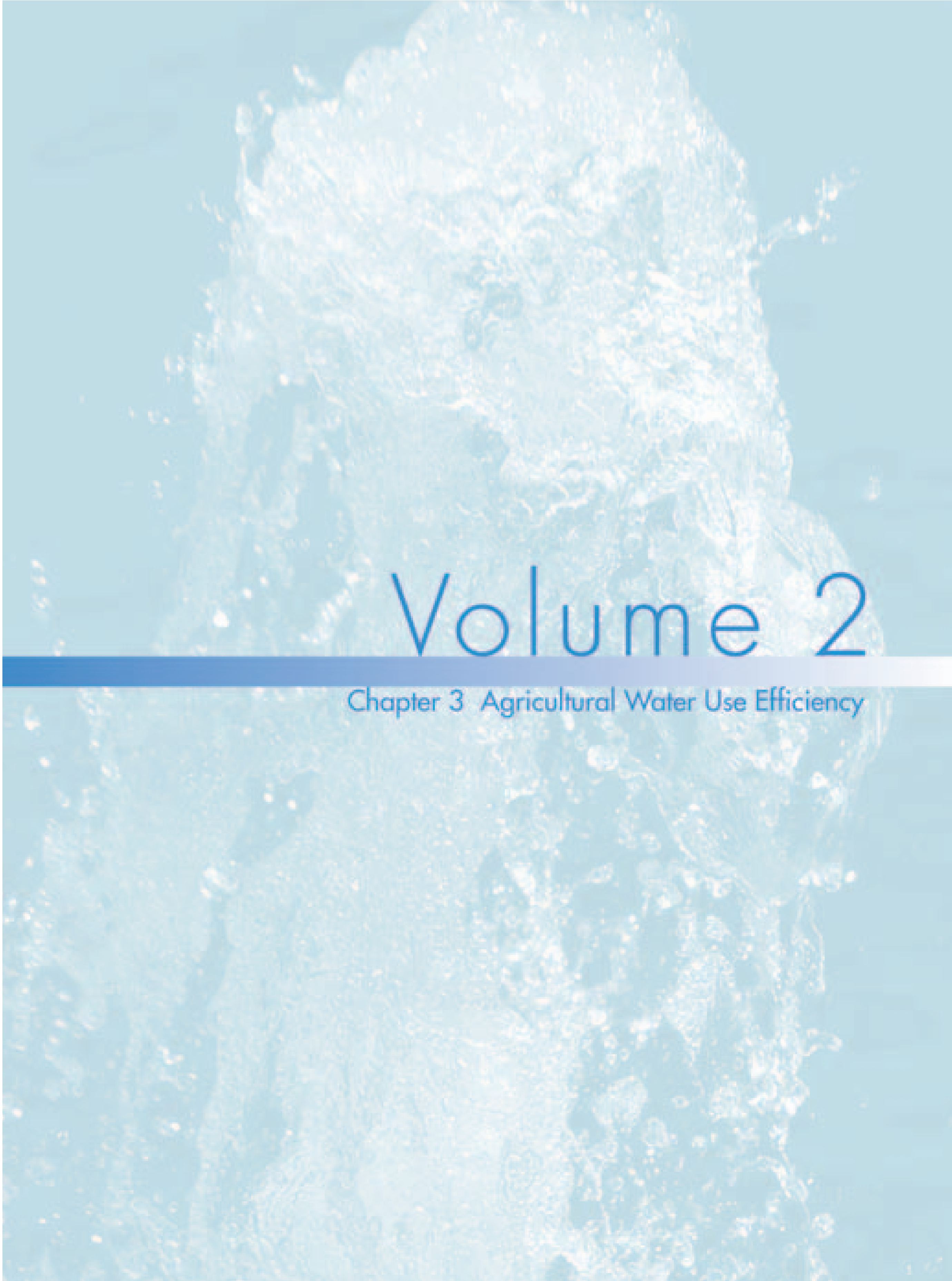


Volume 2

Chapter 3 Agricultural Water Use Efficiency

In California, growers and water suppliers implement state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water.

Chapter 3 *Agricultural Water Use Efficiency*

Agricultural water use efficiency involves improvements in technologies and management of agricultural water that result in water supply, water quality, and environmental benefits. This narrative discusses efficiency improvements such as on-farm irrigation equipment, crop and farm water management, and water supplier distribution systems.

Current Agricultural Water Use Efficiency Efforts in California

Agriculture is an important element of California's economy, generating $27.6 billion in gross income in 2001 according to the California Agricultural Statistics Service. In 2000, California irrigated an estimated 9.6 million acres of cropland with about 34.2 million acre-feet of applied water.

In California, growers and water suppliers implement state-of-the-art design, delivery, and management practices to increase production efficiency and conserve water. As a result, they continue to make great strides in increasing the economic value and efficiency of their water use. One indicator of agricultural water use efficiency improvement is that agricultural production per unit of applied water (tons/acre-foot) for 32 important California crops increased by 38 percent from 1980 to 2000. Another indicator is that inflation-adjusted gross crop revenue per unit of applied water (dollars/acre-foot) increased by 11 percent between 1980 and 2000.

The Agricultural Water Suppliers Efficient Water Management Practices Act of 1990 (AB 3616) and the Federal Central Valley Project Improvement Act of 1992 (CVPIA) established guidance for improving agricultural water use efficiency. As of September 2005, the Agricultural Water Management Council unites, through a Memorandum of Understanding (MOU), 74 agricultural water suppliers and three environmental organizations in an effort to improve water use efficiency through implementation of efficient water management practices. The council recognizes and tracks water supplier water management planning and implementation of cost-effective efficient water management practices through a review and endorsement procedure. The signatory agricultural water suppliers voluntarily commit to implement locally cost-effective management practices (see Box 3-1). The agricultural water suppliers represent more than 4.6 million acres of irrigated agricultural land. Some signatories to the MOU submit water management plans, most of which are endorsed by the council. Additionally, 24 signatories subject to federal CVPIA planning requirements have council-endorsed plans.

Growers invest in on-farm water management improvements to stay economically competitive. Likewise, local water suppliers invest in cost-effective, system-wide water management improvements in order to provide quality service at a fair and competitive price. In addition to water savings, efficiency measures can provide water quality and flow-timing benefits. The CALFED Program's Quantifiable Objectives (QOs) and Targeted Benefits — which can be local, regional, or statewide — are numeric targets of water savings that address CALFED objectives of water supply reliability, water quality, and ecosystem improvements.

Substantial financial support for research, development and the demonstration of efficient water management practices in agriculture comes from the agricultural industry and State and federal efforts. Support also comes from the early adopters of new technology who often risk their crops, soils, and money when cooperating to develop and demonstrate technology innovations. Further investments in research and demonstration are critical, especially in support of university-based research, field station studies, and cooperative extension demonstration projects.

Improvements in agricultural water use efficiency primarily occur from three activities:

- **Hardware –** Improving on-farm irrigation systems and water supplier delivery systems
- **Water management –** Improving management of on-farm irrigation and water supplier delivery systems
- **Crop water consumption –** Reducing non-beneficial evapotranspiration

Hardware Upgrades

Due to water delivery system limitations, growers are often unable to apply the optimal amount of irrigation water. Water delivery system improvements such as integrated supervisory control and data acquisition systems, canal automation, regulating reservoirs, and other hardware and operational upgrades, can provide flexibility to deliver water at the time, quantity, and duration required by the grower. At the on-farm level, most orchards and vineyards, as well as some annual fruits and vegetables, are irrigated using pressurized irrigation

Box 3-1 Agricultural Water Management Efficient Water Management Practices (EWMPs)

The Agricultural Water Management Council has three classifications of EWMPs as follows:

List A - Generally Applicable Efficient Water Management Practices—Required of all signatory water suppliers

1. Prepare and adopt a water management plan
2. Designate a water conservation coordinator
3. Support the availability of water management services to water users
4. Where appropriate, improve communication and cooperation among water suppliers, water users, and other agencies
5. Evaluate the need, if any, for changes in policies of the institutions to which water supplier is subject

List B - Conditionally Applicable Efficient Water Management Practices – Practices Subject to Net Benefit Analysis and Exemption from Analysis

1. Facilitate alternative land use (drainage)
2. Facilitate use of available recycled water that otherwise would not be used beneficially
3. Facilitate the financing of capital improvements for on-farm irrigation systems
4. Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, the environment, or third parties
5. Construct improvements (lining and piping) to control seepage from ditches and canals
6. Within operational limits, increase flexibility in water ordering by, and delivery to, the water users
7. Construct and operate water suppliers' spill- and tail-water recovery systems
8. Optimize conjunctive use of surface and groundwater.
9. Automate canal-control structures

List C - Practices Subject to Detailed Net Benefit Analysis without Exemption

1. Water measurement and water use report
2. Pricing or other incentives

For detailed information on the Agricultural Water Management Planning and Implementation process, implementation of EWMPs, Net Benefit Analysis and schedules, see the Memorandum of Understanding at AWMC Web site, www.agwatercouncil.org/aboutusmain.htm

Table 3-1 Trends in irrigation method area (in million acres)

Irrigation method	1990		2000		Change from 1990 to 2000
	Area	% of Total	Area	% of Total	(change in acreage)
Gravity (furrow, flood)	6.5	67	4.9	51	- 16
Sprinkler	2.3	24	2.8	29	5
Drip/micro	0.8	9	1.9	20	11
TOTAL	9.6	100	9.6	100	

Source: DWR

systems. Almost all trees and vines established since 1990 are irrigated using micro-irrigation. Between 1990 and 2000, the crop area under micro-irrigation in California grew from 0.8 million to 1.9 million acres, a 138 percent increase (see Table 3-1 and Box 3-2).

Many growers use automated irrigation systems for irrigation, fertilizer application, and pest management. Advanced technologies include Geographic Information System (GIS), Global Positioning System (GPS) and satellite crop and soil moisture sensing systems. These technologies allow growers to improve overall farm water management.

The use of pressurized irrigation systems, such as sprinkler, drip, and micro-spray, in addition to being energy intensive, often requires modernization of water supplier delivery systems to provide irrigation water at the time, quantity, and duration required by the grower. Increasingly, water suppliers are upgrading and automating their systems to enable accurate, flexible, and reliable deliveries to their customers. Also, suppliers are lining canals, developing spill recovery and tail water return systems, employing flow regulating reservoirs, improving pump efficiency, and managing surface water conjunctively with groundwater. With the advancement of both water supplier and on-farm water management systems, there is potential to improve irrigation efficiencies at both on-farm and water supplier levels.

Growers continue to make significant investments in on-farm irrigation system improvements, such as lining head ditches and using micro-irrigation systems. Many growers take advantage of mobile laboratory services to conduct in-field evaluation of irrigation systems. Once considered innovative technologies, these are now standard practice. In terms of future improvements, the California Polytechnic State University, San Luis Obispo, Irrigation Training and Research Center estimates that an additional 3.8 million acres could be converted to precision irrigation such as drip or micro-spray irrigation. While this will not reduce crop water consumption, it can improve the uniform distribution of water and reduce evaporation and non-beneficial evapotranspiration, thus allowing more efficient use of water. Research on drip irriga-

Box 3-2 Example of Irrigation Efficiency Improvement

Kern County Water Agency reports significant improvements in irrigation efficiency. An analysis of data in 1986 compared to 1975 showed an 8 percent improvement (from 67 percent in 1975 to 75 percent in 1986). This improvement reduced the total applied water use in the San Joaquin Valley portion of Kern County by about 250,000 acre-feet, enough water to irrigate about 70,000 acres. Since 1986 Kern County has added 61,500 acres of trees and vines. These now make up 37 percent of the total irrigated crop area. Nearly all of this new crop area has low volume drip irrigation systems installed. KCWA estimates the overall on-farm water use efficiency now is about 78 percent. Note that the remaining 22 percent constitutes leaching requirement, irrigation system distribution nonuniformity, and cultural practices, which includes both recoverable and/or irrecoverable flows.

tion of alfalfa has shown an applied water reduction of two to three percent with yields increasing from 19 to 35 percent, an increase in productivity of 30 percent with the same amount of applied water. Conversion of traditional irrigation systems to pressurized systems and installation of advanced technologies on water supplier delivery systems require more investment in facilities as well as use of additional energy that increases farm production costs and water supplier operational costs.

Water Management

Both on-farm and water supplier delivery systems must be managed to take advantage of new technologies, science, and hardware. Personal computers connected to real-time communication networks and local area networks allow transmission of flow data to a centralized location. These features enable water supplier staff to monitor and manage water flow and to log data. With such systems, the water supplier staff spends less time manually monitoring and controlling individual sites, allowing them to plan, coordinate system operation, and reduce costs. Such systems improve communications and provide for flexible water delivery, distribution, measurement, and accounting.

Some of today's growers use satellite weather information and forecasting systems to schedule irrigation. Many growers employ evapotranspiration and soil moisture data for irrigation scheduling. Users generate more than 70,000 inquiries per year to the California Irrigation Management Information System (CIMIS), the Department of Water Resources' weather station program that provides evapotranspiration data. Universities, water suppliers, and consultants also make this information available to a much wider audience via newspapers, Web sites, and other media. Growers use many other water management practices. Furrow, basin, and border irrigation methods have been improved to ensure that watering meets crop requirements while limiting runoff and deep percolation. Growers use plastic mulch to reduce non-essential evaporation of applied water.

Reducing Evapotranspiration

Evapotranspiration is the amount of water that evaporates from the soil and transpires from the plant. Growers can reduce evapotranspiration by reducing unproductive evaporation from the soil surface, eliminating weed evapotranspiration, shifting crops to plants that need less water, or reducing transpiration. In addition, growers deficit irrigate their crops during water short periods and for agronomic purposes (see Box 3-3).

Potential Costs and Benefits of Agricultural Water Use Efficiency

The CALFED Water Use Efficiency Technical Appendix of the CALFED Record of Decision (ROD) estimates the costs and benefits of water savings. Recently, the California Bay Delta Authority (CBDA) sponsored a study that estimates the costs and benefits of water use efficiency as a part of the CBDA Year Four Comprehensive Report (Year Four Report). These two estimates are based on different approaches and assumptions. The ROD's potential costs and benefits are based on assumed on-farm efficiency improvements of 85 percent within each hydrologic region and consider total irrigated crop area,

Box 3-3 Regulated Deficit Irrigation

Some growers use regulated deficit irrigation (RDI) to stress trees or vines at specific developmental stages to improve crop quality, decrease disease or pest infestation, reduce production costs, while maintaining or increasing profits. Conventional irrigation management strategy has been to avoid crop water stress. Research on RDI began in California in the 1990s on tree and vine crops. Initial results show potential for reducing evapotranspiration while increasing or maintaining crop profitability and allowing optimum production.

Wine grapes are a clear example: Mild stress imposed through the growing season decreases canopy growth, but produces grapes with higher sugar content, better color and smaller berries with a higher skin to fruit-volume ratio. This is a very common practice in the premium wine regions of California.

RDI has been primarily used as a production management practice and the extent of its application in California has not been quantified. Before RDI can be applied to other crops, information on its costs, risks, long-term impacts, and potential benefits including water savings must be determined. Once that is done, practical guidelines for growers on how to initiate, operate, and maintain RDI should be developed and disseminated. (See Volume 4 Reference Guide for details on RDI.)

crop water use, applied water, and depletions. The Year Four Report estimates are based on crop water use, irrigated crop area, irrigation system type, and applied water within each Water Plan planning area. It uses cost and performance information for on-farm and water supplier improvements to estimate costs, considers various levels of funding and local implementation, and accounts for quantifiable objectives developed for the CALFED Bay-Delta Program's Water Use Efficiency Element. In addition, it includes an estimate of potential water use reduction from implementing a moderate level of regulated deficit irrigation.

Potential Benefits

The ROD estimates that efficiency improvements will result in a water savings (reduction in irrecoverable flows also referred to as net water use) ranging between 120,000 to 563,000 acre-feet per year by 2030. The study also showed a 1.6 million acre-foot per year reduction in applied water (combined recoverable and irrecoverable flows) that provides environmental and crop production benefits. Additionally, water use efficiency measures in the Colorado River Hydrologic Region will reduce irrecoverable flows by 68,000 acre-feet per year (at a cost of $135.65 million) by lining the All American Canal and 26,000 acre-feet per year (at a cost of $83.65 million) by lining the Coachella Branch Canal for a total of 94,000 acre-feet per year. The Quantification Settlement Agreement (QSA) will result in 413,000 acre-feet per year of agricultural water use efficiency by the Imperial Irrigation District in the Colorado River Hydrologic Region. However, the water conserved under the QSA will not result in new water supplies for California; rather it is a step to help California water users reduce their use of Colorado River water by 800,000 acre-feet per year – from 5.2 to 4.4 million acre-feet per year. (For details, see Volume 3, Chapter 11, Colorado River Hydrologic Region and following Web site: www.usbr.gov/lc/region/g4000/crwda/index.htm.

Benefits resulting from implementation of other advanced technologies in hardware and water management, and in crop evapotranspiration, crop shifts, and reducing crop transpiration have not been quantified for this narrative.

The Year Four Report study used Water Plan Update land and water use data for the year 2000 and a DWR survey of irrigation methods used by growers in 2000. The analysis was conducted based on a 27-year implementation horizon (2003-2030) at the on-farm and local water supplier level. The Year Four Report estimates do not include the potential reduction of 94,000 acre-feet per year of irrecoverable flow in the Colorado River Hydrologic Region, because that region's ongoing conservation and transfer activities are outside the CALFED Program's solution area. On-farm improvements were based on natural replacement from lower to higher performing systems over time as well as various state funding levels. Water supplier improvements were based on the implementation of efficient water management practices and various state funding levels.[1] Table 3-2 presents the reduction in recoverable and irrecoverable flows at both the on-farm and water supplier levels. The cost information in Table 3-2 represents the State's investment in water use efficiency actions that generate statewide benefits.

Water use efficiency estimates at the water supplier level are based on cost and performance of supplier management changes and infrastructure improvements. A regional baseline of water supplier improvements was developed based on water availability and knowledge of local delivery capabilities and practices. In addition it was assumed that all locally cost-effective efficient water management practices are implemented. The initial investment for improvements is allocated for management changes that provide an improved level of delivery service – mainly through additional labor and some system automation. Higher levels of water supplier delivery system performance are achieved through infrastructure improvements such as regulating reservoirs, canal lining, additional system automation, and spill prevention.

At the water-supplier level, most of the benefit of water use efficiency is with recoverable flows. However, since recoverable flows, especially surface return flows, are typically being used by downstream farming operations, the location of the water diversion in the basin is critical for determining if implementing a water use efficiency measure would adversely reduce the supply of downstream agricultural water users. Consequently, many consider the reduction of irrecoverable flows (or net water use) a better estimate of potential agricultural water use efficiency.

On-farm water use efficiency estimates are based on cost and performance information for feasible irrigation systems. Depending on crop type, irrigation systems can include various forms of surface irrigation (furrow and border strip), sprinkler irrigation, or drip irrigation. The performance of any irrigation system also depends on how well it is managed. For a given crop, the irrigation system and management will determine

[1] The potential savings estimated in the Year Four Report are based on a set of specific assumptions about the distribution and effective use of investments in agricultural water use efficiency. See the *CBDA Draft Year Four Water Use Efficiency Comprehensive Report* for details on those assumptions.

Table 3-2 On-farm and water supplier recoverable and irrecoverable flow reductions. Estimated to be fully realized by 2030

Investment Level	Investment Area	Annual State Spending[1]	Reductions in Irrecoverable Flows[2]	Reductions in Recoverable Flows[2]	Quantifiable Objective[3]
		$ Million/year	thousand acre-feet per year		
1	On-farm[4, 5]	0	33	147	507 (total flow for 11 major rivers in the Bay-Delta watershed, does not include the San Joaquin River)
	Water Supplier	2.9	1	4	
2	On-farm	7.5	93	545	
	Water Supplier	7.5	10	20	
3	On-farm	15	143	876	
	Water Supplier	15	48	72	
4	On-farm	25	196	1208	
	Water Supplier	25	105	134	
5	On-farm	50	287	1723	
	Water Supplier	50	222	188	
6	On-farm	75	346	2006	
	Water Supplier	75	275	196	

1. Total spending from all sources used for improvements that are not locally cost-effective. For investment levels 2-6, the annual dollar amount includes local spending induced by the availability of state or federal grants.
2. Estimates do not include the Klamath Project (North Coast Region) or Imperial Valley (Colorado River Region).
3. Complete description of Quantifiable Objectives is found at www.calwater.ca.gov
4. On-farm irrecoverable flows include an annual savings of 143,000 acre-feet per year due to regulated deficit irrigation.
5. Much of the on-farm savings would not be achieved without the corresponding water supplier level spending. Water supplier improvements conserve water themselves and are required to enable much of the on-farm conservation.

the water use characteristics: how much of the applied water is used beneficially and how much is irrecoverable. Irrecoverable flows include those to transpiration, saline sinks and non-beneficial evaporation. In Table 3-2, the reduction in irrecoverable flows at investment level 1 is due to natural replacement of irrigation systems over the horizon of the projections. Recoverable flows encompass surface runoff and deep percolation to usable water bodies. The recoverable flow results in Table 3-2 are based on the Quantifiable Objectives that express in-stream flow needs for Bay-Delta tributaries. Although recoverable and irrecoverable flow reductions are reported separately for on-farm and water suppliers, it is not appropriate to assign benefits solely to on-farm or water suppliers due to the strong connection between on-farm recoverable flows and water supplier efficiency improvements.

Environmental benefits of water use efficiency actions are the improvement in aquatic habitat through changes in in-stream flow and timing. Additional benefits may include water quality improvements by reducing thermal loading, subsurface drainage water, and contaminant loads. Growers may receive water quality benefits by complying with pollutant reduction rules under the State's total maximum daily load requirements. However, depending on the timing of flow changes, improvements in water use efficiency can cause negative environmental effects, such as reduced runoff to downstream water bodies and increased concentration of pollutants in drain water unless the drainage water contaminants are isolated and properly disposed of. The Quantifiable Objectives flows in Table 3-2 represent the aggregate in-stream Bay-Delta watershed flow needs that can potentially be met through water use efficiency actions. When comparing the recoverable flows in Table 3-2 to the Quantifiable Objectives flows it is important to remember that the in-stream flow needs are location and time specific – thus an acre-foot to acre-foot comparison is not appropriate.

Potential Costs

The ROD estimates the cost of 563,000 acre-feet net water savings at $35 to $900 per acre-foot. The total cost of this level of agricultural water use efficiency to year 2030 is estimated at $0.3 billion to $2.7 billion, which includes $220 million for lining the All American Canal and Coachella Branch Canal.[2]

The Year Four Report cost estimate for water use efficiency improvements are summarized in Table 3-2. The water supplier improvements are assumed required to achieve on-farm improvements. The irrecoverable flow reduction estimates range from 34,000 to 620,000 acre-feet per year at a cost of $2.9 million to $150 million per year, respectively, for on-farm and water suppler level improvements. The Year Four Report estimates do not include potential water use reductions in the Klamath Project or Imperial Valley. Efficiencies calculated for the Year Four Report are lower than the ROD estimates because rice irrigation systems can only achieve about 60 percent efficiency on an individual field basis and rice acreage is significant in certain hydrologic regions (the ROD assumed that irrigation efficiency improves to an average value of 85% in every hydrologic region). Marginal costs of irrecoverable flow reduction are shown in Figure 3-1.

The cost of achieving the 620,000 acre-feet per year of irrecoverable flow reduction estimated in the Year Four Report over 25 years (about $3.75 billion), plus the cost of 94,000 acre-feet per year of water use reductions resulting from lining the All American and Coachella Branch canals (a total of 714,000 acre-feet per year) will total about $4 billion, expressed in 2004 dollars. It should be noted that costs and flow for each investment level identified in Table 3-2 includes costs and water use reductions of all previous investment levels.

The Year Four Report estimates show increasing statewide average seasonal application efficiency as a function of annual investment (Figure 3-2).

Major Issues Facing Additional Agricultural Water Use Efficiency

Funding

Funds dedicated to water use efficiency have fallen below estimates of the 2000 CALFED Record of Decision that called for an investment of $1.5 billion to $2 billion from 2000-2007. The CALFED Framework For Agreement stated that State and federal governments would fund about 50 percent (25 percent each), with local agencies paying the remaining 50 percent of CALFED water use efficiency activities.

Although the need is great, small and disadvantaged communities may not be able to apply for State and federal grants, because of the difficulty of the application and grant management processes for what are often limited funds. In addition, such water suppliers rarely have the technical and financial abilities to develop plans or implement expensive water management practices.

For some water suppliers, funding for water use efficiency comes from the ability to transfer water, such as in Colorado River region. While transfers to urban areas may reduce the amount of water available to grow crops, they are expected to play a significant role in financing future water use efficiency efforts.

Implementation

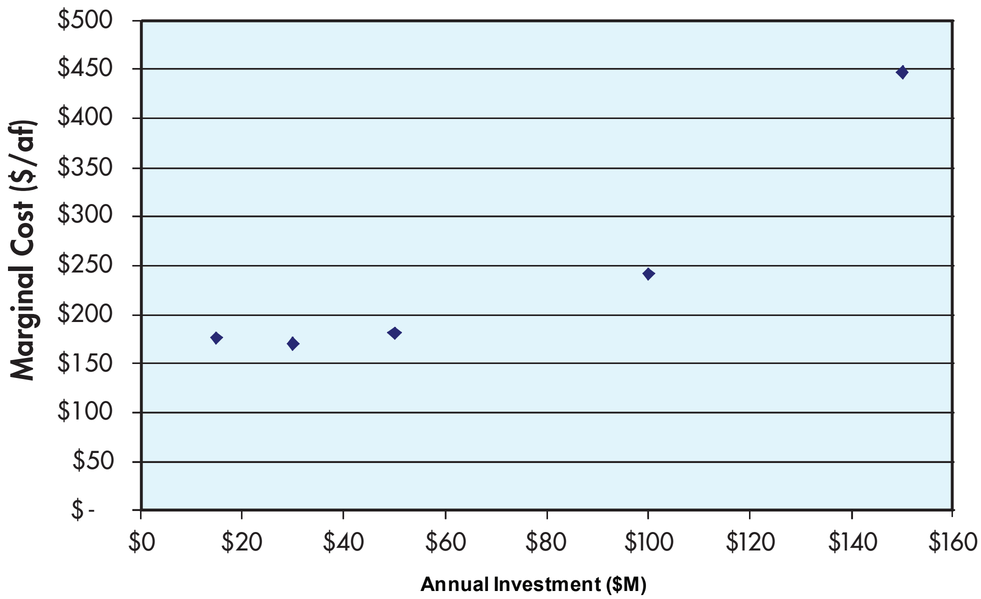
Implementation of agricultural water use efficiency depends on many interrelated factors. Farmers strive to optimize agricultural profits per unit of land and water without compromising agricultural economic viability, water quality, or the environment. Success depends not only on availability of funds but also on technical feasibility and cost-effectiveness, availability of technical assistance, and ability and willingness of growers, the irrigation industry, and water suppliers. Opportunities exist through CALFED to implement efficiency measures beyond efficient water management practices to provide water quality and flow timing benefits for the local water supplier and to provide regional or statewide benefits. Designing and installing efficient irrigation and water distribution systems will not necessarily result in improved efficiency if the systems are not well managed.

Reducing evaporation requires precise application of water. Stressing crops through regulated deficit irrigation (RDI) is one approach which requires careful scheduling and application of water and may have additional costs and adverse impact on crop quality or soil salinity. In the case of RDI, research is needed to evaluate the level of current practices, extent of implementation of these practices, and quantification of RDI benefits and impacts.

Many growers and irrigation districts believe that implementing efficiency measures could affect their water rights. They believe

[2] The cost estimates are derived from potential on-farm and water supplier efficiency improvements associated with savings in irrecoverable flows. Details of estimates and assumptions are in the CALFED WUE Program Plan (Final Programmatic EIS/EIR Technical Appendix- July 2000).

Figure 3-1 Marginal cost of irrecoverable flow reduction



Shown is marginal cost of reducing irrecoverable agricultural water uses by increasing agricultural water use efficiency. Studies show marginal costs relatively constant at about $175 per acre-foot with annual investments up to $50 million and about $450/af with annual investments at about $150 million.

that conserved water may be used by others, causing a loss of rights to the conserved water. This belief is a factor that may impede implementation of water use efficiency strategies.

Measurement, Planning, and Evaluation

Lack of data is an obstacle for assessing irrigation efficiencies and planning further improvement. The State lacks comprehensive data on the cropped area under various methods of irrigation, applied water, crop water use, irrigation efficiency, water savings, and the cost of irrigation improvements per unit of saved water. Collection, management and dissemination of data to growers, water suppliers, and water resource planners are necessary for promoting increased water use efficiency. A concern identified by some members of the Advisory Committee is a lack of statewide guidance to assist regions and water suppliers to collect the data needed for future Water Plan Updates in a usable format.

The Independent Panel on the Appropriate Measurement of Agricultural Water Use (www.Calwater.ca.gov) convened by the CBDA made specific recommendations for measurement of water supplier diversions, net groundwater use, crop water consumption, and aggregate farm gate deliveries. In addition, the panel recommended increased efforts to measure water quality, return flows, and stream flow.

Resource Requirements

Water supplier infrastructure improvements and the increasing use of pressurized irrigation systems require additional energy resources such as electricity, gas, and diesel. Pressurized systems also require pipelines, pumps, filters and filtration systems, and chemicals for cleaning drip systems.

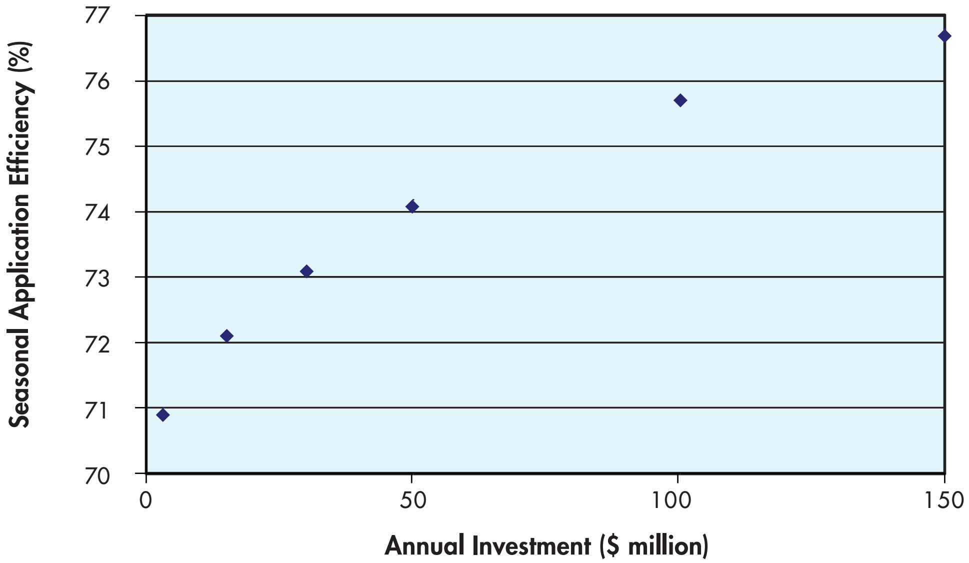
Education and Motivation

Improving agricultural water use efficiency depends on disseminating information on the use, costs, benefits, and impacts of technologies and on providing incentives for implementation. Existing evidence, although limited, indicates a strong response to financial incentives.

Dry-Year Considerations

In dry years, California's water supply is inadequate to meet its current level of use, and agriculture is often called upon to implement extraordinary water use efficiency or even land fallowing. Standard water use efficiency approaches to meet water

Figure 3-2 Statewide average on-farm seasonal application efficiency[1] at various levels of investment.



[1] Seasonal Application Efficiency is defined here as the evapotranspiration (ET) of applied irrigation water divided by the applied irrigation water.

CALFED studies show increasing statewide average seasonal application efficiency for additional annual investments in agricultural water use efficiency measures. This figure shows seasonal application efficiency increased from about 71% to 77% as annual investments were increased from zero to $150 million.

needs during dry years should to be reviewed and adopted. New approaches should be explored such as alfalfa summer dry-down and regulated deficit irrigation to save water.

Recommendations to Achieve More Agricultural Water Use Efficiency

The following recommendations can help facilitate more agricultural water use efficiency:

1. The State should identify and establish priorities for grant programs and other incentives as has been done by the CALFED Program for its solution area. This should include a process for quantifying and verifying intended benefits of projects receiving State loans and grants.
2. The State should fund technical and planning assistance to improve water use efficiency including local efforts to implement efficient water management practices and meet CALFED water use efficiency goals:
   - Provide technical and financial assistance to the Agricultural Water Management Council for implementation,monitoring, and reporting of all cost-effective efficient water management practices
   - Cooperate with the agricultural community to fund research, development, demonstration, monitoring and evaluation projects that improve agricultural water use efficiency
   - Support programs that encourage the development of new cost-effective water savings technologies and practices and evaluate cost-effectiveness of practices
   - Develop methods to quantify water savings and costs associated with hardware upgrade, water management, and evapotranspiration reduction projects identified in this strategy.
3. The Agricultural Water Management Council should continue to incorporate CALFED Quantifiable Objectives within the agricultural water management planning and implementation process, where applicable.
4. State loans and grants should provide ample opportunities for small water suppliers and economically disadvantaged communities, tribes and community-based organizations to benefit from technical assistance, planning activities, and incentive programs based on environmental justice policies.

5. The Agricultural Water Management Council should continue to encourage more water suppliers to sign the Memorandum of Understanding to broaden its support base. The Council should seek the support of the State and local agencies for full implementation of efficient water management practices by signatories and encourage the addition of new efficient practices as benefits are identified.
6. Expand CIMIS, mobile laboratory services, and other training and education programs to improve distribution uniformity, irrigation scheduling, and on-farm irrigation efficiency.
7. The State should provide additional funding for long-term ET reduction (regulated deficit irrigation, mulch, alfalfa dry down, etc.) demonstration and research plots and fund other promising programs to reduce evapotranspiration. Based on the long-term ET reduction studies and research, DWR should develop informational guidelines that define the crop water consumption reduction practices, identify how they can be implemented for each crop, and estimate the potential crop benefits and impacts, water savings, and costs for growers and water suppliers.
8. Encourage billing by volume of water-delivered rate structures that improve water use efficiency.
9. Collect, manage and disseminate statewide data on the cropped area under various irrigation methods, amount of water applied, crop water use, and the benefits and costs of water use efficiency measures. Develop statewide guidance to assist regions and water suppliers to collect the type of data needed in a form usable for future Water Plan Updates. DWR should work with the AWMC to develop a database of information from the Water Management Plans on water use-related data for dissemination and use in the Water Plan Update. DWR should work with CBDA to implement the recommendations of the Independent Panel on the Appropriate Measurement of Agricultural Water Use.
10. Develop community educational and motivational strategies for conservation activities to foster water use efficiency, with the participation of the agricultural and water industries and environmental interests. Develop partnerships with State, federal, UC Cooperative Extension Service, farm advisors, irrigation specialists, and State educational and research institutions to provide educational, informational, and training opportunities to growers, water supplier staff, and others on variety of water and irrigation management practices, operations, and maintenance.
11. The State should explore and identify innovative technologies and techniques to improve water use efficiency and develop new water efficiency measures based on the new information. Consider fast-track pilot projects, demonstrations, and model programs exploring state-of-the-art water saving technologies and procedures, and publicize the results widely. Foster closer partnership among growers, water suppliers, irrigation professionals, and manufacturers who play an important role in research, development, manufacturing, distribution, and dissemination of new and innovative irrigation technologies and management practices.

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