in the adjudication of a neighboring basin, the San Gabriel Valley Basin. The two basins are hydrologically linked with subsurface flows from San Gabriel Valley Basin to the Central Basin through Whittier Narrows. Increased pumping by upstream users in San Gabriel Valley had decreased the flow through the Narrows into the Central Basin. In 1959, Central Basin Municipal Water District joined the city of Long Beach in an action against upper basin water users north of Whittier Narrows. The final judgment in 1965 identified a guaranteed flow amount to be delivered to lower area users. The amount of the entitlement each year depends on rainfall conditions in the San Gabriel Valley. The amount actually delivered must be accounted for and compared to the entitlement figure. The judgement defined usable and unusable water for accounting purposes, and set up institutional mechanisms for accounting for the water, as well as credits for deliveries above the agreed-upon amount, and "make up" water for years with lower deliveries.

Central Basin users undertook adjudication of their own basin in 1961 when it was clear that additional surface water supplies were not sufficient to stop overdraft. The newly formed replenishment district, founded in 1959, served as the plaintiff, filing suit against 750 well owners in the Central Basin. The plaintiff argued that continued overpumping had lowered water levels below sea level in 80 percent of the basin and damaged all basin users by increasing



Rio Hondo spreading grounds in the Montebello Forebay (Photo courtesy of Los Angeles Department of Public Works) pumping costs and by allowing salt water to intrude into the basin. The plaintiff sought an adjudication of rights and control and reduction of groundwater extractions. The settlement committee worked to create a formula for determining prescriptive rights and a pumping allocation. By 1964, the committee had worked out a stipulation for judgment that the court accepted. The judgment set forth an annual pumping allocation totaling 217,367 acre-feet and established an exchange pool for the transfer of rights.

Artificial replenishment

In both West and Central Basin adjudications, pumping limits were set above the sustainable yield of the respective basins, and thus each required additional action to protect basin supplies. The focal point for replenishment activities was spreading and percolation at the Montebello Forebay. The Los Angeles County Flood Control District (LACFCD) has spread floodwaters in the Montebello Forebay since 1938. Looking to increase those activities, the groundwater users in both basins worked to obtain an amendment to the county's flood control act to allow for the establishment of conservation zones to serve as special taxing districts to finance groundwater recharge projects. From 1953 to 1961, the LACFCD purchased and spread imported MWD water at the Montebello Forebay, funded by an *ad valorem* tax rate of two cents per $100 of assessed valuation of property for residents of both basins. However, substantially more water was required to replenish supply, and it became necessary to develop an institutional mechanism for purchasing and controlling imported water for regular basin recharge.

The other major protection measure needed was to stem the seawater intrusion problem. The West Basin Water Association successfully appealed to the state to finance a mile-long prototype injection barrier in the Manhattan Beach area (Blomquist 1992). LACFCD was contracted to install and operate the prototype. In 1953, LACFCD began injecting imported water into a series of nine injection wells approximately 500 feet apart and parallel to the coast about 2,000 feet inland. The injection of fresh water raised the water table in those areas, creating a freshwater barrier to prevent further salt water intrusion. However, 10 miles of exposed coastline remained. Funding for supplying the prototype with fresh water was accomplished through yet another special *ad valorem* tax on property owners in the West Basin. Substantially more funds were needed to construct and maintain additional facilities.

The Water Replenishment District was created in 1959 to establish an institution that could fund and manage a replenishment program for both basins. District formation was approved through a special election and received 4-to-1 voter support (Blomquist 1992). It was authorized by the California Legislature's Water Replenishment District Act passed in 1955. The Act allowed seven Southern California counties to create districts to raise funds for groundwater replenishment operations. The newly formed district opted to levy a pump tax on every groundwater pump, following the example of the Orange County Water District. Rates are set each year to cover the anticipated costs of purchasing water for replenishment activities. Imported water must be purchased from the Metropolitan Water District via the Central or West Basin Municipal Water Districts. Recharge activities carried out at the Montebello Forebay and injection at the three seawater barriers, however, continue to be operated by the county Department of Public Works (formerly the Los Angeles County Flood Control District). Injection activities were found to have recharge benefits as well, offering the pressure areas an additional source of recharge.

Current Groundwater Management Activities

This section briefly describes the activities undertaken by the Water Replenishment District (WRD). Since the early 1990s, WRD has been taking an increasingly active role in managing and protecting basin resources. Its principal missions are replenishing the groundwater basin, halting salt water intrusion, and assuring quality groundwater for area residents (Community Report 1993).

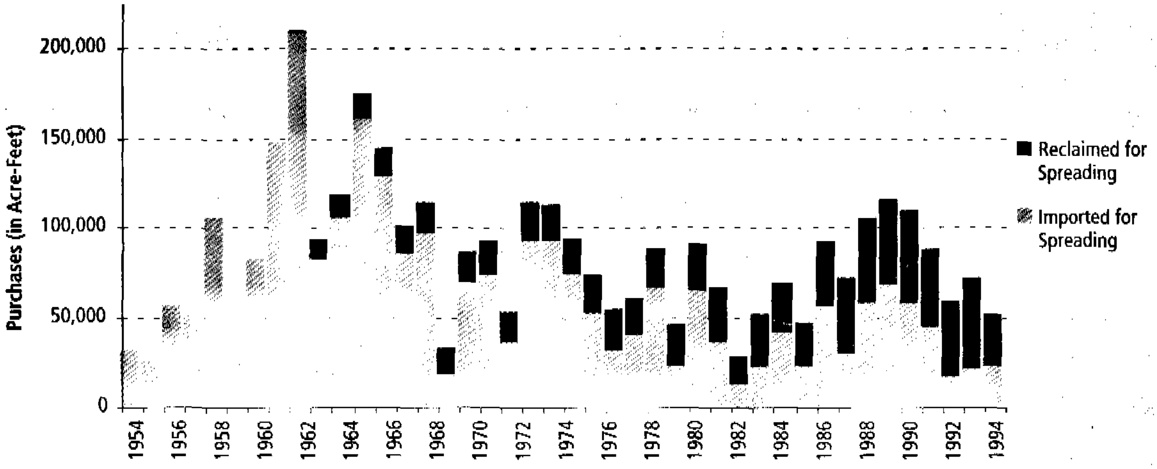
Replenishment Activities

In acquiring water for replenishment activities, WRD has continually sought alternatives to using costly imported water. WRD currently undertakes three main programs to replace imported water: increasing capture and use of local surface water runoff, maximizing use of recycled water, and supporting in-lieu recharge through purchase of less expensive, seasonally-priced, imported water.

Increasing the use of local surface water runoff involves working with various flood control and conservation agencies to identify ways to increase the capture of storm runoff while maintaining flood protection. Existing dams and reservoirs along the San Gabriel River capture nearly 90 percent of storm runoff for later use. However, 95 percent of the stormwater runoff from the Los Angeles River is lost to the sea. The District is working with both the Los Angeles River Storm Water Task Force and the U.S. Army Corps of Engineers to identify opportunities for additional storage.

WRD has used recycled water for its spreading operations since the 1960s (see Figure 27-5). Its use of recycled water is regulated by the Regional Water Quality Control Board, which has limited spreading to the lesser of 60,000 acre-feet per year or 50 percent of the total inflow into the Montebello Forebay for that year. Further, the board's order stipulates that the three-year running average cannot exceed 50,000 acre-feet—or 35 percent of the total inflow into the forebay. The District currently purchases its recycled water for spreading from two sources, the Whittier Narrows Water Reclamation Plant and the San Jose Creek Water Reclamation Plant. Both facilities treat wastewater to tertiary standards to meet discharge requirements. The District has negotiated to purchase this water for minimal fees. In 1997 the cost was expected to be $7.00 per acre-foot and $15.36 per acre-foot, respectively, from the two facilities.[13] This is far less costly than imported water, which was estimated at $244 per acre-foot in 1997.[14] WRD continues to maximize its use of recycled water for spreading as guided by the Regional Water Quality Control Board. It is working with the Los Angeles Coun-

Figure 27-5
Water Purchased for Spreading Operations, 1954–1995



Source: WRD Annual Survey and Report 1997

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[13] The fee paid the San Jose Creek Water Reclamation Plant reflects the additional treatment required (removing chlorine residual) for open-stream discharge into the San Gabriel River.

[14] This is the seasonal rate for untreated water. Seasonal water is made available as excess supplies permit during the October–May wet season.

ty Department of Public Works to study ways to improve the operation of the facilities to completely capitalize on the availability of free local stormwater and fully utilize the District's permitted amount of recycled water.

The District began using recycled water in its injection activities in 1995. Treatment requirements for injection are higher than for spreading, requiring advanced treatment beyond tertiary standards. Recycled water for injection at the West Coast Basin Barrier is purchased from the WBMWD's West Basin Recycling Plant. WBMWD has priced its recycled water lower than its imported water price—recycled water in 1998 is approximately $430 per acre-foot, which is less than the $528 per acre-foot cost of imported water.[15] This contributed 5,000 acre-feet per year to the West Coast Basin Barrier Project, and increased to 7,500 acre-feet in 1997.

The In-Lieu Program was established in 1965 with a pilot program involving one pumper. The pumper purchases surplus water from MWD, and WRD offers a payment to the pumper to offset the difference in cost between the purchase and pumping the same amount of groundwater (about $120 per acre-foot). In exchange, the pumpers agree to retire those unused pumping rights for that fiscal year. Thus groundwater remains in the basin through in-lieu recharge. When MWD restructured its pricing policy to make more surplus and interruptible water available at a lower price, the program expanded. High participation by pumpers near the coasts has had the additional benefit of reducing the need for more expensive injection at the barriers. More recently, the District has attempted to use the program to influence geographic pumping patterns and not just reduce pumping basin-wide. In the 1997–1998 water year, the in-lieu program was limited to those specific areas where it would be most beneficial to reduce pumping, rather than being offered basin-wide. The District provides in-lieu participation to pumpers in areas that are not easily recharged by the forebay activities, namely the Central Basin pressure area and West Basin.

Difficulty implementing this program arises primarily from perceptions of equity and the selection of the appropriate incentive level. Pumpers were concerned that limiting the program to certain geographic areas could affect the value of pumping rights in the lease market by decreasing the value of pumping rights in areas that could not participate in the program. Extensive discussions with pumpers have largely alleviated this fear. Choosing a single incentive level has created some difficulty in targeting participation since pumping and imported water costs will vary. Pumping costs will depend largely on water table conditions, and imported water costs will depend on who the purveyor is. Attempts to create a tier system of incentives have met with resistance from pumpers, who are concerned with equity issues and impacts on the value of pumping rights in the lease market. Thus, while this program is a valuable management tool, it is currently limited by these constraints.

Water-Quality Protection

The District's second major function is to protect basin water quality. Its activities include source control programs, clean up, and monitoring. There are two major sources of contaminants that are being carefully monitored. One is the migration of contaminants from the neighboring San Gabriel Basin.[16] The second major contaminant source is approximately 240,000 acre-feet of salt water that was trapped inland when the West Basin seawater barrier was established. This saline plume contaminates about 10 percent of the basin. Both these sources represent potential long-term threats to basin water quality, and the District continues to monitor their progress and consider alternatives to eliminate the contamination. Currently, there are plans for saline water desalters in the plume area to begin removing the contaminated water. The District has also undertaken an aggressive investigation of potential sources of contamination, to prevent their entry into the basin. These potential sources include leaking underground storage

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[15] WBMWD's Water Recycling Program is partly funded by a surcharge on imported water. Thus, despite the fact that WRD is paying lower recycled water charges, they are also paying higher imported water charges for WBMWD water purchased.

[16] In 1984, four large areas of groundwater contamination in the San Gabriel Basin were declared Superfund sites.

tanks, defense fuel storage sites, Los Angeles International Airport, and hazardous waste sites.

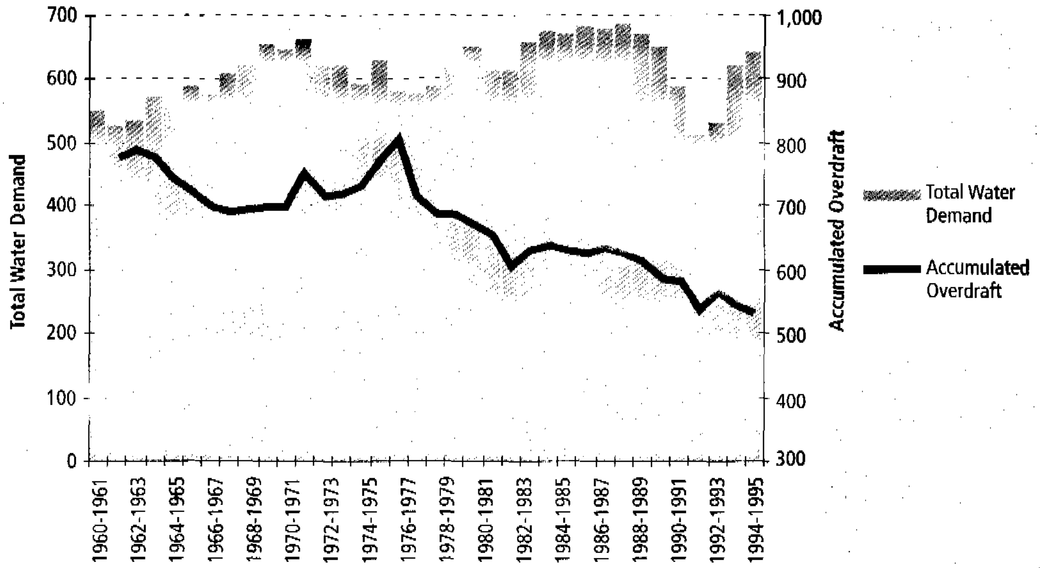
The primary cleanup challenges are the saline plume and VOCs. VOC clean up is largely accomplished by pumping the contaminated water and treating it to remove the contaminants. This prevents further spreading of the contaminants and allows abandoned wells to re-open. The District supports two programs to assist clean up of VOCs: a wellhead treatment program to assist cities or agencies in building treatment plants in severely contaminated areas; and a rebate program to encourage pumpers to clean up moderately contaminated well sites by offering a $25 rebate per acre-foot of treated water.

Evaluation of Success

Faced with well over one million acre-feet of overdraft between the two basins, and seawater intruding into each, residents in both basins successfully took action to halt these threats. No single action was enough, but a combination of institutional structures has allowed the basins to meet the needs of their growing communities without compromising future use.

Total water use for the two basins increased from 551,200 acre-feet in the 1960–1961 water year to 643,234 acre-feet in the 1995–1996 water year. Over that same period, accumulated overdraft decreased by 245,200 acre-feet (see Figure 27-6). The excessive groundwater pumping from the basin was mitigated by the establishment of pumping limits, identification of the supplemental surface waters, and replenishment activities. Replenishment activities, in fact, increase the sustainable yield of the basins. Creation of the replenishment district created the institutional structure necessary to acquire a regular supply of water for replenishment and protection activities. As mentioned previously, adjudicated limits were set above the sustainable yield of each basin, and thus replenishment activities have allowed the basins to maintain pumping at adjudicated levels without increasing overdraft. In fact, in recent years, pumping levels have actually been below the adjudicated limits, largely due to participation in WRD's in-lieu program. Thus, WRD's replenishment activities have helped prevent annual overdraft and have reduced accumulated overdraft (see Figure 27-6).

Figure 27-6
Total Water Demand and Accumulated Overdraft (in Thousands of Acre-Feet)



Source: WRD Annual Survey and Report 1997

With the expense of imported water and increased concerns about reliability, WRD continues to search for other sources for its replenishment activities. One manifestation of this is the increased use of recycled water. WRD has used recycled water for spreading operations since the 1960s and more recently has begun using recycled water for injection activities. Further studies of impacts on water quality may allow for a change in regulations to allow greater use of recycled water for spreading. The use of recycled water for injection activities is primarily limited by its cost, which is high compared to purchasing imported water.

When the various institutions were created, the most pressing threat to basin water quality was salt water intrusion. The injection barriers provided a technical solution, and the replenishment district offered the institutional mechanism to maintain adequate supplies for injection. With the barriers in place, the ongoing intrusion problem was effectively halted, but a plume of salt water was trapped inland. WRD is still dealing with this major source of contaminants as well as monitoring for potential contamination from neighboring San Gabriel Valley Basin. In addition, the District works aggressively to identify and prevent other sources of contamination, as described above. Cleanup programs have made progress removing contaminants from the basins. The Wellhead Treatment Program will clean critically- contaminated wells, and the rebate program has treated over 4.5 billion gallons of water in its first six years.

From an equity standpoint, the institutions created allow costs to be borne largely by the water users. The West Basin and Central Basin Municipal Water Districts finance supplemental surface supply primarily through water rate charges. The watermaster costs related to adjudication in both basins are paid for by the parties remaining in the suit, proportional to their groundwater use. The Water Replenishment District finances its activities through its pump tax. An exception to the "user pays" principle was the capital costs for the barrier infrastructure. These costs were largely funded by taxing property owners in specially designated conservation zones. Thus, in this case, costs were spread over the basin residents and not the water users directly. In addition, county taxes also pay for Los Angeles County Department of Public Works operation and maintenance costs for the spreading and barrier operations.

Because groundwater basins and surface water systems are interconnected, it is not surprising that institutions governing the different systems also overlap. Rather than working independently, the West and Central Basin institutions coordinate their activities—the two municipal water districts, the Water Replenishment District, which serves both basins, the watermaster, and the Los Angeles County Department of Public Works. WRD is also working to improve communications with groundwater users to allow for greater participation in the District's policy making. The recent expansion of the WRD programs (and increased groundwater assessments to fund those programs) in the 1990s has raised some concerns among groundwater users. The interconnectedness of water systems is also reflected in cooperative agreements the Central and West Basins have established with the San Gabriel Valley and Orange County Water Districts. Regulatory agencies such as the Regional Water Quality Control Board and the Department of Health Services will have tremendous impact on operations with respect to rulings on recycled water and other water-quality requirements. Agencies have thus placed great emphasis on working cooperatively and constructively with both regulatory organizations.

In spite of what could be perceived as a rigid court adjudication, the agencies have shown flexibility and adaptability in addressing new problems. In 1984, West Basin users amended the court judgment to allow for "nonconsumptive water rights." This has allowed users to engage in cleanup activities that involve intensive pumping over short periods in excess of adjudicated rights. After treatment, the water is returned to the basin. Another example is the increased emphasis on water-quality protection. In 1990, the WRD gained well-defined authority to clean up, contain, and prevent groundwater contamination through legislation supported by agencies and pumpers. This allowed the District to levy pump assessments to fund water-quality programs. The In-Lieu Program evolved in recognition of the need to continue to find new ways to recharge the basin and influence pumping patterns.

Conclusion/Lessons Learned

Increasingly, localities are recognizing the importance of supporting groundwater management to ensure the productivity and future protection of the basin. The high activity surrounding the AB 3030 management plans is one example. OCWD and the Central and West Basins have pioneered many institutional structures and technologies that have served as a guide for others in their groundwater management efforts. OCWD was one of the first groundwater replenishment districts in the state, the first to institute a pump tax for its replenishment activities, and a leader in using recycled water for groundwater injection. The Central and West Basins were leaders in using recycled water for planned recharge. West Basin developed the injection barrier prototype that would serve other California coastal communities with salt water intrusion problems.

Despite the differences in basin conditions and the institutional structures each adopted, there are similarities in some of the factors contributing to success. In both cases, the critical nature and urgency of the problems helped spur collective action. There was an early emphasis on monitoring and collecting data on the basin. Management strategies reflected the need to coordinate activities with other agencies and actors. Basin strategies evolved to address multiple problems, and agencies demonstrated flexibility in adapting strategies to changing conditions. Again, adequate monitoring and understanding of the basin was key to this adaptive approach.

In all three basins, the critical condition of each basin compelled groundwater users to organize. The basins were also urbanizing rapidly and most groundwater use had become concentrated in a small number of large institutional users. Faced with the consequences of continued unsustainable use of the basins, groundwater users took the lead in establishing the institutions necessary to protect the basin and their continued productive use of the resource, despite the fact that it meant ceding some control to a new institution.

One of the first steps users in each basin took was collecting data and monitoring activities and impacts on the basin to better understand the problems they faced. Monitoring of groundwater use, groundwater levels, and groundwater quality continues to be vital for sound analysis, planning, and effective management, and the various institutions created to manage groundwater supplies maintain such data gathering and monitoring as a central purpose. This has allowed the agencies to identify potential problems, monitor success, and adjust strategies as necessary. After aggressively pursuing one strategy, an agency can assess its success and adopt another if necessary.

The various agencies undertook a wide variety of strategies that ultimately combined to achieve successful management. No single strategy was sufficient, and management improved as the various strategies in combination addressed the assorted problems of overdraft and contamination. Pursuit of these various strategies always recognized the interconnections between groundwater and surface water, upstream and downstream users, and different basins. The Central and West Coast Basins sought to increase surface supplies, limit groundwater pumping through adjudication, improve replenishment activities of local and imported surface waters, and create additional incentives to impact pumping activities. OCWD also pursued a supply-side solution of increasing surface supplies and aggressive replenishment. It also sought to influence groundwater use through pricing incentives. All three basins eventually turned to seawater barrier injection when it was clear replenishment at spreading grounds would not effectively raise groundwater levels at the coast. Throughout, the agencies worked in concert with other actors—user associations, replenishment districts, water agencies, neighboring basins, and various regulators.

With limited surface supplies, the three basins also promoted the use of recycled water in replenishment activities and later, barrier injection. Recycled water for recharge was largely driven by its lower costs and abundant supply. Recycled water for use in barrier injection was driven by its reliability, even during times of drought, and is becoming increasingly attractive as treatment costs are reduced. As proponents for expanded recycled water use, both OCWD and WRD have placed a priority on continuing research to make recycled water use more cost-effective and to study its impacts on groundwater basin quality.

Finally, even as agencies work to correct the overdraft problem, their recent focus has been protecting against and correcting contamination of the basin. Again, capacity to carry out a monitoring program is paramount. And while each district has developed treatment programs for identified contaminants, emphasis is being placed on prevention. Identifying potential sources of pollutants and reducing known sources has required cooperation and coordination with regulatory agencies, businesses, and individuals. The more difficult problem of nonpoint source pollution has led to participation in broader watershed activities.

Contacts

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References

Blomquist, W. 1992. *Dividing the Waters: Governing Groundwater in Southern California*. San Francisco, CA: ICS Press.

California Department of Water Resources. 1994a. *California Water Plan Update. Bulletin 160-93*. Sacramento, CA.

California Department of Water Resources. 1994b. *General Comparison of Water District Acts. Bulletin 155-94*. Sacramento, CA.

California Department of Water Resources. 1996. *Water Facts*. (Numbers 2–6.) State of California. The Resources Agency.

California Department of Water Resources. 1997. Materials published on website. *www.dpla.water.ca.gov/cgi-bin/supply/gw/main.pl (www.dwr.water.ca.gov)*

Garcia, M. 1997–1998. Water Replenishment District of Southern California. Cerritos, CA. Personal communications.

Herndon, R. 1997–1998. Orange County Water District. Fountain Valley, CA. Personal communications.

Kennedy, J. 1997. Orange County Water District. Fountain Valley, CA. Personal communications.

Orange County Water District (OCWD). 1996. *1995-96 Annual Report*. Fountain Valley, CA.

OCWD. 1994. *The Groundwater Management Plan*. Fountain Valley, CA.

OCWD. 1991. *Groundwater Management Plan 1991 Update*. Fountain Valley, CA.

Sperry, M. 1997. Water Replenishment District of Southern California. Cerritos, CA. Personal communications.

Water Replenishment District of Southern California (WRD). 1998. *Groundwater Management Plan*.

WRD. *Annual Survey and Report on Groundwater Replenishment*. For the years 1997 and 1998.

WRD. 1994. *1993–1994 Community Report*.

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Legal Protection for Rivers: the State and Federal Wild and Scenic Rivers Acts

Lisa Owens-Viani

Introduction

With the exception of the Yellowstone River in Montana, all rivers longer than 1,000 kilometers in the contiguous 48 states have been severely altered for hydropower, water management, or navigation (Benke 1990). Large-scale damming, diverting, dredging, and other modifications of our waterways for flood control, water supply, navigation, and electricity[1] began in the early 19th century and accelerated in the 1930s. On California rivers alone there are over 1,200 dams; at least 150 of these are of considerable size (Simon 1994).

In the past three decades, however, interest in and knowledge of the negative impacts of dams and other human interventions on the ecology and biota of rivers and streams have greatly increased, and many river and stream conservation groups, from the local to the national level[2] have become active in efforts to protect waterways (see *Restoring Riparian Forests, Improving Passage for Spring-Run Salmon, Watershed Management Above the Dams,* and *Restoring Urban Streams* (Chapters 20–24)). As public support for restoring and preserving waterways grew, so did formal, legislative efforts to protect them. In passing the National Wild and Scenic Rivers Act in 1968, Congress made a conscious effort to balance development of rivers with conservation of these valuable natural resources. California passed a similar act in 1972.

The majority of the country's Wild and Scenic-designated rivers (outside of Alaska) are in California and Oregon. While most free-flowing river systems in California were altered in the early part of this century, California still possesses many *sections* of rivers that have not been dammed or altered. Threats to those and other waterways led to passage of the National Wild and Scenic Rivers Act and the California Wild and Scenic Rivers Act, which protect rivers once they are designated for inclusion under these Acts (and during the process of designation). This case describes the California rivers and streams protected and the different levels of protection offered them under the Acts.

As of 1998, over 1,900 miles of California rivers and streams are protected under the federal Act and 1,344 miles under the state Act. These rivers are treasured by environmentalists, white-water enthusiasts, millions of California residents, and visitors from around the country and world.

Background

The National Wild and Scenic Rivers Act of 1968

In 1968, Congress passed the National Wild and Scenic Rivers Act, declaring that the

> *"established national policy of dams and other construction at appropriate sections of the rivers of the United States needs to be complemented by a policy that would preserve other selected rivers or sections thereof in their free-flowing condition to protect the water quality of such rivers and to fulfill other vital national conservation purposes."* *(P.L. 90-542)*

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[1] Most of these projects were constructed by the three large federal water management agencies—the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the Tennessee Valley Authority.

[2] A 1986 study by the non-profit American Rivers organization found that over 269 local and state groups and 24 at the national level were involved in efforts to protect the nation's rivers.

The Act protects eligible rivers in their free-flowing states and prohibits federal agencies from constructing, authorizing, or funding the construction of water resources projects that would directly and adversely affect the values for which a river is designated. To be eligible for inclusion, a river must possess "outstanding, remarkable, scenic, recreational, geologic, fish and wildlife, historic, cultural, or other similar values" (Palmer 1993).

The National Wild and Scenic Rivers Act establishes three classifications for designated rivers, based on the amount of development that exists within a river's corridor:

Wild Rivers: Rivers or sections of rivers free of impoundments and generally inaccessible except by trail, with watersheds or shorelines that are essentially primitive and have unpolluted waters.

Scenic Rivers: Rivers or sections of rivers free of impoundments, with shorelines or watersheds still largely primitive and shorelines mainly undeveloped, but accessible in some places by road.

Recreational Rivers: Rivers or sections of rivers that are easily accessible by road or railroad and that may have undergone some development along their shorelines or even some diversion or impoundment in the past.

As long as a proposed river segment flows freely (without large impoundments or substantial channelization or diversion projects) and possesses values that fall under one of the above categories, it is eligible for designation. The existence of "low dams, diversion works, and other minor structures" does not automatically bar a river from consideration (Curtis 1992). Urban rivers—such as California's lower American River—are most often included under the Recreational category; however, the majority of rivers given federal protection are not urban. After a river is designated, the managing federal agency develops a plan for guiding the agency's activities in the river corridor, which encompasses an area of approximately one-quarter mile on either side of a river. The management plan is to be the blueprint for protecting the river's "free flowing character, outstanding values, and classification status" (Friends of the River (FOTR) 1997). A river may be designated as part of the system even if it flows through private lands; new dams are prohibited once the river has been designated. However, many of the law's protective standards apply only to federal agencies and activities on federal public lands. The Act does not prohibit development on private property adjoining a river. On average, about one-third of the land surrounding designated rivers is privately owned (Watanabe 1988). Federal agencies are only specifically required to prepare management plans for rivers designated after 1986, when the Act was amended to include such a requirement. In 1991, the Forest Service and the Bureau of Land Management (BLM) adopted detailed guidelines for determining the types and intensity of activities they will allow in river corridors (Frost 1992–1993).

Federal Agencies Responsible for Rivers

Managing agencies include the **National Park Service**, the **Bureau of Land Management**, the **U.S. Forest Service**, and the **U.S. Fish and Wildlife Service**. In 1993, these agencies formed the Interagency Wild and Scenic Rivers Coordinating Council, the goal of which is to improve interagency coordination in addressing concerns about rivers in the system and to suggest potential additions from the National Rivers Inventory and state-designated rivers, as well as to offer technical assistance to other governments and non-profit agencies *(http://www.nps.gov/rivers/wildriverscouncil.html)*.

Listing Process

A river can be listed through one of three processes:

1. Congress can, at its discretion, direct a federal agency to study a particular river (this happened with California's Tuolumne and Kern Rivers);

2. Federal agencies can initiate studies of rivers and are required (under Section 5(d) of the Act) in the course of their land

management activities to consider rivers for listing (the 280 rivers currently listed as "eligible" in California were identified this way);[3]

3. Under Section 2(a)(ii) of the Act, state governors can ask the Secretary of the Interior (as former Governor Jerry Brown did in 1981) to add state-listed rivers to the national system.

When either of the first two methods is used to list a river, the federal agency involved must complete an Environmental Impact Statement (EIS) before making a formal recommendation to the Department of Agriculture. From the Department of Agriculture, the recommendation is sent to the President, and then to Congress. This process can sometimes take four to five years to complete, at a cost of between $100,000 and $200,000 (Evans 1998). However, Congress can set deadlines by which the federal agency involved must complete an EIS; it can also allocate funding for the study. Although the listing process can be slow, rivers are protected under the Act while they are being considered.

The State Wild and Scenic Rivers Act of 1972

By the late 1950s, dams had been proposed for almost every California river. Although some of those dams were built, in 1972 California established its own Wild and Scenic Rivers system (see Public Resources Code Section 5093.50 et seq.), declaring that specified rivers possessing extraordinary scenic, recreational, fisheries, or wildlife values should be preserved in their free-flowing states for the benefit of the people of California. It declared preservation the highest and most beneficial use of the rivers under Article X, Section 2 of the California Constitution (DWR 1994). Segments of the Smith, Klamath, Scott, Salmon, Trinity, Eel, Van Duzen, and American Rivers were included in the original State Wild and Scenic Rivers Act, and segments of the East Carson River and West Walker River were added in 1989.

Protecting North Coast Rivers

In the California Department of Water Resources' Water Plan for 1957, massive projects were proposed for the Klamath, the Trinity, and the Eel. These projects would have diverted more water from those rivers, taken it under the Coast Ranges in tunnels, and then sent it south (Evans 1998). Already, the Trinity had the Trinity and Lewiston Dams (built in 1960 and 1963), the Klamath the Copco I and II Dams (built in 1922 and 1925) and the Iron Gate Dam (built in 1962), and the Eel the Van Arsdale (built in 1907) and the Benbow (built in 1932) on the South Fork, and the Scott on the main stem (built in 1921).

The Klamath is the state's second longest and largest river and one of the nation's finest steelhead rivers. It also has the second longest free-flowing stretch of river on the West Coast (Palmer 1993). The Trinity supports trout, salmon, steelhead and white sturgeon in its lower reaches (Palmer 1993). When he listed the Trinity, Interior Secretary Cecil Andrus also ordered the release of 300 cubic feet per second in the Trinity year round. Although these releases improve conditions for fish, the great fishery that once existed was irreversibly altered when the Lewiston and Trinity Dams were built (Palmer 1993).

The 1957 California Water Plan had proposed four dams for the Eel, at a cost that, in 1990 dollars, would have totaled close to $3 billion (Simon 1994). The Dos Rios Dam proposed for the Eel's Middle Fork would have eliminated the state's largest summer steelhead run, drowned the city of Covelo, buried much of the Round Valley Indian Reservation, and flooded 30 miles of prized whitewater rapids (Palmer 1993).

Construction of the Dos Rios was prevented by the passage of Senator Peter Behr's bill proposing a state Wild and Scenic Rivers act. Just three days after he took office in 1970, Behr shocked the California legislature by proposing a bill to protect rivers not even located in his district. Angered by Behr's action, Senator Richard Collier (in whose district the rivers flowed) managed to defeat the bill, but

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[3] An EIS has been completed and formal recommendation for inclusion under the Act made for 50 of these rivers.

Middle Fork of the Eel River (Photo by Tim Palmer, courtesy of Friends of the River.)

Behr proposed a modified version in 1972 that was calculated to pick up more votes (Simon 1994). Collier proposed his own bill, and the two bills passed through the State Assembly in tandem. During the process, Behr was forced to alter his bill. As a compromise, the bill would only protect the Eel for 12 years. In November, both bills were passed and sent to then-Governor Ronald Reagan, who signed Behr's bill, ensuring that no major projects would be built on the Eel (for 12 more years) or on the Klamath, the Trinity, and the Smith, Scott, Salmon, Van Duzen, and lower American Rivers. In 1981, all of these rivers were given federal protection when they were designated under Section 2(a)(ii) by Interior Secretary Andrus just minutes before leaving office.

This designation prompted an angry response by certain California senators, however, that led to weakening of the state Act. The California legislature amended the state Act by limiting protection to the "high water line" and eliminating the requirement for state management plans. It removed several tributaries of the Smith River from the state system, and although the remaining "Andrus" rivers were supposed to be managed by the state, no state agency took responsibility for them. Federal agencies thus manage those rivers by default (FOTR 1996). In 1990, Congress redesignated the main forks of the Smith and its tributaries from 2(a)(ii) status to 3(a) status, formally acknowledging federal management. It also included six tributaries not previously designated.

Because of these weaknesses in the state Act, federal designation is preferable. Also, while dams are prohibited on state-designated rivers, the Federal Energy Regulatory Commission (FERC) can override the state designation and issue licenses to build dams—another reason federal designation is the preferred conservation tool. Despite its weaknesses, the state system has promoted conservation. State designation was critical in protecting the Smith, Klamath, Scott, Salmon, Trinity, Eel, Van Duzen, and the lower American Rivers until they were added to the federal system. State designation has also indirectly promoted conservation—after a state Wild and Scenic study was proposed for Deer and Mill Creeks, the California legislature passed a bill prohibiting new dams and diversions on these rivers (see *Improving Passage for Spring-Run Salmon,* Chapter 21).

National Wild and Scenic River Protection for California's Rivers

Over 124 of the nation's rivers, totaling 93,000 miles, now have federal Wild and Scenic designation and protection. Approximately 40 percent of that mileage lies within Alaska, however (Palmer 1993), with the majority of the remaining miles concentrated in California and Oregon (Benke 1990). Some crucial points in the history of California-river protection under the Act are described below. These examples show the many diverse coalitions of sports fishermen, recreational boaters, ecologists, city dwellers, rural ranchers and growers, and others who have joined together over time to protect valued stretches of California rivers.

Table 28-1
Rivers in the California Wild and Scenic System

River System (includes main stems and some forks and tributaries)	Year Listed	Miles Protected	Outstanding and Remarkable Values (also, see national listing)
Smith	1972	340	Fisheries; recreational
Klamath	1972	286	Fisheries
Trinity	1972	203	Fisheries
Eel	1972	394	Fisheries; recreational
North Fork American River	1972	50	Scenic, recreational, historic/cultural; hydrologic
Lower American River	1972	23	Fisheries; recreational
East Carson River	1989	10	Recreational and scenic
West Walker River	1989	37	Fisheries; recreational; scenic; ecological; hydrologic; other
Leavitt Creek	1989	1	Scenic
Total segments: 54		**Total Miles: 1,344**	

Source: Friends of the River 1997

Landmarks in the Protection of California's Wild and Scenic Rivers

1968

Middle Fork Feather River

The first California river to be given federal protection (as part of the original Act) was the Middle Fork of the Feather River above Oroville Dam (completed in 1968), which was threatened by additional proposed hydroelectric projects. Although the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the Federal Power Commission, and the Soil Conservation Service vigorously opposed listing the Feather (and other western rivers), President Lyndon Johnson included them anyway (Palmer 1993). In 1976, under pressure from upstream ranchers, Congress amended the Act to remove mileage that meandered through private land above Beckwourth—the only deletion ever made to the system.

In the 1970s, the strength of the Act was challenged when the Forest Service issued an Arizona mining company a permit to dredge a mile-long gravel bar within the protected stretch of river. The Forest Service did not consider the project significant enough to require an EIS, but two non-governmental organizations, the Northern California Flyfishers and Friends of the River, appealed and halted the dredging. In 1981 the mining claim was rejected (Palmer 1993).

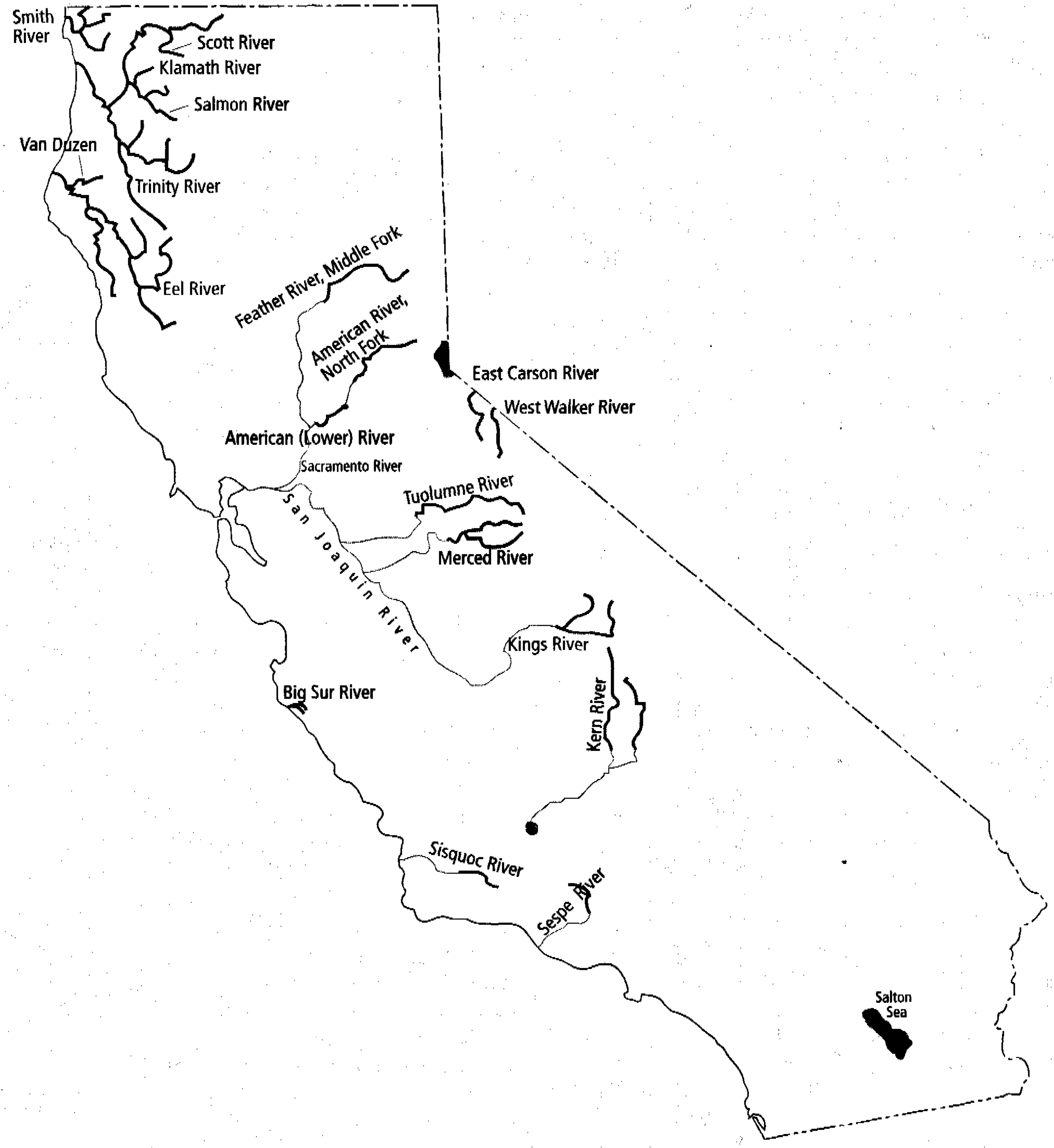
Since the designation of the Feather River in 1968, 15 California rivers have been added to the system (this does not include tributaries), bringing the total length of protected rivers in California to over 1,900 miles (see Figure 28-1).

1978

North Fork American River

In the 1960s, the Placer County Water Agency studied the feasibility of building a hydroelectric/alternative water supply project

Figure 28-1
State and Federally-Designated Wild and Scenic Rivers



Source: Adapted from U.S. Forest Service Map of the National Wild and Scenic Rivers System on the North Fork of the American River, at Giant Gap, but concluded the project was not economically feasible. A small group of people joined forces to lobby for Wild and Scenic status, and the North Fork was listed under the state Act in 1972. In 1975, Congress ordered the BLM and the Forest Service to study the river as a federal Wild and Scenic candidate. As a result of that study, the river was given federal protection in 1978. Designation stops at the high water mark of the proposed Auburn Dam, however, which had been authorized by Congress in 1965, three years before the National Wild and Scenic Rivers Act became law. Friends of the River then forced the Bureau of Reclamation to conduct an eligibility study of the section of river that would be impacted by the dam. Although the Bureau found this section of the river eligible, it has not taken the necessary next steps to list the river (Evans 1998).

1981

The North Coast Rivers

Listings of portions of the Trinity, Klamath, Eel, Smith, Scott, Salmon, and Van Duzen Rivers in 1981 under the Carter Administration permanently prevented additional dams from obstructing their flows. Although Southern California water agencies and northern timber companies sued to rescind the listings and a federal judge agreed with them, the federal appeals court found that their arguments hinged on technicalities and allowed the designations under the federal Act to stand.

The Eel River has an excellent coho and Chinook salmon fishery, and is one of only four national rivers whose main stem is designated for its entire length from its headwaters to the ocean. The Salmon offers excellent salmon and steelhead habitat and begins with the only glacier in the Coast Ranges. The Smith is the only major river basin remaining in California with no dams and is a fine example of a nearly pristine river in a forest environment (Palmer 1993). The Smith flows through the Siskiyou Wilderness area and one of 12 National Recreation Areas established in 1991.

A Model Urban River

The lower American River, from Nimbus Dam to its confluence with the Sacramento River, was designated in 1981 as a Recreational River. It is one of just a few urban rivers to receive federal protection and one of the most popular urban rivers in the nation (Palmer 1993). Swimming, fishing, and boating are allowed on the lower American, and its management is considered a model for other urban rivers. Since the late 1960s, Sacramento County has purchased land within the levee system on the lower American, creating a parkway that extends for most of the length of that stretch. The parkway is used by pedestrians, bicyclists, and even equestrians. Although the river is confined within levees, a riparian corridor lines its banks: deer, beaver, muskrats, river otters, and many birds use this habitat, even though it is in the midst of a city (Palmer 1993).

1984

The Tuolumne

The Modesto–Turlock Irrigation District and the city of San Francisco both planned to build diversion projects on the main stem and the South Fork of the Tuolumne and were going through the FERC licensing process, when a group of sport fishermen, recreational boaters, private landowners, developers, and representatives of local, state, and federal agencies formed the Tuolumne River Preservation Trust, and succeeded in acquiring federal designation and protection for 83 miles of the river, from its source to New Don Pedro Reservoir (excepting Hetch-Hetchy). The Tuolumne, which has its headwaters in the Sierra high country of Yosemite National Park and is considered one of the most exquisite high mountain rivers anywhere, is one of California's finest trout fisheries (Palmer 1993).

1986

In 1986, in *Swanson Mining Corp. v. F.E.R.C.*, the United States Court of Appeals for the District of Columbia reviewed FERC's denial of a license for a hydroelectric project on the South Fork of the Trinity. The Court upheld Section 7 of the National Wild and Scenic Rivers Act, which prohibits FERC from licensing or relicensing any water resources project on a federally-protected river, regardless of whether or not FERC's denial of a license would result in any adverse effects (Frost 1992–1993).

1987

The Merced

In 1987, a hydropower developer had completed plans to dam the main stem of the Merced River at the boundary of Yosemite National Park and the river's wild South Fork, and was merely awaiting "red-tape" approvals (Palmer 1993). However, the Forest Service studied the river and recommended its designation while a group of citizen activists, the Merced Canyon Committee, gathered enough political support to have the main stem and the wild, picturesque South Fork listed.

The Kings

Segments of the Kings River were given Wild and Scenic designation after trout anglers organized to prevent a dam proposed by the Kings River Conservation District. Although the designation stopped short of the proposed dam site, another bill was passed, with a "special management" provision that prevented the dam. The Kings and its forks carve the deepest canyon in the United States (8,300 feet from Spanish Peak to the river), and the river flows over the greatest undammed vertical drop of any river in North America (Palmer 1993).

The Kern

Friends of the River succeeded in having the South Fork of the Kern designated along with the North Fork, which had been studied and recommended for Wild and Scenic status by the Forest Service. Friends of the River first had to convince residents of Kernville that a listing would not affect their private property rights, as a few influential individuals in the community feared (Evans 1998). Once enough community support was generated, California's senators agreed to sponsor inclusion of both forks of the Kern; Kernville now promotes its Wild and Scenic river as a tourist attraction (Evans 1998).

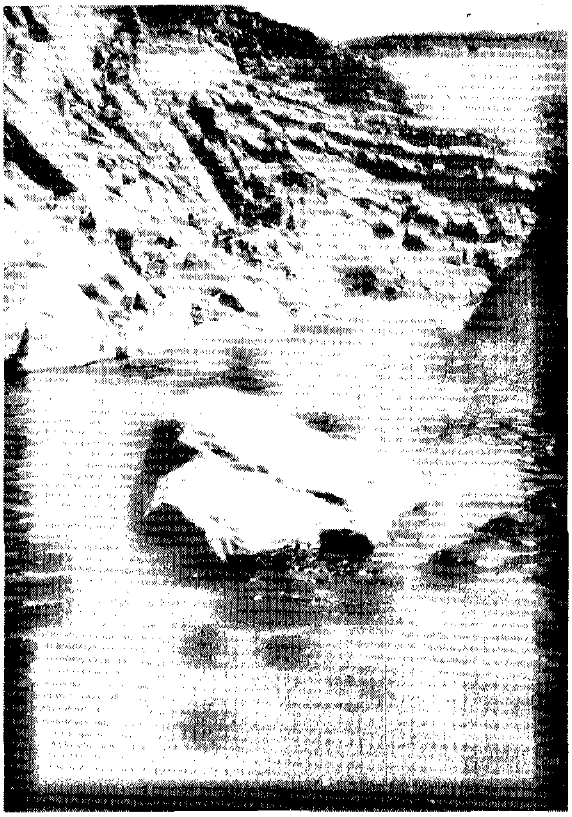
North Fork, Kern River (Photo by Steve Evans, courtesy of Friends of the River)

The North Fork begins as an exquisite Sierran stream that flows over granite; the South Fork, flowing between the Sierra Nevada and the Mojave Desert, is an area of extraordinary biodiversity (Palmer 1993).

1992

In 1992, portions of the Big Sur, Sisquoc, and lower Merced Rivers and Sespe Creek were listed. The Big Sur, which flows through the southernmost range of the coast redwoods, the Sisquoc, which offers prime habitat for black bears, mountain lions, and California condors, and the Merced, which flows through Yosemite Valley, were not directly threatened by dams, but a dam had been proposed for Sespe Creek (Evans 1998). Sespe Creek is considered one of

Big Sur River (Photo by Tim Palmer, courtesy of Friends of the River)



Sespe Creek (Photo by Tim Palmer, courtesy of Friends of the River)

Table 28-3

Summary of National Wild and Scenic Rivers in California

STATUS	SEGMENTS	MILES
Designated	80	1,902.8
Recommended	56	767.8*
Eligible (under study)	173	1,616.3*
Not recommended	45	438.5*

**Source: Friends of the River 1997*

the few Southern California streams with the potential for restored steelhead runs (Palmer 1993). Listing now protects most of Sespe Creek, which flows into the Santa Clara River.

Wild and Scenic Issues

Despite the growth of and number of rivers listed under the National Wild and Scenic Act, the Act is not without its critics or problems. Those problems include bureaucratic delays in listing new stretches, slow implementation of the Act, and fears about its restrictions. These fears may keep the Act from being used as the powerful legal tool it can be. Critics claim, for example, that if any conflict over a river's designation is anticipated, Congress will not list the river. Although the basic premise of the Wild and Scenic River System is to maintain rivers in their current states and protect their wild, scenic, and recreational values, loggers fear and oppose restrictions on cutting, boaters fear restrictions on recreation, and private landowners worry designation will mean condemnation of their property.

Fears about private property restrictions and condemnation are largely unfounded. For example, a 1988 survey of Forest Service land acquisition surrounding 16 West Coast Wild and Scenic-designated rivers found that none of the 200,000 acres of private land within the river corridors had been condemned and that easements had been taken on only 751 acres. The survey also found that the BLM had condemned no land outright on the 442,420 acres it managed and had acquired scenic easements on only 624 acres (Watanabe 1988). Nonethe-

Table 28-2

Summary of California Rivers included in the National Wild and Scenic System

River	Year Designated	Total Miles Protected	Designation Area	Classification under the Act
American, lower	1981	23	Nimbus Dam to mouth of Sacramento River	Recreational
American, North Fork	1978	38.3	The Cedars to Colfax– Iowa Hill Bridge	Wild
Big Sur	1992	19.5 (with North and South Fork tributaries)	Sources of North and South Forks to their confluence to the Ventana Wildnerness Boundary	Wild
Eel	1981	346 including Forks	Van Arsdale Dam to mouth at Pacific Ocean (main stem); Middle Fork: South boundary of Middle Eel–Yolla Bolly Wilderness to mouth; North Fork: Old Gilman Ranch to mouth; South Fork: confluence with section Four Creek to mouth at Eel River	Wild (97.5 mi.); Scenic (6 mi.); Recreational (242.5 mi.)
Feather River	1968	108	Railroad Bridge near Beckwourth to Oroville Reservoir	Wild (32.9 mi); Scenic (9.7 mi); Recreational (65.4 mi)
Kern	1987	151 (North and South Forks)	North Fork: source to Tulare–Kern County boundary; South Fork: source to south boundary of Dome Land Wilderness	Wild (123.1 mi); Scenic (10.6 mi); Recreational (17.3 mi)
Kings	1987	81.5* (main stem, Middle and South Forks) *Only the upper 6 miles of the main stem are protected under the Act; an additional 11 miles (not counted in this chart) are considered a Special Management Area where no dams may be built without specific authority of Congress. These 11 miles have been designated for inclusion under the Act.	Main stem: source at confluence of Middle and South Forks to one mile above Pine Flat Reservoir; Middle Fork: source to mouth at South Fork	Wild (66 mi); Recreational (15.5 mi)
Klamath	1981	188	Iron Gate Dam to mouth at Pacific Ocean	Scenic (13 mi); Recreational (175 mi)

Sources: Palmer 1993; Friends of the River 1998

Table 28-2 (continued)

Summary of California Rivers included in the National Wild and Scenic System

River	Year Designated	Total Miles Protected	Designation Area	Classification under the Act
Merced	1987	114 (including Headwaters Forks and South Fork	Main stem: source to Halls Gulch below Briceburg; Headwaters Forks: sources to mouths; South Fork: source to mouth at main stem	Wild (72.5 mi); Scenic (19 mi); Recreational (22.5 mi)
Salmon	1981	63 (including North and South Forks)	Main stem: source at confluence of North and South Forks to mouth at Klamath River; North Fork: Marble Mountain Wilderness Area to mouth; South Fork: Cecilville to mouth	Wild (3 mi); Scenic (14 mi); Recreational (46 mi)
Scott	1981	68-mile-long tributary to the Klamath; only the lower 24 miles designated	Shackleford Creek west of Fort Jones to mouth at Klamath River	Scenic (6 mi); Recreational (18 mi)
Sespe Creek	1992	31.5	Trout Creek confluence and downstream for 27.5 miles; confluence with Rock and Howard Creeks downstream to Trout Creek (four miles), excluding a reach with private land and a potential dam site	Wild (27.5 mi); Scenic (4 mi)
Sisquoc	1992	33	Source to Los Padres National Forest boundary	Wild
Smith	1981, plus additions in 1988; 1990	351 (including Middle, North, and South Forks and 13 miles of the North Fork in Oregon)	Main stem: source at Middle Fork confluence to mouth at Pacific Ocean; Middle Fork: source to mouth; North Fork: Oregon border to mouth at Middle Fork plus 13 miles in Oregon; South Fork: source to mouth	Wild (74.75 mi); Scenic (39.25); Recreational (195.75) (classification for some smaller branches unavailable)
Trinity	1981	200 (including North, South, and New River Forks)	Main stem: Lewiston Dam to mouth at Klamath River; New River and North Forks: Salmon–Trinity Primitive Area to mouth; South Fork: Hwy. 36 bridge to mouth	Wild (45 mi); Scenic (38 mi); Recreational (117 mi)
Tuolumne	1984	83	Source to New Don Pedro Reservoir (except Hetch-Hetchy Reservoir)	Wild (47 mi); Scenic (23 mi); Recreational (13 mi)
Van Duzen	1981	48	Dinsmore Bridge to mouth at Eel	Scenic (14 mi); Recreational (34 mi)

less, some local river communities have implemented their own protection plans, fearing federal condemnation or state involvement. These community-based programs can also be very successful (Watanabe 1988), though the rivers may not have as much protection as they would under the federal Act.

Some critics complain that segmentation—designating some river segments while ignoring others—erodes the protection intended by the Act. Critics also cite the fact that for the rivers that most need protection, prolonged, expensive campaigns at the state and federal levels are often necessary. On the other hand, those campaigns have united diverse interests such as sport fishermen, recreational boaters, private landowners, conservationists, and nonprofit groups in cooperative efforts to protect rivers, as occurred in the case of the Tuolumne River (Water Education Foundation 1992).

The Tuolumne River, Clavey Falls (Photo courtesy of Friends of the River)

Critics also claim that too much emphasis is placed on the classification scheme itself—the wild, scenic, or recreational designation—and suggest that simply designating rivers as "national" rivers could streamline the listing process. Yet it is the specific designation that guides management decisions about the river—on rivers designated as "wild" for example, large access areas cannot be created, nor is heavy recreation encouraged (Palmer 1993). On the other hand, some critics claim the designations are used more to gauge how much degradation of a river will be allowed instead of using the designation to preserve the river's existing qualities—i.e. that recreational rivers are managed to allow greater degradation than on scenic rivers (Huddleston cited in Watanabe 1988). They also say not enough emphasis is given by the managing federal agencies to the Act's mandate to protect the outstanding values which made the river eligible for protection in the first place (Evans 1998).

Various ideas have been proposed about how to better protect rivers, including establishing new legislation to protect entire watersheds rather than just river corridors (Benke 1990), or designating rivers as "National Rivers," which protects wide segments of land along rivers (Benke 1990). "National River" designation requires a special act of Congress and has thus been rarely used, and the few rivers so designated[4] are not protected from detrimental upstream practices. While legislation to protect entire watersheds would offer more complete protection, it might also generate greater conflict over private property rights.

Future of the Act: Expanded Protection?

The National Wild and Scenic Rivers Act has saved many stretches of California rivers from dams—over 95 percent of California's dams were built before 1968 and the passing of the Act. Yet

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[4] The only rivers that have been accorded National River protection are Missouri's Current River (and a tributary), Arkansas's Buffalo River, the South Fork of the Cumberland River in Tennessee, and the New River Gorge in West Virginia. River segments protected by other special acts of Congress include the Grand Canyon portion of the Colorado River, portions of the Snake River in Oregon and Idaho, and portions of the Gauley and Meadow Rivers in West Virginia (Benke 1990).

the Act has the potential to do much more, even to protect entire ecosystems (Evans 1998). Recently, that potential has successfully been tested in the courts. The Act has protected river values not only by preventing dams, but also by stopping logging and grazing practices that would have damaged watersheds and harmed rivers. Although the Act prohibits new mining activities in the beds and within a quarter mile of the banks of rivers designated as Wild, no published legal cases have yet invalidated mining activities under the Act (Frost 1992–1993).

Logging

In 1990, in *Wildnerness Society v. Tyrrel*, the U.S. Court of Appeals for the Ninth Circuit rejected the Forest Service's argument that the Act did not prevent it from salvage logging 18.4 million board-feet of burned timber and building 8.7 miles of new roads more than a quarter mile from the South Fork of the Trinity River (Frost 1992–1993; 1998). The Court found that logging, whether conducted on land within the river area's boundaries or adjacent to the river area, would adversely affect protected values. The Ninth Circuit remanded the case to the district court for factual determination of whether landslides and erosion would occur and would destroy the Trinity's anadromous fishery. The district court found that the cumulative effect of the salvage logging and other sources of sediment would degrade fish habitat, and the Forest Service subsequently withdrew its decision authorizing the timber sale (Frost 1992–1993).

Dams

In 1996, the United States District Court for the District of Columbia ruled in favor of the state of Oregon, American Rivers, and the Secretary of the Interior (among other defendants), when the city of Klamath Falls challenged the Secretary of the Interior's designation of 11 miles of the Klamath River. In 1988, Oregon voters had approved a ballot initiative designating the Upper Klamath as a state scenic river. In 1990, the BLM recommended that Congress designate the river as Wild and Scenic, and in 1993, Oregon Governor Barbara Roberts requested that the Secretary of the Interior designate the river even though Congress had not yet acted on the BLM's recommendation. The city of Klamath Falls, which had been planning since the early 1980s to build the Salt Caves Hydroelectric Project on the Klamath as a way to "improve the suffering economy of the city" (*City of Klamath Falls v. Bruce Babbitt, et al.* 1996), filed a lawsuit arguing, among other points, that because various "management options" (such as the hydroelectric project) existed, there was no "status quo" on the Klamath River that could be protected under the National Wild and Scenic Rivers Act. The Court rejected all of the city's arguments and upheld the listing.

Grazing

In 1997, a federal district court in Oregon ruled in favor of the National Wildlife Federation,[5] which had charged the BLM with violating the Wild and Scenic Rivers Act by preparing a river management plan for the Donner and Blitzen River that allowed grazing and construction of new parking lots and access roads. The plaintiffs argued—and the Court agreed—that the Act does not "grandfather" in existing uses, such as livestock grazing, and that by allowing these activities, the BLM failed to protect and enhance the river's native plant communities and fisheries as required under the Act.

Flows

In 1997, the National Wildlife Federation filed another lawsuit against the BLM, alleging that it has violated the Act by failing to protect and enhance the John Day Wild and Scenic River and its South Fork by building (and allowing others to build) small reservoirs, impoundments, and springboxes in the river, depleting its free flows. This lawsuit is one of the first brought under the Act alleging that a managing federal agency has an obligation to obtain flows

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[5] Other plaintiffs included the Oregon Natural Desert Association; Oregon Trout, Inc; Oregon Natural Resources Council; Oregon Wildlife Federation; Oregon Chapter, Sierra Club; Central Oregon Audubon Society; Northwest Environmental Defense Center; Rest the West; American Rivers, Inc.; National Parks and Conservation Association; and the National Wildlife Federation.

sufficient for maintaining and restoring salmon habitat. If the National Wildlife Federation succeeds, the court may finally utilize the Act's potential for protecting the natural values of rivers and ecosystems (Frost 1998).

Conclusions/Lessons Learned

The National Wild and Scenic Rivers Act is the most significant piece of legislation passed to date to protect rivers (Benke 1990) and offers conservationists a valuable tool to help preserve rivers. The Act does not preclude the need for citizen-based advocacy: advocacy may be needed now more than ever before, as pressure to develop water and power resources for California's growing population and cutbacks in federal funds for managing protected rivers continue to threaten California's rivers. As can be seen in various stories in this publication, the most successful examples of river and stream preservation have involved the efforts and cooperation of many stakeholders. The National Wild and Scenic Rivers Act can offer an important layer of protection to those efforts. In California, many rivers once threatened by dams and diversions flow freely today only because concerned communities and activists used the National Wild and Scenic Rivers Act as the powerful tool it can be. If the Act continues to be successfully tested in the courts, preventing logging, grazing, and other detrimental impacts to rivers, its benefits could expand to include better flows and habitat for fish and other wildlife, and to protect and enhance entire ecosystems.

Contacts

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References

Benke, A. 1990. "A Perspective on America's Vanishing Streams." *Journal of the North American Benthological Society* 9(1):77-88.

Curtis, C. 1992. "Grassroots River Protection/ Saving Rivers Under The National Wild and Scenic Rivers Act Through Community-Based River Protection Strategies And State Actions." American Rivers, Washington, DC.

DWR (California Department of Water Resources). 1994. *Bulletin 160: The California Water Plan Update.* Sacramento, CA.

Evans, S. 1998. Friends of the River. Sacramento, CA. Personal communications.

FOTR (Friends of the River). 1997. "National Wild and Scenic Rivers in California: A Status Report." Sacramento, CA.

Frost, P. 1992–1993. "Protecting and Enhancing Wild and Scenic Rivers in the West." *Idaho Law Review.* College of Law, University of Idaho.

Frost, P. 1998. National Wildlife Federation. Portland, OR. Personal communications.

Oregon Natural Desert Association, et al. v. Michael Green, et al. 1997. U.S. District Court, District of Oregon. Civil Action No. 95-2013-HA. Opinion and Order. January 31.

Palmer, T. 1993. *The Wild and Scenic Rivers of America.* Covelo, CA: Island Press.

Simon, T. 1994. *The River Stops Here/How One Man's Battle to Save His Valley Changed the Fate of California.* New York, NY: Random House.

Watanabe, A. 1988. "Two Decades of River Protection/A Report on the National Wild and Scenic Rivers System/Past, Present, and Future." American Rivers. Washington, DC.

Water Education Foundation. 1992. "Wild and Scenic Rivers." *Layperson's Guide to California Rivers and Streams.* Sacramento, CA.