Water Conservation Programs—A Planning Manual

MANUAL OF WATER SUPPLY PRACTICES

M52

First Edition

American Water Works Association

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AWWA MANUAL M52

First Edition

American Water Works Association

Science and Technology

AWWA unites the entire water community by developing and distributing authoritative scientific and technological knowledge. Through its members, AWWA develops industry standards for products and processes that advance public health and safety. AWWA also provides quality improvement programs for water and wastewater utilities.

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Contents

Figures

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Tables

Foreword

This publication is the first edition of the American Water Works Association Manual M52, *Water Conservation Programs—A Planning Manual*. The manual provides information on how to develop, implement, and measure the success of a utility conservation program.

This manual is intended for use by water utilities that are contemplating the development of a conservation program. Also, water suppliers that already have a conservation program can use this information for improvement and gain the benefits of a more comprehensive approach.

The Water Conservation Division (and its working committees) welcomes feedback on the content of this manual. As this field evolves, adjustments to the manual will be necessary. Reader comments are a critical part of the review and revision process.

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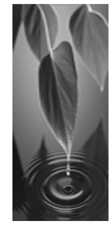

Chapter 1

Introduction

Water conservation is a key component of overall water resources planning. Conservation programs that are carefully designed and implemented can bring many benefits. Among these are the efficient utilization of available sources of supply, public recognition and participation, and improved support for water pricing adjustments.

WHAT IS WATER CONSERVATION?

If this question was asked of water professionals in the 1930s through the 1960s, most would have said "water conservation involves building a reservoir to capture runoff that would otherwise be wasted by flowing into an unusable water body, like the ocean." Starting in the 1970s, water professionals became aware that minimizing water waste was essential. For example, AWWA's water resources policy in 1975 included the statement, "Every effective means to prevent and minimize waste and promote wise use should be employed by all entities, public and private, engaged in water resource activities." AWWA's first handbook on water conservation, *Water Conservation Management*, was published in 1981 followed by an updated handbook, *Water Conservation*, in 1987.

This manual is an update of these original works. Shown in Figure 1-1 is AWWA's current policy on water conservation. A more extensive description of the role of water conservation in water resources management is contained in AWWA M50, *Water Resources Planning*. AWWA's White Paper on conservation can be found at the end of this chapter.

Long-Term Versus Short-Term Conservation

A common public perception is that water conservation means restricting or curtailing customer use as a temporary response to drought. Though water use restrictions are a useful *short-term* drought management tool, most utility-sponsored water conservation programs emphasize lasting *long-term* improvements in water use efficiency while maintaining quality of life standards. Water conservation, very simply, is doing more with less, not doing without.

Accepted definitions. Long-term water conservation is often used interchangeably with the terms *demand management* and *efficient use*. For example, the California Water Code states (Section 10611.5): "Demand management means those water conservation measures, programs, and incentives that prevent the waste of water and promote the reasonable and efficient use and reuse of available supplies." The Texas Water Code (Section 11.002) defines water conservation as "those practices, techniques, and technologies that will reduce the consumption of water, reduce loss or waste of water, improve the efficiency of the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses."

Adopted by the Board of Directors Jan. 27, 1991, revised Jan. 31, 1993, and June 15, 1997, and reaffirmed Jan. 20, 2002.

The American Water Works Association (AWWA) strongly encourages water utilities to adopt policies and procedures that result in the efficient use of water, in their operations and by the public, through a balanced approach combining demand management and phased source development.

To this end, AWWA supports the following water conservation principles and practices:

1. Efficient utilization of sources of supply;
2. Appropriate facility rehabilitation or replacement;
3. Leak detection and repair;
4. Accurate monitoring of consumption and billing based on metered usage;
5. Full cost pricing;
6. Establishment of water-use-efficiency standards for new plumbing fixtures and appliances and the encouragement of conversion of existing high-water-use plumbing fixtures to more efficient designs;
7. Encouragement of the use of efficient irrigation systems and landscape materials;
8. Development and use of educational materials on water conservation;
9. Public information programs promoting efficient practices and water conservation by all customers;
10. Integrated resource planning;
11. Water reuse for appropriate uses; and
12. Continued research on efficient water use practices.

Figure 1-1 AWWA official policy on water use efficiency

WHY CONSERVE WATER?

There are many reasons for water utilities to pursue wise water use and establish a water conservation program. The specific reasons will be different for each utility, and the appropriate level of conservation for a utility should be tailored to local needs. This manual will show utilities how to customize a program to local needs.

There is a broad array of reasons to pursue efficient water use. Some examples for consideration are included below:

- Cost savings—lowering water production and/or distribution costs will save the utility and its constituents money in reduced operation cost and possibly deferred capital costs. Conservation is often an important part of a least-cost future water supply plan.
- Wastewater treatment and disposal benefits—reduction of interior water use cuts wastewater flows, resulting in cost savings and lessened environmental impacts of treated wastewater disposal.
- Environmental benefits—water removed from a water body for human use could be used for environmental and other purposes. For example, protection of endangered species often requires a reliable source of good quality water, which might be lessened by water withdrawals.
- Competing beneficial uses—in addition to the environment, water left in place could be used for agriculture, power production, recreation, aesthetic enjoyment, etc.
- Water supply limitations—few places now enjoy unlimited water supplies. Water conservation can stretch existing supplies, whether supply is from groundwater or surface water.
- Utility stewardship and sustainability—utilities that conserve water demonstrate leadership in resource management and are working toward a goal of sustainability. More economic activity can occur on the same water resource.
- Energy savings—reducing water production will save energy and reduce greenhouse gas emissions.
- Improved supply reliability—conservation can reduce the frequency and duration of drought water use curtailments by essentially increasing supply.
- Customer benefits—customers who conserve water may enjoy lower water bills and possibly lower wastewater and energy bills.
- Regulatory compliance—some state regulatory agencies require water conservation plans and/or implementation progress to qualify for permits, grants, and loans.
- Public perception—the public often insists on demonstrating efficient use of existing water supplies before supporting expansion of supplies to meet new water needs.

Are There Any Drawbacks to Pursuing Efficient Water Use?

Sometimes there are factors that must be carefully weighed before deciding to pursue aggressive conservation. Considerations may include the following:

- Reduction of water use often requires utilities to modify their demand and revenue forecasts, rates, and/or rate structures.
- Some utilities need assistance from specialists in water conservation to provide specific expertise on how to implement conservation programs and properly assess the benefits from such programs. Selling less water seems unconventional.
- Many utility billing systems do not support customer sector water use data needs and analysis.
- In some locations, conservation can threaten the “use it or lose it” doctrine of water law and water rights.

This manual attempts to overcome many of these considerations and potential drawbacks to enable utilities to pursue new ways to meet the needs of customers or to improve existing methods.

TEN STEPS TO DEVELOP A WATER CONSERVATION PLAN

To start a water conservation program, a water conservation plan should be developed. The following ten basic steps outline the activities undertaken in a water conservation planning effort to develop a cost-effective plan.*

1. Review detailed demand forecast
2. Review existing water system profile and descriptions of planned facilities
3. Evaluate the effectiveness of existing conservation measures
4. Define conservation potential
5. Identify conservation measures
6. Determine feasible measures
7. Perform benefit–cost evaluations
8. Select and package conservation measures
9. Combine overall estimated savings
10. Optimize demand forecasts

Review demand forecast. A baseline forecast of the water use analyses and the demographic (customer account or population) projections should be created. The impacts of current and selected additional conservation measures can be superimposed on the baseline forecast.

Review existing water system profile and descriptions of planned water supply facilities. As water demands increase, utilities need to maintain information necessary to develop and update a system profile from an inventory of existing resources and conditions. A review of this information is essential for accurately targeting water conservation measures as appropriate emerging needs, for example reductions in peak-day water use.

Evaluate the effectiveness of existing conservation measures. If existing conservation measures are present in the water use analyses, the degree of current and prospective conservation stemming from these measures needs to be quantified. Some of this effect could be naturally occurring if it results from code requirements,

***USEPA Water Conservation Planning Guidelines*, EPA-832-D-98-001, August 1998 for example, in the US Energy Policy Act of 1992, which requires that replacement fixtures and fittings in new construction are the water-efficient types. Forecasts of the overall water savings from naturally occurring conservation measures is about 5 to 15 percent of total water needs by 2030 (*Impact of the National Plumbing Efficiency Standards on Water Infrastructure Investments* [*California Urban Water Conservation Council, 2001*]).

Define conservation potential. A detailed assessment of the indoor and outdoor water use for existing and new customers is essential to determine the conservation potential. A comparison of the water use profile with AwwaRF studies, such as the *Residential End Uses of Water Study* (AwwaRF, 1999) and the *Commercial and Institutional End Uses of Water Study* (AwwaRF, 2001), should be made to identify the potential for additional conservation.

Identify water conservation measures. Even though many water conservation measures are transferable among locations, water conservation measures should be tailored on a case-by-case basis to develop the most effective program for local conditions within a given service area.

Numerous water agencies around the world, particularly in the arid climates (for example the arid parts of the southwest–US), have been implementing water conservation programs for well over 20 years. General conservation methods, both as internal utility actions and through customer participation, that can be targeted include

Basic measures:

- Public education
- Codes and standards
- Water waste restrictions
- Consumption-based metering and billing
- Water distribution system improvements (leakage reduction)

More advanced measures:

- Irrigation efficiency improvements
- New home xeriscaping (low water use landscaping)
- Large landscape irrigation improvements
- Residential home water efficiencies
- Large commercial efficiency projects
- Small commercial efficiency projects
- Municipal, publicly owned building interior and exterior retrofits
- Low-flush toilet replacements
- Commercial landscape ordinances
- Industrial and institutional efficiency projects
- A conservation rate structure using water budgets—consumption benchmarking tool against local standard—versus individual customer

Most utilities that have not implemented a conservation program will want to look first at the basic measures. After they have some experience, they can proceed to the more advanced measures.

Determine feasible measures. Not all conservation measures will be practically, politically, or economically feasible for a given utility. For example, drought-tolerant landscaping is not suitable for some climates or some utilities; an inclining block rate structure is not suitable for an unmetered area or where there is strong customer resistance; and capital-intensive reclamation facilities will not provide an economic return in smaller communities. To complete the feasibility analysis, the number of accounts that could and would use each measure and the specific savings over time that would accrue to its implementation must be determined. In addition, the existence of legislative or institutional obstacles to implementation needs to be researched. Estimates of market penetration are based on measure design and experience from similar measures implemented by other water utilities.

More than 100 individual conservation measures could be implemented among the residential, commercial, industrial, irrigation, agricultural, and public authority accounts in large metropolitan areas. The implementation of conservation programs usually includes customer education, sometimes financial assistance (toilet rebates), sometimes financial incentives (conservation rates), and sometimes legislation (plumbing codes for ULFT replacements). Measures can be qualitatively screened to a shortlist of the most promising measures. The short-listed measures can be evaluated for water savings, benefits, costs, and practicality.

Perform benefit–cost evaluations. If supply is critical, the benefits of conservation are virtually priceless: it is a matter of having enough water for essential indoor residential and commercial needs. Under less extreme circumstances, however, it is necessary to conduct a basic benefit–cost analysis that relates the value of water saved to the cost of implementing the program over a useful program life. A frequent basis for valuing conservation programs is through the benefits associated with the delay, downsizing, or averting of new facilities. Some communities engage in modest conservation efforts as part of public-spirited programs that link with ecological and environmental goals for a better world to live in. Benefits are often measured from the consumer's point of view, usually in terms of less water consumption to pay for and less energy cost for heating water.

Select and package conservation measures. Individual conservation measures should be packaged into a comprehensive program for implementation. The package will include that array of justifiable outdoor and indoor measures that meet the payback criteria and will achieve needed and targeted results. This package must also be acceptable to the utility management and governing bodies to be included in long-range demand forecasts. A stakeholder–public process should be used to confirm or guide the selection of the best package of measures.

Combine overall estimated savings. Once an optimal mix of conservation measures has been determined, an overall estimate of program water savings can be developed with a cautious summation that avoids counting estimated water savings from individual measures more than once (e.g., residential toilet leak water savings and ULFT replacement). Also, an overall program implementation schedule for the package of measures is necessary to determine the timing of conservation effects on the demand forecasts.

Optimize demand forecast. The baseline demand forecast should be modified for quantification of demand reductions and graphical comparison of the water forecast with and without conservation. Modification of demand forecasts may be done iteratively or simultaneously with different cost-effective packages of conservation measures to meet desired conservation targets. By integrating anticipated conservation, utilities can avoid rate revenue surprises. By integrating demand with the rate forecasters, utilities should recognize that implementing water conservation is successful.

DEVELOP A WORK PLAN

Responsibilities of the Water Conservation Program Manager

The responsibilities of the water conservation program manager are, initially, to develop the long-range efficiency plan and then organize and direct the various measures that the recommended program comprises. This begins with preparing a work plan that defines the schedule and budget for each task identified to implement the plan. In a small utility, the manager will work part-time on water conservation and be responsible for carrying out most tasks. In larger utilities, managers will have the option of assigning other staff to individual tasks while they coordinate the overall program.

Work Plan

Implementation can be a long, slow process, similar to planning, designing, and building capital facilities. A 10-year time period from implementation to actual water savings benefits may often be appropriate. Many conservation measures take about three to four years to become fully operational. The following guidelines may help utilities with implementation:

- Establish clear lines of communication for staff and management
- Obtain the necessary funding for selected measures
- Decide appropriate mix of staff and contractors for each measure
- Consider teaming with neighboring utilities to capitalize on economies of scale
- Hire or assign staff to coordinate each measure
- Design the individual measure startups
- Advertise the measures to the target participants
- Involve elected officials in the launching of each measure
- Involve the public in marketing measures
- Publicize the success of each measure
- Evaluate the cost-effectiveness of each measure
- Update the efficiency plan every two to three years

Examples of implementation tasks for specific measures may include

- Developing a public information and in-school education program
- Setting up and conducting speakers' groups with volunteer or paid presentations about the water efficiency program
- Disseminating information and conducting public education activities
- Supervising retrofit device or fixture distribution

- Offering assistance to large users on the system such as industries, universities, parks, etc.
- Overseeing the utility water loss control and leak reduction program
- Revising local laws, codes, or ordinances to require the installation of water-saving fixtures
- Developing incentives to encourage efficiency, including appropriate water pricing and rebates
- Liaising and coordinating with the program run by neighboring water supply utilities

RESPONSIBILITY OF PROGRAM PARTICIPANTS

In addition to the water conservation program manager, other individuals and groups may be involved in program implementation. These persons or groups and their roles include

- The water utility manager who approves the final efficiency plan and authorizes budget and staffing requests. The manager will also extend formal requests for participation on a water efficiency advisory committee, if desired.
- The water utility board of directors, whose members may be publicly elected, is often supportive of water conservation programs, as such programs are popular with customers and public interest groups. The efficiency program manager should use all possible opportunities for presenting success stories at board meetings to advocate the authorization of additional programs and funding.
- The water efficiency advisory committee. Medium-sized and large utilities often have an advisory committee, the role of which is to review and comment on plans, potential measures, and implementation strategies. The committee can either be internal or a citizen advisory committee.
- Consultants specializing in developing efficiency plans, providing advice on the implementation of measures, and evaluating water savings and cost-effectiveness resulting from completed measures.
- Contractors, who are sometimes hired to conduct programs.
- Public information specialist. Special skills are required to handle the program aspects related to publicity and public education. In the beginning and periodically, this specialist can direct the stakeholder–public process used to help select the plan and periodically update it. The task can be implemented in-house or contracted to a public relations company.
- Participants. The program will not succeed without the participation of targeted customers. They should be encouraged, with an offer that is too attractive to decline, to participate in making the changes in order to achieve efficiency. Education, regulations, and incentives such as rebates can all convince customers to participate.

PARTNERSHIP OPPORTUNITIES

One way to prepare and implement a conservation plan is to work with another water utility planning process. This can reduce plan preparation and implementation costs and make for more effective programs. Opportunities to partner include

- **Integrated resource plans** (IRPs) can be prepared to address future supply and demand imbalances. This is probably the best way to address the role of conservation in utility water resources planning. IRPs often identify stakeholders and potential partners.
- **Wholesale water agencies** may offer an opportunity to partner on planning and implementing water conservation programs. Often the wholesale agency can implement certain elements of the plan more cost-effectively. For example, preparation of regional educational materials, regional promotions, discount purchases, and purchase of media time are examples of getting the wholesale agency involved. Often funding this approach is a matter of amending one master agreement.
- **Energy, storm water, solid waste, and wastewater utilities** sometimes have common interests relating to water conservation. Oftentimes, partnerships increase the likelihood of program implementation. Examples of water and energy partnerships abound, such as promoting water-efficient clothes washing machines that save both water and energy. Wastewater agencies may be interested in jointly funded flow reduction programs, such as a toilet rebate program, if it can help them meet discharge requirements or capacity constraints. These partnerships are more likely to help in the area of program implementation, rather than in plan preparation.

ORGANIZATION OF MANUAL

The manual is organized into six chapters and three appendices. The content is briefly described as

- **Chapter 1 Introduction—**The first chapter sets the stage for what follows by defining water conservation, listing reasons to conserve water, and stating AWWA's policies and positions on efficient water use.
- **Chapter 2 Need for Efficiency and Setting Goals—**This chapter describes how to assess the need for conservation and describes the pros and cons of establishing a program in more detail. A process to set conservation program goals, qualitatively and quantitatively, is proposed. Coordination of utility goals with other department and agency goals is described. The goals of leading organizations focused on water conservation are highlighted.
- **Chapter 3 Analysis of Water Use and Water Savings—**Chapter 3 provides a method to forecast future water needs before additional conservation is considered. Methods to assess and reduce water losses are covered, and a list of customer conservation measures is presented. The reader is referred to various sources for costs and savings data on conservation measures. A screening process can be used to reduce the number of measures to be quantitatively evaluated.
- **Chapter 4 Evaluation of Benefits and Costs—**This chapter describes how to estimate water savings from conservation measures, benefits, and

costs and how to find the ratio of benefits to costs so as to be able to compare cost-effectiveness of alternate conservation programs. Different perspectives on benefit–cost analysis are offered, and an example calculation is provided.

- **Chapter 5 Creating a Formal Water Conservation Program Plan—** Once future water needs have been assessed, options to conserve water have been analyzed, and goals set, the recommended plan can be selected and detailed with schedule, budget, etc.
- **Chapter 6 Dealing With Perceptions, Barriers, and Obstacles to Provide Effective Demand Management—**Involving the public in developing and carrying out the program is covered. The final chapter describes what is necessary to carry out a successful program. Having an adopted conservation plan is important but having the tools to carry it out and overcome obstacles requires a unique set of skills and support of key stakeholders.
- **Appendixes—**References are provided in Appendix A, and case studies of successful implementation of conservation measures are contained in Appendix B. Appendix C is an example drought ordinance.

APPENDIX 1 TO CHAPTER 1
AWWA WATER CONSERVATION WHITE PAPER

(www.awwa.org/advocacy/govtaff)

Approved June 28, 1995.

Water conservation can be defined as practices, techniques, and technologies that improve the efficiency of water use. Increased efficiency expands the use of the water resource, freeing up water supplies for other uses, such as population growth, new industry, and environmental conservation.

Water conservation is often equated with temporary restrictions on customer water use. Although water restrictions can be a useful emergency tool for drought management or service disruptions, water conservation programs emphasize lasting day-to-day improvements in water use efficiency.

The Role of Water Conservation

Community water supply management requires balancing the development of adequate water supplies with the needs of the utility's customers. Traditionally, water utilities have focused primarily on developing additional supplies to satisfy increasing demands associated with population growth and economic development. Increasingly, however, water utilities throughout the United States are recognizing that water conservation programs can reduce current and future water demands to the benefit of the customer, the utility, and the environment.

The increasing efforts in water conservation, often called demand-side management, are spurred by a number of factors: growing competition for limited supplies, increasing costs and difficulties in developing new supplies, optimization of existing facilities, delay or reduction of capital investments in capacity expansion, and growing public support for the conservation of limited natural resources and adequate water supplies to preserve environmental integrity.

The focus of any supply strategy is to satisfy customer water needs in the most cost-effective and efficient manner, minimizing any adverse environmental impact and preserving the quality of life. Although conservation is sometimes an alternative to developing additional supplies, it is more often one of several complementary supply strategies for a utility. A conservation strategy, like any supply strategy, is part of a utility's overall planning and part of the integrated resource planning to ensure that all important community objectives and environmental goals are considered.

Water conservation in the broad sense is a key element in the day-to-day management of the modern water utility. Sound management includes the following basic water conservation practices:

- Reduction of water losses through universal metering and accounting of water use, routine meter testing and repair, and distribution system leak detection and repair
- Cost-of-service–based water rates
- Public information and education programs to promote water conservation and to assist residential and commercial customers with conservation practices

Beyond these fundamental conservation practices, effective water conservation programs are tailored to the needs and priorities of each community and recognize local and regional water demand characteristics and water supply availability.

Water Savings and Reliability

Conserved water can be considered a reliable water source. Great strides have been made over the past decade in evaluating and documenting the effectiveness of various conservation programs. Today there is a body of knowledge on water conservation, gained from the experiences of utilities, that provides a relatively high degree of confidence in the reliability and predictability of various water conservation measures. Some water planners feel, however, that the predictability and permanence of conservation measures have not been proven to the same degree as traditional supply measures.

The reliability of conserved water depends on accurate estimates of potential savings, expected benefits, and costs. Careful analysis and planning is a prerequisite to major utility investments in conservation programs. Reliability concerns also underscore the ongoing need for utilities to monitor and document the effectiveness of their conservation programs, just as they do water supplies and facilities.

Long-term conservation programs can affect short-term demand management practices. Reductions in water demands from long-term conservation programs and reductions from short-term demand management measures can overlap. Customers who have installed retrofit devices under long-term conservation programs may have less ability or willingness to further conserve.

In the event of water shortages, agencies with broad-based water conservation programs are able to mitigate short-term and long-term effects better than those without a conservation program.

Financial Aspects of Conservation

Conservation programs typically involve up-front costs, including revenue losses. The full benefits of conservation are realized only after all savings have materialized. However, reduced water sales because of conservation often develop slowly in small increments that can be accommodated in periodic rate adjustments.

Over the long-term, conservation can decrease a utility's need for new capital facilities for supply acquisition, treatment, storage, pumping, and distribution. It may also reduce the costs of operating those facilities. Deferring investment in such facilities or reducing their size can provide significant cost savings. In areas experiencing population growth, conservation can provide additional capacity to accommodate growth, resulting in a larger customer base over which to spread future capital costs. Water rates may be lower with conservation than without.

Water conservation can affect wastewater collection and treatment systems. Reduced hydraulic loadings can improve treatment performance in terms of effluent quality and reduced operating costs. Reducing wastewater flows through conservation can result in cost savings by deferring the need to enlarge wastewater treatment facilities.

Rates. The first goal of any rate structure is to generate sufficient revenues to maintain efficient and reliable utility operations, and the second is fairness in the allocation of utility service costs. Generally, it is possible to satisfy both of these goals in a rate structure that encourages water conservation or penalizes excessive water use.

Conservation-oriented water rate structures by themselves do not constitute an effective water conservation program. Rate structures work best as a conservation tool when coupled with a sustained customer education program. Customer education is important to establish and maintain the link between customer behaviors and their water bill. Utility customers require practical information about water-conserving practices and technologies. Participation in other water conservation programs, such as plumbing-fixture retrofit and replacement programs, can also be enhanced by rate incentives and customer education. Finally, public acceptance of rate structure changes is often enhanced if customers understand the need for and benefits of water conservation.

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Chapter 2

Need for Efficiency and Setting Goals

This chapter presents an overview of incentives for conservation, discusses the overall need for conservation, outlines the iterative process of setting goals, explores potential advantages and disadvantages, defines the potential benefits of partnerships with other types of local utilities or public works departments, and gives an overall approach to demand management programs.

Given that the focus of this manual is exclusive to defining the appropriate, cost-effective level of water use efficiency for a water utility, basic goals that will direct the analysis of cost-effectiveness, as discussed in chapter 4, should be established. General descriptions of the issues that demand management measures may help to solve are the first step. Some of these issues that commonly serve as incentives for an efficiency program are discussed in the following section. Clarity in transforming these fundamental goals into cost-effective water conservation targets is essential; and the targets will be further refined through the planning process. Goals focus the program and allow for tracking implementation efforts, which is the key to demand management program success.

TYPICAL INCENTIVES FOR WATER UTILITIES

Water use efficiency is a necessary component of a successful overall water supply plan. Efficiency is achieved when demand is decreased to optimize available or planned future water supplies. When investigated as part of the integrated resources planning (IRP) process, efficiency may serve as a complementary parallel partner to water supply planning or as a stand-alone supply (deferral) alternative. These concepts are further described in the AWWA M50 *Water Resources Planning* and the AWWA White Paper on integrated resources planning (www.awwa.org/advocacy/govtaff).

The principal reasons for undertaking efficiency programs are to reduce demand and extend water supplies, reduce long-term customer cost, or to address utility emergencies. However, drought emergencies have led to the start of overall long-term water conservation programs in numerous communities. Long-term shortages are the overall focus of this manual with short-term shortages discussed in various other AWWA publications, such as the AWWA *Drought Management Handbook*.

The primary incentives for efficiency are (1) cost savings on water and wastewater capacity and operating expenses; (2) regulatory requirements; (3) long-term water supply planning needs; (4) customer service; and (5) short-term emergencies (or curtailment needs).

Regulatory Requirements

Increasing pressure from local, state, and federal regulatory authorities is leading utilities to establish water efficiency programs. This trend is expected to continue as more new water sources grow more scarce and concerns escalate over water quality, environmental issues, aquatic habitat of endangered species, etc. In some cases, regulatory agencies are mandating water use efficiency programs before authorizing the development of new water sources or the construction of capital facilities.

In the US, federal and state agencies encourage conservation through implementation of laws and regulations, codes, and standards; development of guidelines; sponsorship of research; dissemination of information to water utilities; and assistance with program funds through grants or loans. For example, the US Department of Energy oversees the National Plumbing Efficiency Standards, which mandate water efficient plumbing fixtures. In addition, many states require a water conservation plan before a new water right or permit of use is granted.

Long-Term Planning Considerations and Issues

The AWWA M50, *Water Resources Planning*, along with many other leading references on IRP, addresses the complex matrix of long-term planning issues that face a water utility. Certain themes focused on water efficiency are repeated in many of these references, for example:

- Rates of increased demand can be slowed by conservation, even though demand often increases because of demographic influences.
- Conservation will reduce both the average and the peak demand.
- Conservation will decrease operation and management (O&M) (see chapter 4) as well as capital expenditures.
- The full benefits of conservation can be measured only by including the financial value of deferring capital expenditures.
- In addition to downsizing or avoiding water supply costs, some wastewater capital expenditures can also be deferred. These benefits should also be counted as avoided costs.
- Geographic differences need to be considered in estimating avoided conservation cost.
- Environmental externalities and energy savings must be evaluated.
- Long-term planning goals are provided as a customer service from a political basis with elected officials and directors.

These themes will serve as a foundation for the qualitative goals of a water efficiency program.

QUALITATIVE NEED FOR CONSERVATION

The qualitative need for conservation will be individual to each utility. This need should be guided by a stakeholder (utility personnel, public officials, customers, regulators) involvement process to brainstorm the key reasons to undertake an efficiency program. To assist in the brainstorming process, the following section outlines some key questions and some potential advantages and disadvantages for pursuing water efficiency alternatives.

Setting Goals

Water demand reduction goals are essential to water conservation programs. Goals provide a yardstick against which to measure progress in reducing consumption and should be set by local water utilities, based on meeting the targets established. Goal setting should also be based on the need to save water, taking into consideration the region-wide need to extend available water supplies and prevent capacity shortages in individual utility water systems, as well as to provide important environmental benefits. On the supply side, answers to the following questions will help formulate specific goals for individual utilities:

- If the system has a water supply shortage, is it limited to one utility or one portion of the service area, or is it a region-wide shortage?
- Is the supply constrained by a drought emergency or long-term (multiyear) occurrence?
- Is the shortage occurring now or is it projected to occur in the future?
- What is the primary cause of the long-term supply shortage? Possibilities could include high growth in demand, system leaks, withdrawal permit limits, transmission mains or water treatment plant capacity issues, distribution pipeline delivery limitations, or inadequate water supply.
- Does the supply shortage occur during peak demand periods each day, during the high use seasons of the year only, or does it occur throughout the year?

On the demand side, answers to the following questions will enable a quantifiable goal to reduce demand to be set:

- What level of water use reduction is needed? (Typically a 5–10 percent reduction could be considered small, 10–20 percent medium, 20 percent or more is a large reduction or an ambitious goal.)
- What type of users will be impacted the most?
- What categories of use are growing the fastest?
- Where is the conservation potential?
- How much can be saved in a cost-effective manner?
- How are the revenue impacts defined and integrated?

General overall goals can be expressed in terms of

- total water savings at some point in the future, expressed as a percent of total production and/or quantity of water saved; and

- benefits realized, such as a major project deferred or avoided and water made available for future growth.

Specific conservation measure goals should be developed. Goals that measure implementation progress in terms of specific activities, such as the number of audits completed in a year, can also be useful for monitoring progress. This information is easier to acquire and track and is generally available before water savings can be measured.

Measurement of progress against goals is useful to the utility to ensure continued program support and funding; to state and federal regulatory or permitting authorities to show that water is being used efficiently and progress can be ascertained; and to modify goals, if necessary. Water savings for some measures, such as public information, are not easily quantified. Water savings from measures such as plumbing fixture retrofits are easier to quantify, because reliable water savings data have been published. Water savings are best approached on an individual measure basis, as described further in chapter 3.

Defining Program Advantages and Disadvantages

By defining the overriding benefits to the utility and identifying any potential disadvantages, the planner will establish a tailored set of qualitative goals. Once established, the utility planner will be better organized when assessing the quantitative goals for water savings, as presented in chapter 3. In addition, understanding the benefits of the demand management program assists with identifying approaches to implementing measures that are targeted at end uses of water that have the highest probability of gaining desired water savings.

Potential Advantages

The benefits of water efficiency apply to utilities of all sizes located throughout the US and abroad. An overview of general benefits to water efficiency programs is summarized in Table 2-1.

Potential Constraints and Perceptions

Relying on demand management measures may also have some potential constraints for utilities or have negative perceptions from stakeholders. Some of these issues are summarized along with potential solutions in Table 2-2.

The process of reviewing both the advantages and disadvantages will be beneficial, as the goals become defined and further refined.

IDENTIFY MUTUAL GOALS WITH OTHER UTILITIES OR DEPARTMENTS

There is synergy available through working with other local utilities or internal public works departments. A brief summary of each type of organization and their potential interest in water efficiency programs follows.

Wastewater: There are two primary benefits to reductions of wastewater volumes caused by decreases in indoor water use from more efficient plumbing fixtures and appliances. Most notably, benefits are in the form of (1) reductions in O&M costs (energy, chemicals, land disposal); (2) assistance in meeting waste discharge regulatory requirements that are volume, and in some limited cases, concentration based (e.g., reductions in oil and grease from limiting household garbage disposal use).

Table 2-1 Overview of benefits from water use efficiency

Recipient of Benefit	Type of Benefit	Description
Water Utility	Supply System O&M	Short-term and long-term O&M costs reduced as a result of lower energy expenses because of reduced pumping and chemical use in water treatment and disposal. (The Electric Power Research Institute estimates that from 4 to 5% of all electricity used in the US is used for pumping water.) For city governments, energy usage for water and wastewater utilities can exceed 60% of total energy expenses.
Water Utility	Supply System Capital Investment	Capital facilities can be deferred or downsized.
Water Utility	System Reliability	Less water purchased from wholesale water purveyors and more reliability of supply yield, depending on capacity availability.
Wastewater Utility	System O&M	Short-term and long-term O&M costs reduced as a result of lower energy expenses because of reduced hydraulic loading on collection systems, volume pumping, aeration, and chemical use in wastewater treatment.
Wastewater Utility	Disposal System Capital Investment	Capital facilities for land disposal can be deferred or downsized. Additional benefits when wastewater discharge restrictions exist.
Environment	Quality Enhancement	Decreased need for dams and reduced construction disturbance in natural waterways.
Environment	Quality Enhancement	Higher in-stream flows for fish and wildlife habitat and lower withdrawals from supply sources.
Environment	Quality Enhancement	Lower discharges of treated wastewater to receiving waters.
Environment	Quality Enhancement	Reduced pollution because of less construction of capital facilities.
Community	Aesthetic Quality	Diminished aesthetic effects on waterways from avoided capital projects.
Community	Environmental Justice	Fewer social equity issues with facility concerns.
Community	Economic	Increased economy on the same resource, creation of water conservation jobs, and customer savings in utility bills.
Community	Economic/Political	Fiscal savings from avoided or delayed new capital expenditures or bond indebtedness.

Adapted from: AWWA M50, *Water Resources Planning Manual*.

Energy utilities: The benefits from less heated water use (e.g., water efficient showerheads and clothes washers) directly translate into energy savings for energy utilities. Many energy utilities cofund programs with local water utilities to capture these mutual benefits.

Stormwater: Reductions in runoff translate into decreases in pollutant loading of nutrients from fertilizers and pesticides through stormwater systems in summer

Table 2-2 Overview of potential constraints and perceptions

Issue	Perception	Potential Solution
Lack of customer participation/ understanding	Customer's view: conservation vs. rationing (sacrifice only needed in times of drought).	Marketing and customer education on their water use and opportunities for everyday cost savings on energy and water bills, such as looking at life-cycle costs of more efficient clothes washers.
Conserving water reduces revenues	Lower water sales results in less revenue for the utility.	Adjustments in rate structure may be necessary. Similarly, adjustments would be needed to raise capital for the investment in the next water supply project. The cost savings from avoided O&M costs and deferred capital facilities are directly accounted for as a benefit to the demand management program, see chapter 4.
Expense of demand management program	Efficiency programs, particularly rebate incentive programs, are not always cost-effective.	As described in chapter 4, evaluate demand management measures for level of cost-effectiveness prior to implementation.
Ineffectiveness in achieving desired water savings	Estimated water savings do not develop.	If water savings do not develop, reevaluate program design (e.g., delivery mechanisms, community attitudes, recent successes of other utilities) and adjust as needed (see below). Water savings estimates continue to be refined with new information and technologies becoming available. Quantifying water savings with best available information is necessary, as discussed in chapter 5.
Short-term drought savings become more difficult	Conservation measures over the long term reduce the available amount of water savings. Otherwise known as *demand hardening* may limit a future drought response in ability of customers to save water.	Long-term conservation programs result in reducing both the frequency and severity of drought.
Capital investment up-front required to start programs	Water savings accrue over time with avoided costs to the utility but the investment is required at beginning of the program	Avoid disjointed investments ($5mil one year and none the next) and even out over multiple years. Seek grant or loan funding to assist with subsidizing program costs and evening out the cost outlay to match the cost savings. Consider establishing a rate structure that includes a "sustainability fund," "reliability fund," or "surcharge for excessive peak summer use," which creates reserve funds to assist with funding the demand management program. These reserve funds are similar to the fees assessed to pay for new water supply projects. See case study for city of Albuquerque (Appendix B).

Table continued next page.

Table 2-2 Overview of potential constraints and perceptions—*continued*

Issue	Perception	Potential Solution
Reduction in indoor water use creates insufficient sewer flows	Public works staff concerned that retrofitting older homes with newer water-efficient toilets, showerheads, etc., will increase sewer system maintenance	A huge benefit has not been mentioned—that of deferring the capital costs for plant expansion. For example, the City of San Jose's primary reason for originally implementing a water conservation program was to reduce the wastewater flows to their regional wastewater facility. It may be instructive to note that while most wastewater treatment plants exceed their ability to treat the organic loading, oftentimes this problem can be addressed by simply adding to the existing facility. However, excessive hydraulic capacities often need to be addressed through a new and expanded facility: a problem that can often be addressed or delayed through conservation.

months. Opportunities for rain catchments systems in some areas may be an option for irrigation with nonpotable supplies.

Solid waste: Similar to stormwater benefits, overwatering of landscapes produces more green waste to be taken to landfills. The primary benefits are seen in reductions in O&M (trucking) costs and landfill space. However, if bioreactors, which convert green waste into energy, are used, reductions in green waste are not beneficial.

Health departments: Principal benefits are found in leakage reduction programs, which lead to repairing leaks that further lowers the risk of contamination into the distribution system. Additionally, water supply reliability benefits exist for water systems overseen by the local or state health departments. Demand reductions allow utilities that use multiple sources to optimize and use the sources with the highest water quality. Additionally, programs using both surface and groundwater sources to meet demands may adjust to accommodate improvements in in-stream water quality, which further enhances the ability to treat higher quality water by downstream users.

Environmental organizations: Other organizations include those focused on environmental quality, such as aquatic ecosystems or wildlife habitat, that seek improvements in water quality or time and place of water withdrawals and/or the quantity and water quality of wastewater discharges.

Professional nonprofit organizations: Organizations, such as the American Water Works Association, Water Environment Federation, American Society of Civil Engineers, track the status and research needs of the water industry, including efforts to promote water efficiency.

Other nonprofit organizations: Numerous nonprofit organizations assist with educating the public on health, environmental, water security, and other concerns. These organizations typically conduct research that may have interest in partnering in demonstration projects with water utilities. Such organizations that have national recognition include the Rocky Mountain Institute, Global Energy Partners, Consortium for Energy Efficiency, and American Council for an Energy Efficient Economy. Other state or local nonprofit organizations exist, for example, local watershed groups that may have interest in partnering on water use efficiency programs. The California Urban Water Conservation Council funds research, provides program guidance publications, and tracks water conservation implementation by water utility member programs. The American Water Works Association Research Foundation (AwwaRF) has also funded research and publications on water conservation.

Federal agencies: The US Environmental Protection Agency (USEPA), Office of Water, assists with disseminating information, funding grants, and developing guidelines for water conservation planners. Partnered with the USEPA, the US Department of Energy oversees both regulatory requirements and the Energy Star program (www.energystar.gov), which promote water-efficient plumbing fixtures and appliances. The US Bureau of Reclamation has an active role, particularly in the western US with promotion of water conservation requirements in their contracts, reporting requirements on implementation, and funding assistance. Also Federal Energy Management Program (FEMP), US Army Corps of Engineers, and the Department of Housing and Urban Development have interest in demand reductions on military facilities and federally owned housing projects.

OVERVIEW OF DEMAND MANAGEMENT APPROACHES TO IMPLEMENT GOALS

In a large region, sometimes defined by watershed boundaries, there will be a variety of regional, state, and federal agencies, and other groups interested in the demand-reduction programs that will want to verify that the plan finally adopted is being carried out.

As a matter of foresight when planning a water use efficiency program, this section lays out options on how the demand management portion of the plan can be verified. This section does not imply that plan performance should be verified or implementation should be regulated, only that plan implementation may be verified. To that end, this section reviews how other areas have addressed this issue and what they have learned from their experiences. At the end of this section, options are offered on how plan implementation could best be verified.

Summary of Approaches

There are three major demand management approaches to consider in reviewing options for evaluating program implementation progress. About half of the states have some form of conservation requirements. Programs in the states of Texas, Kansas, California, Arizona, and Rhode Island, in addition to a program in the United Kingdom, are good examples and are described below:

- Environment Agency and the Office of Water Services (OFWAT) (UK) http://www.environment-agency.gov.uk/subjects/waterres/286587/?version=1
- State of Arizona http://www.water.az.gov/Water_Use_it_Wisely.htm
- California Urban Water Conservation Council's Memorandum of Understanding (MOU) Regarding Urban Water Conservation http://www.cuwcc.org/home.html
- State of Texas, on Environmental Quality (TCEQ) Commission http://www. tceq.state.tx.us/permitting/waterperm/wrpa/conserve.html
- State of Kansas Water Office http://www.kwo.org/
- State of Rhode Island Department of Environmental Management http://www.rules.state.ri.us/rules/wrappers/767.html

Although there is probably no system that can be directly imported into a region or specific utility, the listed programs have implemented approaches that have considerable merit in the context for which they were designed. Although none are recommended, the best features are worth considering in the development of a possible hybrid approach, should that be desired by local utilities. A discussion of the approaches adopted by these organizations is provided in the following section. Web sites listed provide access to considerably more detail on what follows. Readers are encouraged to review that material carefully and weigh the options fully, rather than form opinions based on the summary provided below.

United Kingdom Leakage Targets

United Kingdom (UK) water regulators have successfully used leakage targets to require water companies to take action to reduce leakage. Historical leakage rates in the UK were high, averaging 36 percent of water produced. This meant that more water was being withdrawn from rivers than necessary, and customers were charged for the lost water. In many cases, water loss could only be roughly estimated, as the majority of residential properties were unmetered. The regulatory agency, the Office of Water Services, required the water companies to provide auditable data on the level of leakage in 1992–1993. In 1997, following the 1995 drought, OFWAT set leakage targets based on the principles of reducing leakage to a defined economic level. This approach was based on cost-effectiveness and the desire to reduce diversion of surface water from UK rivers, which had regularly experienced drought conditions. OFWAT also encouraged the installation of residential meters. Demand management programs for customers were also encouraged, although not mandated.

By 2002–2003, leakages had fallen by 29 percent, to a level closer to 23 percent, from their peak in 1994–1995[1]. Most companies have adopted the following policies in reducing their levels of leakage:

- Comprehensive district metering where District Metering Areas (DMAs) are sized at 2,000–3,000 properties with data downloaded for analysis either weekly or monthly, with consequent prioritization of detection activity by zone
- Repairs carried out quickly (typically 2–3 days) following detection
- Maximizing opportunities for pressure reduction
- Localized replacement of mains with high-burst frequencies
- The use of leakage modeling software to optimize policies

Failure to meet leakage targets carried the threat of a water company losing its operating license, which proved highly successful in focusing water companies on leakage management.

A decrease in leakage of 35 percent in six years represents an almost unqualified success. Because water companies are required to submit water balance component data to both OFWAT and more recently the Environment Agency, the reductions in leakage can for the most part be substantiated and verified.

OFWAT has not allowed funding through customer pricing mechanisms on the basis that it is in the company's interests to reduce leakage to their economic level (ELL). Water companies are now stating that if they are required to reduce leakage below their ELL, they will require additional funding for this at a regulated price setting.

The keys to success have been

- the drought of 1995 placing leakage in the media and political spotlight;
- political pressure at the highest level to address the issue;
- the water industry publishing its detailed series of reports, *Managing Leakage*[2], referencing p. 41 in 1994, which placed the UK at the forefront of understanding the issues on a global basis;
- reporting of water balance data in the public domain;
- a strong regulatory framework resulting in a high level of scrutiny (and pressure) from the economic and environmental regulators;
- water companies responding by making the necessary resources and expertise available.

The principal benefits of leakage reduction have been the deferment of new resources to meet predicted imbalances in supply and demand. This has benefited the customer through reduced prices and an improved water environment.

Other benefits have been reported:

- Water companies, by regularly monitoring in some cases thousands of DMAs, have a better understanding of the systems they manage.
- Water companies have developed expertise in leakage management that has allowed them to bid successfully for contracts worldwide.
- The UK is at the forefront of technological development in leakage hardware and software as water companies have been receptive to more efficient approaches to achieve their leakage targets.
- In the drought of 1995, when companies appealed to their customers to reduce demand, because of their high leakage levels, they lacked credibility. This is no longer the case.

In summary, the water companies and the regulator worked together to identify the ELL of leakage specific to local conditions and established targets for improvement. The International Water Association's (IWA), *Performance Indicators for Water Supply Services*[3], presented methods that evolved from the UK process, and the current practice described therein can be used to identify current leakage levels and manage reductions.

State of Arizona Municipal Water Use Requirements

In the 1970s, the state of Arizona was facing a water crisis. Surface supplies had been fully utilized and groundwater table levels were falling rapidly, because of agricultural and municipal pumping far in excess of the natural recharge rate. Arizona had rights to the Colorado River, shared with California, Utah, Nevada, and Colorado, but the water was hundreds of miles away from the areas in need. The federal government offered to build the canals and pumping stations to bring the water to Phoenix and Tucson, but only if Arizona would agree to reduce groundwater pumping to the safe yield level by 2025. A state law was passed, and it created a new state agency, the Arizona Department of Water Resources (ADWR), which devised a plan to reduce groundwater pumping in Arizona's three most populous areas. ADWR decided to reduce extraction in stages and created 10-year plans. The first went from 1980 to 1990; the second from 1990 to 2000; and ADWR is currently implementing the “Third Management Plan,” which will be in effect until 2010[4]. Water use is slowly being reduced, on a per capita basis, and groundwater pumping is being reduced as areas switch over to the new (and more expensive) surface water.

ADWR regulates municipal water use in one of three ways. Originally, there was only one program, the “Total Gallons per Capita per Day Program.” Now, there are two other programs, the “Alternative Program” and the “Non-Per Capita Program.” These programs are defined as follows:

- **Total gallons per capita per day (GPCD) program.** For the first management plan, all water providers were assigned a total system GPCD target based on their 1980 water use, future demand projections, and the potential savings from water conservation measures commonly used in the western US. The targets were modest and ranged from a 6 to an 11 percent reduction over a 10-year period. Generally, the higher the current water use, the higher the target. For the second management period (1990–2000), each provider was assigned a GPCD target based on an extensive analysis of the water use in each provider’s area and the conservation potential. A similar approach is being used in the third period (2000–2010). Providers who do not meet their targets are subject to fines and sanctions. All but five cities in the state are regulated in this way.

- **Alternative conservation program.** This alternative was created to provide flexibility by establishing a limit on groundwater use, a GPCD target for residential water use only, and requirements addressing specific nonresidential uses. Only one small city has signed up for this program.

- **Non-per capita conservation program.** Factors such as rapid commercial and industrial development and changing population characteristics impacted the ability of some providers to meet their GPCD targets. In 1992, the state legislature established this alternative to the GPCD regulatory program. This program requires providers to eliminate groundwater pumping, unless replaced by groundwater recharge, and to implement reasonable conservation measures (RCMs). Four medium-sized cities are now using this program (Chandler, Gilbert, Scottsdale, and Tempe). Several others are considering switching to this program, because compliance is generally easier.

Currently, the ADWR specifies 12 RCMs and provides four substitute RCMs that can be used in lieu of the original 12 RCMs. These RCMs cover all aspects of municipal water use from residential to nonresidential. Agencies that adopt this program agree to the water supply requirements and to implement the RCMs in a specified way, agree to an implementation schedule, and agree to detailed annual progress reporting. Progress reporting covers details on implementation, costs, and estimated water saved per reporting period. Cities can opt for this program at any time and enter into a Memorandum of Understanding with ADWR to carry out the program. ADWR expects most cities to migrate to the Non-Per Capita Program because of the difficulty of managing total per capita water use. The Non-Per Capita Program is similar to California’s use of Best Management Practices (see the following section), except that compliance is mandatory.

In terms of compliance with management plan requirements, the ADWR can levy civil penalties for use of groundwater beyond the agreed limit. This would be triggered by not meeting the provisions of the selected municipal conservation program, for example, if per capita goals are not met or, depending on the program, agreed on RCMs were not carried out as specified. The civil penalty can be up to

$10,000 per day. In deciding whether to levy a fine or not, the ADWR considers the seriousness of the violation and the extent of the water provider's attempts at compliance and mitigation.

California's Memorandum of Understanding on Urban Water Conservation

California built massive water transfer projects in the period from 1930 to 1970. Water is imported, in some cases hundreds of miles, to accommodate the needs of growing cities in the San Francisco Bay Area and Southern California. In the 1960s, it became apparent that more projects would be needed to maintain water supply reliability. By this time, however, the environmental damage caused by existing projects was becoming evident. Laws were passed to require that environmental impacts of projects be mitigated and endangered species be protected. At the same time, "water wars" erupted with northern versus southern urban water suppliers, and both versus agricultural water users (who consume 85 percent of all water used in the state). All urban and agricultural water users opposed the views of environmental groups. The stated water needs of all groups far exceeded the supply, and no progress was made to increase supply or reduce demand. In the 1970s and 1980s, the level of trust among stakeholders was at an all time low.

In 1987, the state of California water regulatory agency, the State Water Resources Control Board, announced that they had found a solution. All that was needed was for cities to conserve and recycle more water, and the problem would be easily solved. Water agencies were very outspoken in their initial criticism of what appeared to them to be an oversimplified and unreasonable solution. However, reasonable minds prevailed and a group of the larger agencies from the north and the south decided to work together to find a solution. Environmental groups were invited to join the negotiations. This was an unprecedented step, because the agencies did not trust each other and especially did not trust the environmental groups, because the groups and agencies had no history of working together. At the time, California was two years into a drought and shortages were evident.

For the next two years, a dedicated group of 15 individuals spent many hours in numerous meetings, negotiating an agreement. A "Memorandum of Understanding regarding Urban Water Conservation in California" (MOU) was developed[5]. The recitals to the MOU present the essence of the agreement and are summarized as follows:

- Signatories recognize the need to provide reliable water supplies and to protect the environment.
- Increasing demands for urban, agricultural, and environmental water uses call for conservation and the elimination of waste as important elements of the overall management of water resources.
- Many organizations and groups in California have an interest in urban water conservation, and the MOU is intended to gain much-needed consensus on a complex issue.
- The urban water conservation practices included in the MOU (referred to as "Best Management Practices" or BMPs) are intended to reduce long-term urban demands below what they would otherwise be and are in addition to programs that may be instituted during occasional water supply shortages.

- It is the intent of the MOU for agencies to pursue cost-effective water conservation in a structured manner and consider water conservation on an equal basis with other water management options.
- The signatories agree to use the MOU as the basis for determining future water needs. This is a major step toward achieving consensus on one major issue related to approving new water supply projects. However, the MOU does not provide agreement on other issues surrounding new supplies.
- The signatories recognize that other forums will decide the issue of how the conserved water should be used and that there are other methods to meet urban water supply reliability and protect the environment.

The MOU was completed in 1991 and signed by more than 120 urban water agencies, environmental groups, and civic, business, and industrial interests in a ceremony on the State Capitol building steps. Interestingly, none of the original signatories of the MOU were state or federal agencies. This was a true breakthrough, in that water utility organizations committed themselves to implementing 16 BMPs.

In the 10 years since the original MOU was signed, it has been amended seven times. The most significant change was collapsing or dropping four BMPs and adding two. In addition to BMPs, a list of about 10 potential BMPs has been maintained. These are possibly good ways to save water but further research is needed to clarify their effectiveness. Two BMPs were added to this list, and four were dropped that proved ineffective or had already been implemented. Thus, the MOU is a living document and not a rigid, inflexible document that locks a water agency into a program that may turn out to be ineffective. Table 2-3 presents a summary of the current best management practices.

Additional features of the MOU:

- An agency is not obligated to implement a program that is not cost-effective. At any time they may request a cost-effectiveness exemption, where they are given the opportunity to prove to their peers that local circumstances show that a particular BMP is either too costly or would not save enough water to justify its pursuit.
- The MOU gives credit for past accomplishments.
- The MOU is supported by periodic research, and savings estimates are changed when new findings become available.
- There are a number of subcommittees working on refining and optimizing how a particular BMP should be implemented, and changes to BMPs are made when a better way of implementing the BMP is agreed on.

This MOU began as a voluntary process and some utilities were more diligent in implementing its provisions than others. Periodic audits over the years showed that overall performance was less than desired, because the incentives were not sufficient for some utilities to make major investments in conservation. Consequently, two important changes have been made:

1. A BMP reporting process has been established. Water utilities now fill out forms in an interactive database on the Internet that shows clearly how much progress is being made on implementing the BMP. Reporting is done every two to four years (depending on the size of the agency—larger utilities report more frequently) and includes details on the implementation schedule, expenditure, and in some limited cases, estimated water

Table 2-3 Urban water conservation best management practices for the California Urban Water Conservation Council[4]

1. **Water survey program for single-family and multifamily residential customers** (Survey 15% of residential customers within 10 years)
2. **Residential plumbing retrofit** (Retrofit 75% of residential housing constructed prior to 1992 with low-flow showerheads, toilet displacement devices, toilet flappers and aerators)
3. **System water audits, leak detection, and repair** (Audit the water distribution system regularly and repair any identified leaks)
4. **Metering with commodity rates for all new connections and retrofit of existing connections** (Install meters in 100% of existing unmetered accounts within 10 years; bill by volume of water use; assess feasibility of installing dedicated landscape meters)
5. **Large landscape conservation program and incentives** (Prepare water budgets for 90% of all commercial and industrial accounts with dedicated meters; provide irrigation surveys to 15% of mixed-metered customers)
6. **High-efficiency washing machine rebate program** (Provide cost-effective customer incentives, such as rebates, to encourage purchase of these machines that use 40% less water per load)
7. **Public information program** (Provide active public information program in water agencies to promote and educate customers about water conservation)
8. **School education program** (Provide active school education program to educate students about water conservation and efficient water uses)
9. **Conservation program for commercial, industrial, and institutional accounts** (Provide a water survey of 10% of these customers within 10 years and identify retrofitting options; reduce water use by an amount equal to 10% of the baseline use within 10 years)
10. **Wholesale agency assistance program** (Provide financial incentives to water agencies and cities to encourage implementation of water conservation program)
11. **Conservation pricing** (Eliminate nonconserving pricing policies and adopt pricing structure such as uniform rates or inclining block rates, incentives to customers to reduce average or peak use, and surcharges to encourage conservation)
12. **Conservation coordinator** (Designate a water agency staff member to have the responsibility to manage the water conservation program)
13. **Water waste prohibition** (Adopt water waste ordinances to prohibit gutter flooding, single-pass cooling systems in new connections, nonrecirculating systems in all new car wash and commercial laundry systems, and nonrecycling decorative water fountains)
14. **Residential ultra-low-flush toilet replacement program** (Replace older toilets for residential customers at a rate equal to that of an ordinance requiring retrofit on resale)

savings (based on calculations defined in the MOU). BMP reporting is publicly available after forms are completed. It is planned to use this database to estimate water savings to-date from BMP implementation on an agency and statewide basis (www.cuwcc.org has the latest findings).

2. A process to certify water agency compliance with the terms of the MOU is being set up. Utilities will have their reported performance audited and their status made public. If an agency does not perform, it will be subject to the following penalties or sanctions:

- Adverse publicity on performance;
- No water use efficiency grants;
- Lack of support from signatories (particularly environmental groups) for proposed water supply projects; and
- Civil penalties.

The California Urban Water Conservation Council administers the MOU. The Council responds to the needs of over 320 more signatories and works on implementation issues. They have a small staff of approximately five persons. Funding for their base operations (staff) comes from dues paid by the signatory members. Research projects and special projects, such as setting up the BMP reporting process over the Internet, were funded by in-kind contributions of utilities that provided staff as well as state and federal grants. The function of the California Council, the MOU, and other documents and research reports, may be viewed at www.cuwcc.org.

One interesting comparison is that the Arizona and California conservation measure implementation systems appear to be converging toward the same approach. Arizona started with a mandatory per capita program, found it was problematical, and is moving toward a mandatory RCM or BMP process. California started with a voluntary BMP process, found that the incentives were not sufficient to ensure implementation in most cases, and is moving to a nearly mandatory BMP process. Compliance is based on a schedule of activity levels, not on water use or water savings.

Texas Water Conservation and Drought Contingency Plans

An entity applying for a new water right or an amendment to an existing water right must prepare and implement a water conservation/drought contingency plan and must submit that plan with the water right application. To be accepted, the plan must meet all minimum requirements contained in Texas Environmental Quality Commission (TCEQ) rule Title 30 Texas Administrative Code (TAC), Chapter 288.

The TCEQ is required to determine whether requested appropriations of state water are reasonable and necessary for the proposed use(s) and that water right applicants will conserve and avoid wasting water. This determination is made through reviewing the applicant's water conservation plan and is considered in the decision to approve or deny a water right application.

Senate Bill 1 (SB1), passed by the Texas Legislature in 1997, increased the number of entities required to submit water conservation and drought contingency plans. Under SB1, in addition to water rights applicants, the following entities were also required to develop, implement, and submit water conservation plans that meet the requirements:

- All municipal, industrial/mining, and other water right holders of 1,000 acre-feet of water per year or more, and
- All irrigation water right holders of 10,000 acre-feet of water per year or more.

- In addition, all wholesale and retail public water suppliers and irrigation districts were required to develop drought contingency plans.

The regulations are based on state legislation passed in 1985. TCEQ and the Texas Water Development Board (TWDB) are both involved in conservation. The TCEQ requires water supply permits and a water conservation plan. They issue the regulations that are used by them and by the TWDB. The TWDB gives financial assistance, and one of the conditions is a water conservation plan, if the grant/loan is more than $500,000. The original regulations of 1986 were modified in 1993. In June 1997, a new water resources bill was passed, SB 1.

Submittal triggers. All utilities are required to submit long range, regional plans. The requirements are fewer for utilities that serve less than a population of 5,000 people. Submittal to the TCEQ with very specific BMPs for all water using sectors is required for a new water supply permit or to the TWDB for a grant/loan of more than $500,000. SB 1 will require water conservation plans for water suppliers using more than 1,000 acre-feet per year.

Utilities serving fewer than 5,000 people are required to submit a minimum plan. Utilities serving more are required to set water conservation goals, do a more thorough analysis of their situation, and evaluate additional water conservation measures.

Plan contents. Plan content is as follows:

Historical/projected water use. As a part of the plan, a worksheet is required to be submitted. The data includes annual water use, by customer class, for the current year and the last five years. Monthly total system water use and per capita use data (residential and municipal) is to be submitted. Water projections over the planning horizon for the utility are also to be submitted.

Recommended conservation measures. The minimum required conservation measures for systems of all sizes:

- Universal metering
- Measures to determine and control unaccounted-for water
- A public education program
- A water rate structure that is not *promotional*
- A drought management plan
- A reservoir systems operation plan
- A means of implementation and enforcement such as an ordinance indicating official adoption of the water conservation plan by the provider

Water conservation plans for utilities of more than 5,000 persons are required to have additional elements including

- a leak detection program;
- a record management system that includes water deliveries, water sales by customer class, water losses;
- a requirement that all water wholesaled will be covered by a water conservation plan by the customer

Additional conservation strategies shall be selected by the utility, if necessary, to meet the goals of the plan. The TCEQ may require these strategies to achieve the goals of the plan:

- Conservation-oriented water rates
- Plumbing codes for new facilities
- Water conservation retrofit programs
- Reuse/recycling of treated wastewater
- A program for pressure control
- Ordinances for landscape water management (Figures 2-1a & b)
- A method to monitor the effectiveness of the water conservation plan

A benefit–cost analysis or alternatives analysis is not required as a part of the plan.

.a Before

.b After

Figure 2-1 (a & b) Water-saving landscape design—before and after appearance

State of Kansas Water Office Guidelines

A unique feature of these guidelines is that certain measures are required to be evaluated in the conservation plan. The guidelines include a table that lists 25 water use efficiency practices and specifies whether they are optimal, recommended, or highly recommended. Recommendations depend on utility size (small, medium, or large) and per capita consumption (low, medium, or high). Per capita use figures for all utilities are published, and those that have a per capita use 25 percent above the regional average are expected to have a more aggressive conservation program. A submitted plan must be approved.

The original guidelines went into effect in 1986. After some experience with this version, a new version was issued in November 1990, which is still in use.

Submittal requirements. Under laws passed in 1986, certain water users are required to prepare water conservation plans, including (1) applicants to appropriate water after January 1, 1989; (2) applicants for a contract for the sale of water from state-owned conservation water supply storage (water marketing program); (3) members of a water assurance district (stakeholders below key reservoirs); and (4)þapplicants for a water transfer. Additionally, water users with high unaccounted-for water, or close to their supply limit, are asked to voluntarily prepare a plan.

The submittal requirements do not vary with utility size, but the recommended measures do.

Plan contents. Regarding historical/projected water use, no data is required to be submitted as a part of the plan, but annual water use reporting is required.

Recommended conservation measures. Kansas has a unique way of encouraging adoption of selected long-term water conservation measures. An excerpt from the state's *recommended practices* table in the guidelines is shown in Table 2-4. Twenty-five practices are covered in the table, two of which are listed in Table 2-4.

The measures to be evaluated are

1. Education
   - Water bills that show consumption in gallons and the cost
   - Water bills that show current and previous year's use
   - Water conservation tips
   - Water conservation articles/issues
   - School education program
   - Water-conserving landscape information
   - Lawn-watering requirements
   - Other
2. Management
   - Source meters
   - Source meter testing/replacement
   - Residential meters
   - Customer meter testing/replacement

- Monthly/bimonthly meter reading
- Coordinate meter readings
- Leak detection and repair if unaccounted-for water is greater than 20 percent
- Pressure regulation
- Water sales based on amount of water used
- Nonpromotional water rate structure
- Water-conserving landscapes for new development
- Irrigation management
- Industrial wastewater recycling
- Other

3. Regulation
   - New and replacement toilets that use less than 3.5 gallons per flush, low-flow showerheads
   - Adopt landscape water conservation ordinance
   - Other

The low, medium, and high per capita water use in Table 2-4 refers to published data in the state. If a utility's water use is more than 25 percent above the regional average, it is defined as high, otherwise it is low or medium. The state publishes *Kansas Municipalities Water Use* periodically, the most recent is dated 1994. This publication ranks all the municipalities in each of eight regions in the state by GPCD so it is easy to see if the utility is in the top 25 percent.

The plan is to be developed using locally derived criteria; a benefit–cost or alternatives analysis is not mentioned or required. The plan includes a drought/emergency element.

Table 2-4 Recommended practices (selected)

Water Use Efficiency Practices	Small Utilities with Low or Medium GPCD*	Small Utilities with High GPCD	Medium Utilities with Low or Medium GPCD	Medium Utilities with High GPCD	Large Utilities with Low or Medium GPCD	Large Utilities with High GPCD
Meters on Residential Services	Optional	Highly Recommended	Recommended	Highly Recommended	Recommended	Highly Recommended
Water Sales based on the amount of water used	Recommended	Highly Recommended	Recommended	Highly Recommended	Highly Recommended	Highly Recommended

*GPCD = total system gallons per capita per day

Rhode Island Water Supply Plans and Conservation Requirements

The Water Supply Management Act (Rhode Island General Law 46-15.4 et seq.) was enacted in July 1991. Passage of the Act has its roots in the USEPA's veto of construction of the Big River Reservoir, a keystone element of the state's water supply plan proposed by the Rhode Island Water Resources Board. A subsequent report, *Water Supply Analysis for the State of Rhode Island*, October 1990, predicted that under a moderate supply and demand and system management scenario that sufficient water would be available for all of the state's needs through year 2010. This led to passage of the Water Supply Management Act in 1991 to ensure the demand and system management elements would in fact be implemented. The Act designates the Department of Environmental Management as the responsible authority to see that the provisions of the Act were carried out. In 1992, the Department of Environmental Management implemented Regulation DEM-DWSM-01-92 setting forth the Rules and Regulations for the Water Supply Management Act. The regulations have been updated several times, including October 2002. The latest version is on their Web site.

Submittal requirements. Utilities providing water on a wholesale or retail basis in amounts of 50 million gallons of water or more per year must submit plans.

Plan contents. Plans are required to contain:

1. Detailed System Description
    - Source of supply, treatment and transmission, interconnections with other suppliers
    - Service area, number of services, population served
    - Historic water production
2. Supply/Demand Analysis
    - Forecast of demand consistent with land use plans
    - Forecast of demand considering demand management measures (including state building code requirements)
    - Available water supply (safe yield of surface reservoirs based on a critical dry period having not more than a 5 percent probability of occurrence plus 90 percent of maximum pumping rate for groundwater sources plus water purchased by contract from other suppliers)
    - Comparison of supply vs. demand (existing, 5 years out, and 20 years out)
    - If average daily demand is greater than available supply, identification of measures to improve water use efficiency and, if necessary, the timing and quantity of additional supplies/facilities
3. Supply Management
    - Description of known or potential contamination sources and measures to be undertaken to protect supply
    - Identification of available alternatives and, if necessary, additional sources of supply

4. Demand Management
   - Establishment of residential retrofit program that makes water-saving plumbing equipment required by the Act available (includes annual notification of availability, at cost or at no direct cost, low flow faucet aerators, showerheads, toilet tank displacement equipment and includes making available installation of same at cost or at no direct cost)
   - Establishment of a program that provides technical assistance to major users (customers using greater than 3 million gallons of water per year are required to be targeted for assistance, and the guidance document states facility audits shall be provided to these customers)
   - Education and information
5. System Management
   - Universal metering of all customers
   - Meter installation, maintenance, and repair with remote reading or automatic reading systems to be installed and operational by July 1, 1996
   - Comprehensive and periodic leak detection and repair (must do immediately if unaccounted-for water use greater than 15 percent)
   - Preventive maintenance plan
6. Financial Management
   - Use of appropriate fees and rates (declining block rates are found by the act "to be no longer conducive to sound water supply management")
7. Emergency Management (major items)
   - Identification of known and potential natural and human caused risks and effect of same on each component of the water supply system
   - Identification of demands on the system, including major users and priority users, and evaluation of the level of service to be sustained during each emergency situation
   - Specification of water supply emergency responses, which become progressively more stringent depending on the severity of the emergency

Plan updating. Utilities are required to review and update the plan every five years. Water suppliers must also report progress on plan implementation every 2.5 years. These reports include updates on demand and production data.

ALTERNATIVE APPROACHES TO TARGET SETTING

Should the utility find it advisable to set targets or specific goals on which to gauge whether utilities are performing up to expected levels, the following alternatives *could* be considered.

- Sector target approach

  This could take the form of

  — a per capita water use target for residential use.

  — a per account target for nonresidential use.

  — a volumetric or Infrastructure Leakage Index (ILI) target for leakage reduction.

- Best practices program approach

  The two options include different methods of agreeing activities and are described as follows:

  — Option A: Develop an MOU comprising a range of activities (Best Management Practices—BMPs, or Reasonable Conservation Measures–RCMs), through a stakeholder consensus process, similar to the California approach. Penalties for noncompliance would be sufficiently harsh to ensure performance.

  — Option B: Mandate, using a regulatory framework, a requirement to develop and implement specific activities (BMPs or RCMs). This would be similar to the current Arizona Non-Per Capita Conservation Program.

- Hybrid approach to target setting

  If targets must be set, a hybrid approach based on the UK Leakage targets and the California BMP and MOU consensus model can be considered. The utility would benefit from direct involvement of stakeholders in the process of developing goals, an MOU and/or BMPs. A hybrid approach could involve the following:

  — Water efficiency program: Include milestones involving specified actions and schedules that could be termed Water Efficiency Activities (WEAs) for the residential and business sectors. The reporting should follow the key details of the WEAs (or BMPs) and should include the following:

    ♦ Planned versus actual activities;

    ♦ Planned versus actual expenditures;

    ♦ Estimated water saved;

    ♦ Any variations made (if allowed) to implement the program in an at-least-as effective manner as originally planned. Reasons for variations should be justified.

  — Leakage reduction program: Include targets for reduction of leakage. Reporting on leakage and recycling progress will, at least initially, be partially activity based, partially results based. Utilities will need to calculate the true potential in water zones and then assess what is cost-effective to pursue, set a goal, and proceed to achieve this goal.

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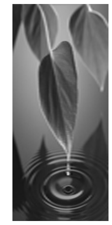

Chapter 3

Analysis of Water Use and Water Savings

It is not possible to estimate the benefit of conservation without first estimating the rate of growth in water demand with and without conservation. Rates of increased demand can be slowed by conservation, even though demand may increase because of demographic influences. Conservation measures can reduce both the average and the peak demand. Conservation will decrease O&M as well as capital expenditures.

A detailed understanding of current water use and an accurate forecast of future water demand is essential for making decisions about the nature and scope of a water conservation program. To estimate water savings of potential conservation measures, the characteristics of water use, such as the seasonal pattern and per capita use values, must be estimated. This chapter provides the following:

1. Methods to understand existing customers' water use and two alternative methods for forecasting future water use
2. Assessing the level of water losses and setting leakage reduction targets
3. Identifying and screening water conservation measures
4. Estimating the water savings from conservation measures

EVALUATE CURRENT WATER USE AND PROJECT FUTURE USE

Describe the Service Area

Table 3-1 can be used as a worksheet to characterize the service area in ways that are useful for forecasting future water use. The table includes sample numbers to demonstrate methodology. Population projections are usually available from local governments and/or regional planning agencies. Employment projections (jobs, unemployed residents) are usually available from the same regional planning

Table 3-1 Describe service area (example)

Service Area Characteristic		Value (Example)
Current Population		100,000
Future Population	5 years	110,000
	10 years	120,000
	20 years	135,000
Number of Residential Service Connections	Single Family	20,000
	Multifamily	5,000
	Total	25,000
Number of Nonresidential Connections	Commercial	3,000
	Industrial	500
	Public	500
	Total	4,000
Current Employment (Jobs)		60,000
Future Employment (Jobs)	5 years	70,000
	10 years	80,000
	20 years	100,000

agencies or from transportation planning agencies. A forecast of 20 years is usually adequate for demand management planning because

1. Matches up with long-term water supply planning
2. Demand management improvements need time to accrue

Describe Water Use

Table 3-2 is an example worksheet that can be used to characterize existing water use. Sample numbers are shown to demonstrate the methods. Characterization includes the following:

Average annual water supplied is the current amount of raw water withdrawn from a source or purchased from a wholesaler and imported or pumped into the service area. If growth has been minor, the water produced over the last few years can be averaged.

Unmetered water use can be estimated. If from a pumped source use the following:

$$\text{Pumping volume} = \text{pumping rate} \times \text{time of operation} \tag{3-1}$$

Time of operation can be obtained from the electric meter by reading the kilowatt demand of an operating pump over a set time interval and using the electric meter monthly billing reads to calculate estimated hours of pump operation (commonly called run time).

Unbilled water can be calculated by conducting a system water audit. The assessment of water losses is discussed later in this chapter. As used in Table 3-2, the value should be the water that is not billed to customers, whether it is authorized and metered or not. Unbilled water can be less than 10 percent in a relatively new, well-managed system. It is not uncommon to find unbilled water to be over 20 percent in an older system. Unbilled water is now widely accepted as the preferred terminology to use instead of the term *unaccounted-for water*, which is too imprecise and had become a poorly defined catch-all term.

Peak-day ratio is water produced on the highest water use day divided by the water use on the average day (annual use in gallons).

Estimated seasonal use is the percentage of water use above some minimum base month of the year indoor water use. Indoor water use is generally the low month's water use prorated over the year. Seasonal use is typically associated with outdoor use, such as landscape watering.

$$\text{Seasonal use, \%} = \frac{100 \times (\text{lowest month} \times 12)}{(\text{annual use} - \text{unmetered seasonal use})} \qquad (3\text{-}2)$$

Average water use by customer class may or may not be available from customer billing records. Depending on the categories used by the utility, complete Table 3-2, expressing the results on a million gallons per day (mgd) basis. In some cases, water use data is only available by meter size. The smallest meters are usually reserved for single family homes (and some small businesses). Larger meters are for apartment complexes, commercial establishments, schools, and industries. Meter size data can usually be used to break water use down into residential and nonresidential, unless multifamily is the predominant type of residential dwellings. Estimating the seasonal use by customer class helps to target conservation programs aimed at reducing peak use.

Check the reasonableness of the data. The following guidelines can be used for the distribution of water use:

- Interior per capita residential may be about 60 to 80 gallons per person per day (gcd); single family use is almost always higher than multifamily use;
- Exterior per capita residential water use varies from a small value (5–20 gcd) in multifamily buildings to an always larger value in single family buildings (10–80 gcd); and
- Commercial water use per employee can vary considerably but is often comparable to per capita interior residential water use, except it is expressed on a gallons per employee per day (ged) basis.

Analyze Historical Water Use

In addition to completing Table 3-2, it is useful to analyze how water use has fluctuated over the past five or more years. Some of the most common incentives of water use change are

- Climate and weather conditions
- Growth (or decline) in water accounts, type of housing, or population served
- Changing demographics of customers (household size, age, income)
- Economic activity and local industrial use

Table 3-2 Example of a detailed water use description

Water Use Characteristic	Description of Use Type	Value (Example)
Average Annual Water Use (Production)		6,570 mg/year 18 mgd
Unbilled Water		2.7 mgd 15% 15.3 Total Metered Water Use
Peak Day Use		28.8 mgd
Peak Day to Average Day Ratio		1.6
Estimated Metered Seasonal Use	Month with Lowest Demand	February
	Average Demand in this Month	10.7 mgd
	Nonseasaonal Water Use	70%
	Seasonal Use	30%
Average Metered Water Use By Customer Category	Single Family Residential	8.4 mgd
	Multifamily Residential	1.5 mgd
	Commercial	2.3 mgd
	Industrial	1.6 mgd
	Public	1.5 mgd
	Water Losses	2.7 mgd
	Total	18 mgd
System Supply Safe Yield		40 mgd
System Capacity		32 mgd

NOTE: mg/year = million gallons per year, mgd = million gallons per day

- Price of water and water and sewer rate structures
- Water system operation and system losses
- The effect of code changes (toilets, washing machines)
- Long- and short-term conservation actions

If historical monthly water use data is available, a spreadsheet should be developed charting use versus time. To normalize the effects of growth, the total monthly water use should be divided by the number of accounts billed for the month. Figure 3-1 is an example of the seasonal fluctuations for single-family water use within a water service area with a humid climate in the US. Note how the water use almost doubles between winter and summer. A 12-month moving average shows trends. In 2001, the impact of water use restrictions to deal with a drought is shown, indicating that using the most recent year in establishing a baseline water use is not always a good idea. In contrast, Figure 3-2 is an example of single-family water use in an arid area of the US. Note how water use can increase by a factor of 5–6 from winter to summer. This area also went through a prolonged drought, a rebound from the drought with water use staying at a lower level than predrought levels because of permanent water use habit and other changes.

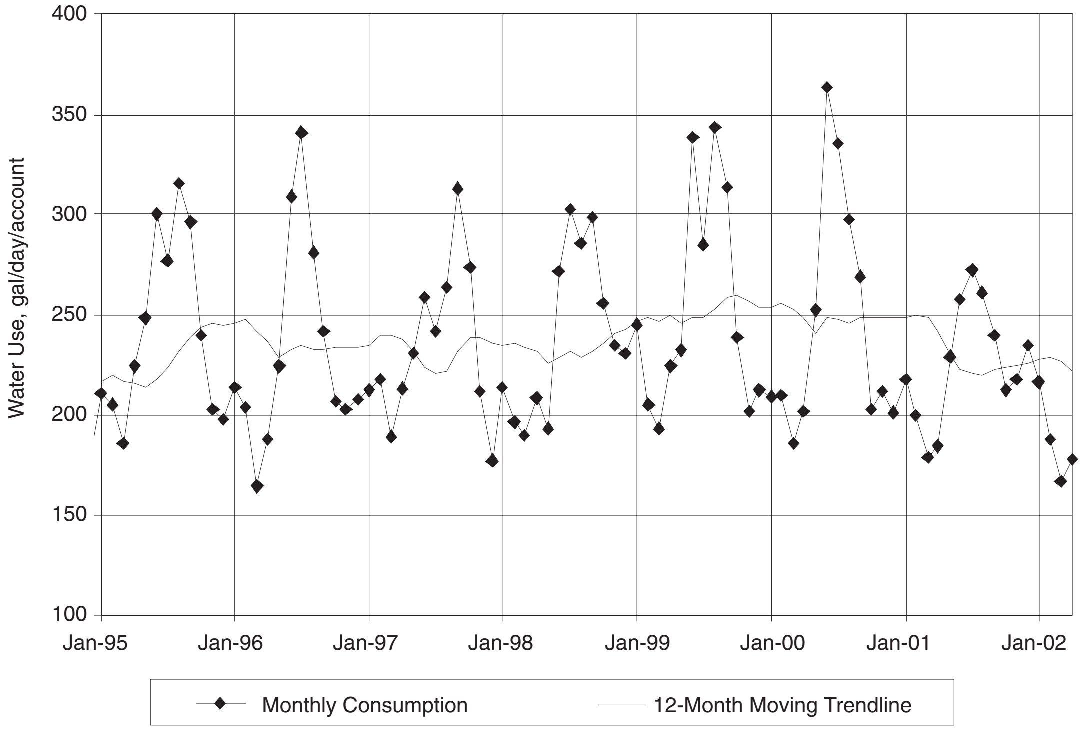

Figure 3-1 Analysis of historical single-family residential water use—example of a humid area, Atlanta, Georgia

Forecast Future Water Demand

In addition to understanding current water use, a detailed forecast of future water needs is necessary for proper planning and evaluating conservation benefits. All of the previously mentioned incentives of water use change can influence future water demand.

Two ways to forecast water use are presented in Table 3-3. Other more sophisticated economic and demographic forecasting methods are available and should be used prior to utility investments to meet future supply. However, the second method is usually adequate for general conservation planning purposes. The table includes extension of the sample data in Tables 3-1 and 3-2 to demonstrate the methods.

Method 1: per capita water use. This frequently used but usually inaccurate forecasting method assumes that growth in water use (total water production) is only proportional to population growth and that per capita use will not change in the future. In doing so, this method completely ignores all the other previously mentioned important incentives of water use. It directly links future demand to future population as follows:

$$\text{Future water use} = (\text{Current per capita water use}) \times \text{future population} \quad (3\text{-}3)$$

Method 2: projection by customer class. Figure 3-3 gives an overview of demand forecasting by category of use. This method allows for different growth rates in different water use categories and thus can be more accurate. For example, if employment is growing faster than population, nonresidential water use may grow

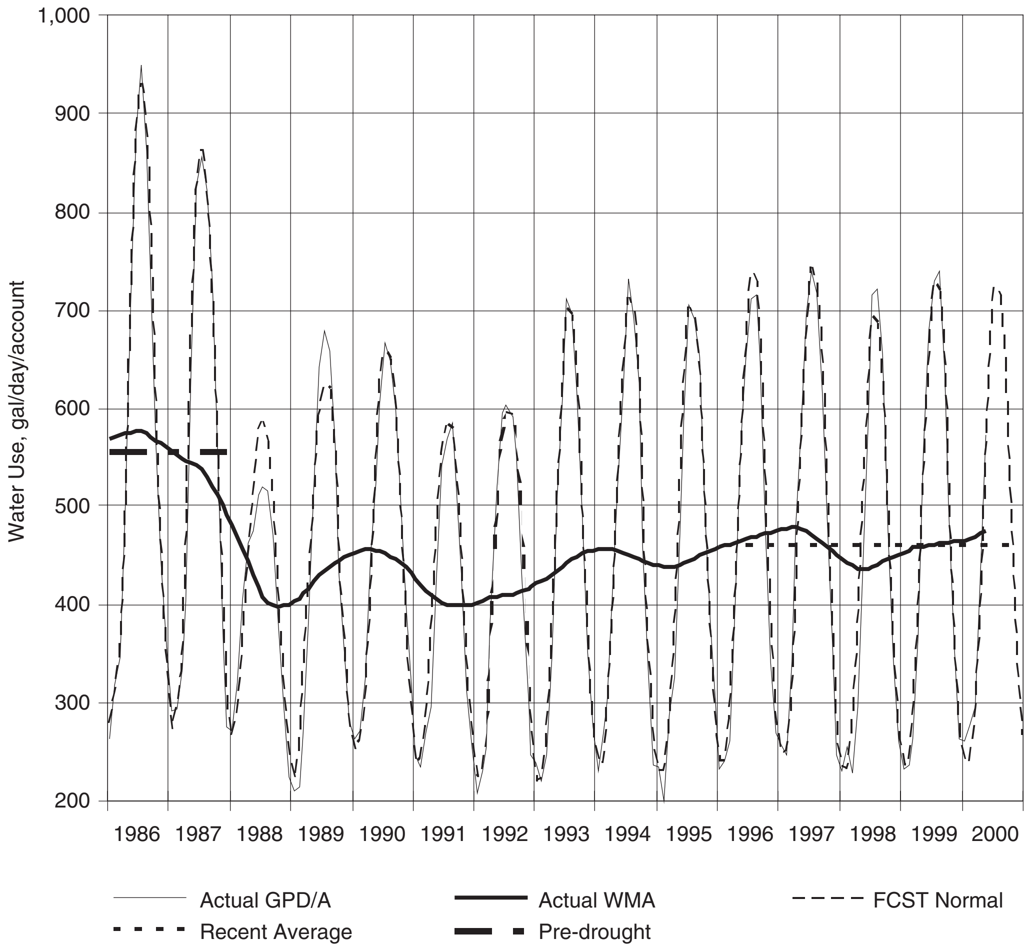

Figure 3-2 Analysis of historical single-family residential water use—example of an arid area, Walnut Creek, California

faster than residential water use. This forecasting method is more sensitive to changes than the per capita water use method.

The second part of Table 3-3 can be used as a worksheet to develop a forecast by customer category. Use factors are developed by residential and nonresidential use. If data is available for additional classes, such as single family and multifamily, further detail can be added.

$$\text{Projected future water use by class} = \text{Use factor} \times \text{future population or employment} \qquad (3\text{-}4)$$

Added to total use is the water supplied but unbilled to get total water needed in future years. Water use can be further subdivided into indoor use and outdoor use using the seasonal distribution. Peak-day use can be computed from the overall peak-day factor.

As shown in the example, where employment is growing faster than population, the Method 2 projection (rather than Method 1) results in a significantly higher

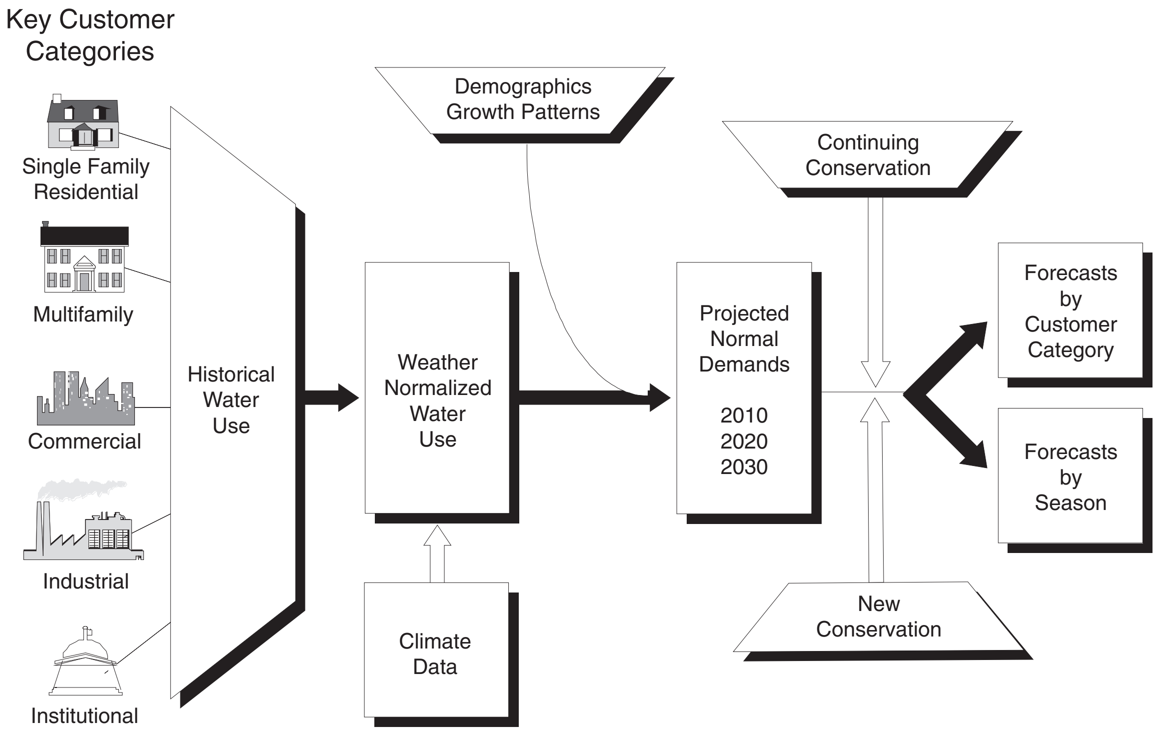

Figure 3-3 Overview of water projection process

Table 3-3 Example forecast future water demand

Method/Parameter		Value (Example)
Method 1: Per Capita Water Use		
Average Annual Water Use (Production)		18 mgd
Current Population Served		100,000
Current Per Capita Use		180 gcd
Population	5 years	110,000
	10 years	120,000
	20 years	135,000
Future Water Use	5 years	19.8 mgd
	10 years	21.6 mgd
	20 years	24.3 mgd
Peak Day Use — 20 Years		38.9 mgd
Method 2: Projection by Customer Class		
Step 1: Develop Unit Water Use Factors		
Residential	Total billed	9.9 mgd
	Population	100,000
	Use Factor	99 gcd
Nonresidential Use	Total billed	5.4 mgd
	No. Employees (Jobs)	60,000
	Use Factor	90 ged
Step 2: Project Future Use		
Residential		
Future Population	5 years	110,000

Table continued next page.

Table 3-3 Example forecast future water demand—*continued*

Method/Parameter		Value (Example)
	10 years	120,000
	20 years	135,000
Future Residential Water Use	5 years	10.9 mgd
	10 years	11.9 mgd
	20 years	13.4 mgd
Nonresidential Use		
Future Employment	5 years	70,000
	10 years	80,000
	20 years	100,000
Future Nonresidential Use	5 years	6.3 mgd
	10 years	7.2 mgd
	20 years	9.0 mgd
Total Future Water Use	5 years	17.2 mgd
	10 years	19.1 mgd
	20 years	22.4 mgd
Unbilled Water in 20 Years		15%
		4.0 mgd
Total Future Water Use — 20 Years		26.4 mgd
Peak Day Use — 20 Years		42.2 mgd

NOTE: gcd = gallons per person per day, ged = gallons per employee per day

projected water use after 20 years, 26.4 mgd versus 24.3 mgd. The difference in peak-day use is even more accentuated. Hence, Method 2 is preferred and should be used where the data required is available.

EVALUATION OF SUPPLIER ACCOUNTABILITY AND WATER LOSS CONTROL

The actions customers use to conserve water is called *demand-side conservation*. The conservation of water from the supply source to where it enters customer properties is termed *supply-side conservation*, and it is a measurement of water distribution system and management efficiency. By volume compared to the distribution system input, the amount of nonrevenue water can vary greatly from under 10 percent in new, well-managed systems to over 20 percent in many older systems having accountability challenges. Important to supply-side water conservation are two factors: the reliability of routine supply auditing practiced by suppliers, and the control of losses that exist. These factors have operational, financial, and—most important to conservation—water resources implications.

Developing a Reliable Water Auditing Structure

Traditional performance indicators, such as the commonly used term *water losses percentage*, often give conflicting impressions of true success in controlling water losses[5]. In the US, the report, *Survey of State Agency Water Loss Reporting Practices*, found considerable variation[1]. Standards were found to vary from 7.5 percent of total water produced to 25 percent. Part of the wide range involves the lack of a consistent definition of water losses. Reducing losses in the United Kingdom (UK) has been a priority since the early 1990s. When the UK suffered a severe drought during 1995–1996 the government regulator, Office of Water Services, imposed new conditions on the private water companies. These water companies actively pursued leak reduction and by 2002–2003 leakage rates had fallen 29 percent to a level close to 23 percent, from their peak in 1994–1995[2].

The International Water Association (IWA), in concert with AWWA, has developed and published a well-defined water audit methodology and an array of rational performance indicators. In 2000, the IWA published their work in the IWA *Manual of Best Practice: Performance Indicators for Water Supply Services*[3]. See www.iawhq.org.uk. The AWWA Water Loss Control Committee published the committee report in "Applying World Wide Best Management Practices in Water Loss Control" in the August 2003 edition of *Journal AWWA*[4]. The committee report advocates use of the IWA/AWWA water audit methodology and suggests application of innovative loss control methods, which have been applied internationally.

The IWA/AWWA Water Audit and Water Balance

A water audit is a compilation of the consumptive uses and losses of the water managed in a single system. The water balance is the summary of water audit components displayed in a format that balances the system input volume with the consumption and losses. The format of the IWA/AWWA Water Balance is shown in Figure 3-4.

Water losses occur in two broad manners. Apparent losses are paper losses including meter and billing system error and unauthorized consumption. Controlling apparent losses is important to conservation programs because they often appear as errors in customer billing data and can noticeably skew consumption data needed to evaluate conservation measures. Real losses are physical losses, including leakage from distribution mains, customer service lines, and overflows from distribution system tanks or other water storage facilities. Reducing real losses has a direct conservation benefit, as every gallon of reduced leakage is one less gallon that must be pumped from a well, river, or other source.

While apparent and real losses differ in the way that they occur, they differ even more dramatically in the impacts that they create. Financially, real losses are valued

A	B	C	D	E
System Input Volume mg/year	Authorized Consumption mg/year	Billed Authorized Consumption mg/year	Billed Metered Consumption (including water exported) Billed Unmetered Consumption	Revenue Water mg/year
		Unbilled Authorized Consumption mg/year	Unbilled Metered Consumption Unbilled Unmetered Consumption	Nonrevenue Water mg/year
	Water Losses mg/year	Apparent Losses mg/year	Unauthorized Consumption Customer Metering Inaccuracies Data Handling Error	
		Real Losses mg/year	Leakage on Transmission and/or Distribution Mains Leakage and Overflows at Utility's Storage Tanks Leakage on Service Connections up to Point of Customer metering	

Figure 3-4 Components of water balance for a transmission system or a distribution system

at the marginal costs to treat and pump water. Apparent losses are valued at the retail rate that the water supplier charges its customers, a cost usually much higher than the production costs. As part of the auditing process, costs should be assigned to all components of consumption and loss to gauge the financial impact of each.

The terms in Figure 3-4 are defined in Table 3-4. The methodology for computing the apparent and real losses is explained in the *Water Loss Control Manual* (Julian Thornton, McGraw-Hill, 2002)[6].

Currently, only limited and varied requirements exist across the US for water suppliers to compile water audits that can be reliably traced. Many industry analysts believe routine water auditing (typically on an annual basis) to be good practice. As both apparent and real losses occur dynamically in water utility operations, auditing should be ongoing, routine, and traceable, if losses are to be controlled. The IWA/AWWA method serves as one basis for US water oversight agencies to begin to implement reliable water auditing structures. In 2003, the State of Texas passed legislation that included the following provision:

> Every five years, a retail public utility providing potable water shall perform and file with the board a water audit computing the utility's most recent annual system water loss.

The board refers to the Texas Water Development Board, which is charged to determine the method and procedures used to assemble the water audit. The IWA/AWWA method is under strong consideration for this purpose. Gradually phasing-in requirements for consistently reporting data and initiating basic loss control programs will be necessary to introduce water suppliers to sound accountability practices. It is recognized that this will require time and be more "evolutionary than revolutionary" in nature.

Controlling Apparent Water Losses

Apparent losses do not represent the physical waste of water and—on surface level—may not seem to offer a strong water conservation benefit. However, a closer evaluation of their nature and impact shows that they have a critical role in managing drinking water supplies wisely.

Apparent losses are errors in data and unauthorized consumption. Errors occur because of inaccurate supply and customer meters as well as errors in estimating, accounting, and billing systems structure. Unauthorized consumption occurs when users by-pass or tamper with meters or meter reading equipment to understate the amount of water consumed. Illegal connections and unauthorized withdrawals from fire hydrants are other examples of this. In all such cases, water suppliers do not accurately account for water that is taken, and revenue is not recovered on this water.

What are the implications of the apparent losses on water conservation programs? The primary factors are

- Controlling apparent losses recovers lost revenue, which can provide much needed funding to continue and/or expand the loss control and conservation program.
- Controlling apparent losses reduces the amount of customer consumption error existing in the billing systems that most water utilities use to collect revenue and warehouse customer data. While designed as financial (revenue) management systems, many water utility billing systems are used as de facto customer consumption databases, but often without sufficient controls to ensure that

Table 3-4 Definition of terms for international standard water audit

Term	Definition
System Input	The volume input to that part of the water supply system to which the water balance calculation relates, allowing for known error in the measurement of this input value. Equal to water from own sources plus water imported.
Water Supplied	System Input minus water exported to others.
Authorized Consumption	Volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier; for residential, industrial, commercial, and institutional use. Note: Authorized Consumption may include items such as fire fighting and training, flushing of water mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.
Water Losses	The difference between System Input and Authorized Consumption. Water Losses can be considered as a total volume for the whole system, or for partial systems such as raw water mains, transmission or distribution systems, or individual zones.
Apparent Losses	Includes all types of inaccuracies associated with customer metering, data archiving and billing; plus all unauthorized consumption (illegal use). Note: Overregistration of customer meters leads to underregistration of Real Losses. Underregistration of customer meters leads to overestimation of Real Losses.
Real Losses	Physical water losses from the pressurized system up to the point of measurement of customer usage. The annual volume lost through all types of leaks, bursts or breaks, and overflows from tanks/reservoirs. These losses depend on the frequency, flow rates, and average duration of individual leaks, breaks, and overflows. Note: Although physical losses after the point of customer flow measurement or assumed consumption are excluded from the assessment of Real Losses, this does not necessarily mean that they are insignificant or unworthy of attention for demand management purposes,
Revenue Water	Those components of System Input, which are billed and produce revenue (also known as Billed Authorized Consumption). Equal to Billed Metered Consumption plus Billed Unmetered Consumption.
Nonrevenue Water	Those components of System Input, which are not billed, or revenue producing. Equal to Unbilled Authorized Consumption plus Apparent Losses plus Real Losses.
Unbilled Authorized Consumption	Those components of Authorized Consumption, which are not billed, or revenue producing. Equal to Unbilled Metered Consumption plus Unbilled Unmetered Consumption.

Source: Reference 3

— all water users are documented in established customer accounts (Example: many municipal water utilities do not bill or otherwise track water consumption at municipally owned buildings.)

— accurate meter reading or water estimating data is entered on a routine basis

— inordinate customer consumption patterns are flagged for scrutiny

— billing (money) adjustments do not distort actual customer consumption (water) data

To reliably evaluate the success of water conservation programs, customer consumption data must have a high degree of integrity. The water conservation manager should attempt to gauge the apparent losses in a drinking water utility when starting a conservation program. Controlling high apparent losses will help ensure that accurate customer data exists before and after conservation measures are implemented in order to evaluate the impact of the conservation program.

- Controlling apparent losses promotes equity among customer ratepayers because water utilities must effectively spread the cost of scofflaws among the honest ratepayer population.
- Controlling apparent losses projects a strong message to the public that the water utility is closely monitoring water consumption and will act quickly to correct meter or billing errors and thwart illegal activity.

Controlling losses (apparent and real) is an endeavor of diminishing returns. Losses can never be completely eliminated. Apparent loss control has the advantage of recouping an almost immediate money gain in recovered revenue. Water conservation managers are urged to meet with the groups within their utility that handle the metering, meter reading, and billing functions to determine the extent of apparent loss that exists in their utility. Reviewing billing records is a good first step. Matching account inventories to population data or other utility data sets can identify nonaccount water users. Analyzing 12-month billing records can detect unusually high or low (watch for consecutive zero consumption months) readings. It is likely that a certain amount of apparent loss will be found in any system. Establishing controls to prevent such losses from occurring and programming alerts when they do will help control these losses.

Controlling Real Water Losses

All water utilities should maintain some capability to identify and control leakage in their distribution systems. The water audit has added value in providing information on the nature, extent, amount, and areas of leakage in their distribution system, providing a good basis to design or optimize the leakage management program.

A leak-free water system is not a technically feasible or an economical objective, because water is under pressure, and a low level of water losses cannot be avoided, even in well-run systems. For each water system, there are several key local influences that govern the magnitude of real losses and may constrain the ability of the water utility to control them.:

- The number of service connections
- The location of the customer meter on the service connection
- The length of mains
- The average operating pressure, when the system is pressurized
- The percentage of time per year for which the system is pressurized, typically 100 percent in US and Canadian systems
- Infrastructure condition, materials, frequencies of leaks and bursts
- The type of soil and ground conditions, in so far as they influence the proportion of leaks and bursts, which show quickly at the ground surface

Using the IWA/AWWA Methodology to Control Real Water Losses

The IWA/AWWA methodology includes an array of useful performance indicators. One of those indicators is the Technical Indicator of Real Losses (TIRL):

$$\text{TIRL} = \frac{\text{Current annual volume of real losses}}{\text{Number of service connections}} \tag{3-5}$$

(TIRL is expressed as gallons service connection/day when the system is pressurized.)

To put the above number in international perspective and benchmark whether it is low or high, another computation is normally made to define what is called *unavoidable annual real losses* (UARL). The UARL represents a theoretical level of loss that could be achieved under the most optimistic circumstances; i.e., applying all of today's best technology in an optimum manner. An equation to estimate the UARL value for a water system is under development by the AWWA Water Loss Control Committee. The equation will use the factors listed above in the bullet points to predict the theoretical lower end value of water losses.

Once this UARL value has been determined, it is useful to compare the theoretical lower end value to the actual measurable estimates of water losses currently occurring in the system. The IWA/AWWA method suggests the use of a nondimensional index of overall system condition and management given by the following relation:

$$\text{Infrastructure Leakage Index (ILI)} = \text{TIRL/UARL} \tag{3-6}$$

The range in international systems has been observed to be from 1.0 to well over 10.0. Well-managed systems in very good condition would be expected to have an ILI close to 1.0. This would mean actual leaks are at the theoretical lower end value for UARL. Higher values of ILI will typically be found for older systems with infrastructure deficiencies and/or no active leakage control program. With additional time and more North American experience, these methods will continue to improve utility efforts to lower water losses.

Economic Level of Leakage

While the ILI is a ratio of actual to unavoidable levels of leakage, it is important to recognize that midway between these levels stands the Economic Level of Leakage (ELL). This level, conceptually defined to be the point where the value of water lost to leakage equals the value of the intervention activities to control it, is envisioned to become the ultimate target indicator for water suppliers. The ELL, which is system-specific, takes into account the local economics such as the financial and societal value of water to set targets. Hence, in areas of scarce water resources, an ELL close to the UARL would apply. In contrast, a region with access to relatively abundant, high-quality water resources would likely establish an ELL somewhat higher than the unavoidable level. The ILI serves as a general benchmarking indicator, useful for comparisons among suppliers. Benefit–cost analysis is a straightforward and reliable means to determine the ELL for a given distribution network (see chapter 4). From this analysis, leakage reduction targets can be set at the break-even point or where the benefit–cost ratio is just over 1.0.

Philadelphia is the first US city to apply this method and use it to organize a program of leakage reduction initiatives. In its 2000 water audit, Philadelphia calculated its ILI at a value of 12.3. By the year 2003, Philadelphia showed improvement with an ILI of 11.9, but the level is still considered high, indicating a good potential for further leakage reductions.

Most North American water suppliers do not compile any type of routine, reliable water audits. Many of these systems operate with losses well above their ELLs. The IWA/AWWA water audit methodology is a new alternative approach for North American utilities to gauge supplier accountability and loss control standing more reliably than the misleading percentages of the past. With potentially large volumes of supplier water lost to leakage or poor accounting, water loss control methods stand to offer immense water conservation benefits that should not be overlooked by water conservation managers, distribution system engineers, and senior management of drinking water utilities. Many new means have been developed to effectively cut leakage and sustain low leakage levels. These methods are thoroughly described in the *Water Loss Control Manual*[6].

IDENTIFY AND SCREEN ALTERNATE WATER CONSERVATION MEASURES

Efficient Technologies for Customer End-Use Reductions for Fixtures and Fittings

The first step is to research information on water efficient fittings, fixtures, and appliances. Key information to be gathered includes costs, water savings, current requirements on the device, and life of the device. There are various sources of this information, one excellent source is the *Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms*[8]. This book has extensive coverage on residential fixtures and appliances, landscape water efficiency measures, and industrial, commercial, and institutional efficiency measures. This manual's focus is on conservation program planning and design and not as a reference on specific conservation measures. However, a summary of some of the commonly utilized measures is provided as an example of how to identify and screen them. The measures in the tables are not intended and should not be used as a complete measure checklist for utilities.

Table 3-5 provides a summary of selected water-efficient devices. Actual savings vary with household size, current devices or technology in use, portion of water used in the garden, etc.

Table 3-5 Summary of water-efficient devices

Device Description	*Flow Rating	Estimated Cost ($ per unit) Supply	Install	*Annual	*Device Life (yr)	End-Use Reduction gal/cap/day	%	Status
Bathroom								
New Showerhead	2.5 gpm	10–35	By user		5–10	2.4[a]	21[a]	Required for New
Shower Flow Restrictor	2.5 gpm	5	By user		10		21[a]	Voluntary
Faucet Aerator	2.2 gpm	3	By user		5	1.6[c]		Required for New
Toilets								
6-Liter Toilets	1.6 gal/flush	65–250+	100–200		20–30	10.4[a]	52[a]	Required for New
New Ballcock and Flapper Valve for Leak Repair	NA	10	25			5+		Voluntary
Early Closure Device	0.5–1.0 gal/flush	5	15		5	2–4		Voluntary
Water Displacement Device	0.5–0.7 gal/flush	2	10		5	2–3[4]		Voluntary
Dual Flush Toilets	3–6 liter/flush							
Composting Toilets	0 gal	2,000	500	200	20+	20.1[a]		Voluntary
Kitchen								
Faucet Aerator	2.5 gpm	3	by user		5	0.3[c]		Required for New
Insulate Hot Water Pipes	NA	25/100 ft	by user		10	2[d]		Voluntary
Efficient Dishwasher	E	500–800	200		10–15	0.6[c]		Voluntary
Laundry								
Faucet Aerator	2.5 gpm	5–10	by user		5	0.3[c]		Required for New
Horizontal Axis Washing Machine	30 gal/load	600–1000	100		15–20	5.5[a]		Voluntary
General Household								
Pressure Reducer	<80 psi	90	200–400		20+	3–6[d]		Regulated
Submetered billing of Apartment Units	NA	50	200	varies	20+		16[P]	
Household Leak Repair	NA	varies	varies		5±	5.0[a]		Voluntary
Graywater Systems	NA	100–2,000	200–500		10–20	10–50		Regulated
Public Education	NA			~1–2/ person	1		1–5[d]	Voluntary

Table continued next page.

Table 3-5 Summary of water-efficient devices—*continued*

Device Description	*Flow Rating	Estimated Cost ($ per unit) Supply	Install	*Annual	*Device Life (yr)	End-Use Reduction gal/cap/day	%	Status
Landscape Irrigation								
Drip Systems	NA	15 for 20 plants	by user		10	Varies[g]		Voluntary
Micro-Spray Systems	NA	25 for 20 ft^2	by user		10	Varies[g]		Voluntary
Hose Timers	NA	10–40	by user		5–10	Varies[g]		Voluntary
Rain Sensor	NA	30	100		10	Varies[g]		Voluntary
Trigger Shutoff Valves on Hoses	NA	3–8	by user		5–10	Varies[g]		Voluntary
Irrigation System Moisture Sensors	NA	30/valve	100		10	Varies[g]		Voluntary
Rainwater Tanks (250 gal)	NA	1,000	4,000		20+	Varies[g]		Voluntary
ET Irrigation Controllers	NA	200–500	100–300		10–15		18–22[h]	Voluntary
Native Plants	NA	Varies	Varies		5–20	Varies[g]		Voluntary
Mulch	NA	1/ft^2	by user		5	Varies[g]		Voluntary
General Commercial (Other than above measures)								
1.0 gal/flush Urinals	1 gal/flush	500	100–400		20+	3[i]		Required for New
No-water Urinals	0 gal/flush	500	100–400	50–100[h]	20+	3[j]	100	Voluntary
Infrared Sensor Flush Controlled Urinal	1 gal/flush	700	100–400		20+	1[k]		Voluntary
Infrared Sensor Faucet	2.5 gpm	400	200		20+	0.3[c]		Voluntary
Restaurant Low-Flow Spray Nozzles	1.6 gpm	60	120		10–15		25 to 50[l]	Voluntary
X-ray Water Recycling Units	NA	2,400	100	1,300	10–15		95[m]	Voluntary
6-Liter (Commercial) Toilets	1.6 gal/flush	300–450	100–200		20+	5.7[n]		Required for New
Commercial Laundry Recycling Systems	NA	100,000 and up	included		20+		65[o]	Voluntary

NOTES: * Denotes *Where Applicable*

[a] Nelson, J.O.,"Household End Uses of Water," posted on www.waterwiser.org, 1999

[b] Based on retrofit to the equivalent of a new low flow showerhead (see note a above)

Table continued next page.

Table 3-5 Summary of water efficient devices—*continued*

NOTES: (continued)
[c] Total savings if installed on kitchen and bathroom sinks, based on note a above.
[d] Maddaus, W.O. "Water Conservation", American Water Works Association, 1987.
[e] Based on Mayer, P.W., et al., "Residential End Uses of Water, American Water Works Association Research Foundation", 1999, and an assumed water savings of an efficient machine of 5 gallons per load.
[f] Dietemann, A. "Sub-Metering: The Next Big Frontier?" Seattle Public Utilities, Conserve99 (AWWA), February 1999, Orlando, Fla.
[g] Depends on amount of water used outside and interaction with other outdoor measures
[h] Berg, J.O. et al., "Residential Weather-Based Irrigation Scheduling: Evidence from the Irvine "ET Controller" Study, June 2001, Irvine Ranch Water District, Calif.; Brown, et al., "Water Efficient Irrigation Study," May 2003, Seattle Public Utilities.
[i] Compared to 2.0 gal/flush urinals using three flushes per employee per day
[j] Compared to 1.0 gal/flush urinals using three flushes per employee per day
[k] Assuming elimination of one extra 1.0 gal flush per employee per day
[l] Personal Communication with John Koeller, Plumbing Consultant, June 2002.
[m] Koeller, J., "X-Ray Film Processors" in the Water Logue, Vol. 1, No. 7, California Urban Water Conservation Council, December, 2001.
[n] Compared to 3.5 gal/flush toilets using three flushes per employee per day
[o] Personal Communication with Randall Jones, Wastewater Resources, Inc., Scottsdale, Ariz., February 2000.
[p] Mayer P. et al., "National Multiple Family Submetering and Allocation Billing Program Study" USEPA et al., 2004.

PREPARE LIST OF POTENTIAL CONSERVATION MEASURES

As part of the evaluation of appropriate measures, a list of potential measures that may be appropriate for the area should be compiled. This process generally yields over 100 potential conservation measures in the typical customer categories of

- Residential
- Commercial
- Industrial
- Public
- Irrigation

Sources of information on conservation measures include the *Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms*[8]. California Urban Water Conservation Council's Memorandum of Understanding that contains a list of Best Management Practices[9] (see chapter 2), the Arizona Department of Water Resources list of Reasonable Conservation Measures[10], and various other states that have conservation guidelines.

SCREENING OF CONSERVATION MEASURES

The first step in any screening is the development of a menu of measures. A typical list of potential measures is provided in the matrix shown in Table 3-6. This table should include all measures being considered. Many of the measures overlap in water savings, i.e., they target the same areas for water conservation. This potential overlap can be accounted for, where necessary, during the combination of measures into alternative programs.

Screening Process

The following terms are used in the screening process:

Device. A physical item of hardware, such as a new toilet, or specific action by individuals, such as commercial audits, that would save water if the recommendations are implemented or carried out by the water utility or some other group.

Measure. A device(s) plus a distribution method and possibly an incentive, such as a rebate, targeted at a particular type of end user that, when implemented, will save water.

Program. A set of one or more measures targeted at one or more customer classes that would be managed by the Water Utility as a separate project.

Plan. A set of one or more programs together with an estimated budget, schedule, and staffing plan.

Screening Criteria

Cost-effectiveness. In some states or regions, a list of which measures are considered cost-effective for most utilities may already be compiled. For the purposes of a first screen of measures, only those that are more than ten times the cost of a utility's alternative next source of supply should be eliminated. As a general guide, the measures other utilities believe are cost-effective should be used, or the list in Table 3-6 can be used. Chapter 4 covers evaluation of detailed costs and benefits. If information is available on what the next least costly source of alternative water supply is for the utility, this should be used to avoid spending a lot of time on measures ten times or more costly.

Table 3-6 Example of potential conservation measures

Device or Program	Measure: Distribution Method & Incentive	Measure: Description
	Single Family Residential—Existing Accounts	
Require low-consumption toilets to be installed at the time of sale	*Water Provider's*–requirement at time of sale	Work with the real estate industry to require a certificate of compliance be submitted to the Water Provider that verifies that a plumber has inspected the property and efficient fixtures were either already there or were installed at the time of sale, before close of escrow. (Model after City of Los Angeles and San Diego.)
Rebates for 6/3 dual-flush or 4-liter toilets	*Water Provider's*–rebate	Provide a rebate or voucher for the retrofit of a 6/3 dual flush, 4-liter or equivalent very low water use toilet. Rebate amounts would reflect the incremental purchase cost and would be in the range of $50 to $100 per toilet replaced.
Rebates for high-efficiency clothes washers	*Water Provider's*–rebate	Together with local energy companies, if possible, offer rebates for purchase of water-efficient machines. Rebates would be scaled to water efficiency as rated by the Consortium for Energy Efficiency Inc.
Low-income home leak detection and repair	*Water Provider's*–promotes	Use leak detection equipment to determine whether and where leaks are occurring on the premises. The Water Provider would then provide a plumber to the customer to repair leaks for free to qualifying households (low income).
Distribute retrofit kits w/low-flow showerheads	*Water Provider's*–requirement	During an audit or through direct mail solicitation, a free retrofit kit would be provided to existing older single-family residential homes. The kit could contain a low-flow showerhead; toilet leak-detection dye tablets, displacement device, or early closure device; a faucet aerator, faucet washers to fix leaky faucets; and a pamphlet on how to conserve water.
Increase school education programs	*Water Provider's*–promotes	The Water Provider would provide school conservation programs with workbooks, presentations, and teaching materials and other educational tools to teach the students the importance of conserving water.
Incentives for outdoor use reductions—new homes		Irrigation system upgrades, soaker hoses, mulch and soil amendments, new plant materials, landscape design, turf reduction, water allocation for landscapes
Require high-efficiency clothes washing machines	*City/County*–requirement	The Water Provider would educate its customers through bill collection brochures, displays at points of purchase, the media, on the latest clothes washer water conserving technology. Building departments would be responsible to ensure that an efficient washer was installed before new home occupancy.

Table continued next page.

Table 3-6 Example of potential conservation measures—*continued*

Measure		
Device or Program	Distribution Method & Incentive	Description
Insulate hot water piping	*City/County*–requirement	Change building codes as necessary to require installation of hot water pipe insulation on new residences.
Rebates for 6/3 dual flush or 4-liter toilets	*Water Provider's*–rebate	Water Provider offers a coupon or rebate to replace an existing toilet with a 6/3 dual flush toilet.
Require 6/3 dual flush or 4-liter toilets in new homes	*City/County*–requirement	Building departments would be responsible to ensure that a 6/3 dual flush or 4-liter toilet was installed before new home occupancy.
Landscape water use improvements		Incentives and regulations

Technology/market maturity. This screening criterion indicates whether the necessary technology is available commercially and supported by the local service industry. For example, a device may be screened out if it is not yet commercially available in the region.

Service area match. This screening criterion seeks to distinguish the technology that is appropriate for the area's climate, building stock, or lifestyle. For example, low water-use landscape measures for commercial sites may not be appropriate where water use analysis indicates there is little outdoor irrigation.

Customer acceptance/equity. Customers must be willing to implement measures or else the market penetration rates (and thus the water savings) would be too low to be significant. Customer acceptance may be based on

- Convenience
- Economics
- Perceived fairness
- Aesthetics
- Environmental values

Measures should also be equitable in the sense that one category of customers should not benefit while another pays the costs without receiving benefits.

Better measure available. If a choice must be made between two or more measures of equal effectiveness for the same targeted end use, where one is obviously more appropriate (i.e., ease of implementation or unit cost), the more appropriate measure will pass the screening. Measures obviously not cost-effective can be screened out.

The criteria can be scored on a scale of 1 to 5, with 5 being the most acceptable. Measures with low scores can be eliminated from further consideration, while those with high scores pass into the next phase—water savings analysis.

Screening process. The measures can be rated in the table such as shown in Table 3-7 and Figure 3-5. As shown in the table, each measure has been scored on a

Table 3-7 Example of screening potential conservation measures and results of screening

Measure		Criteria				Pass
Device or Program	Distribution Method & Incentive	Technology Market Maturity	Service Area Match	Customer Acceptance/ Equity	Better Measure Available	Score Yes or No
Single Family Residential—Indoor						
Existing Accounts						
Require 1.6 gal/flush toilet to be installed at the time of sale	*Water Retailers'* requirement at time of sale	5	4	4	4	17 Yes
Rebates for 6/3 dual-flush or 4-liter toilets	*Water Retailers'* rebate	4	3	3	2	12 No
Rebates for high-efficiency clothes washers	*Water Retailers'* rebate	5	4	4	4	17 Yes
Low-income home leak detection and repair	*Water Retailers'* promote	2	3	3	2	10 No
Distribute retrofit kits w/low-flow showerheads	*Water Retailers'* requirement	5	4	4	4	17 Yes
Increase school education programs	*Water Retailers'* sponsor	5	4	3	4	16 Yes
New Homes						
Require high efficiency clothes washing machines	*Water Retailers'/ City/County* requirement	5	3	2	3	13 No
Insulate hot water piping	*Water Retailers'/ City/County* requirement	5	3	3	3	14 No
Rebates for 6/3 dual-flush or 4-liter toilets	*Water Retailers'* rebate	3	4	3	4	14 No
Require 6/3 dual-flush or 4-liter toilets for new homes	*Water Retailers'/ City/County* requirement	2	4	3	4	13 No

scale of 1 to 5, with 5 being a high rating. Generally measures were eliminated that scored mostly 1's and 2's with a few 5's. The screening is qualitative and subjective and can be done by a group that is likely to interpret and score measures differently. The goal was to reduce the list to about 20 to 30 measures that *pass* the screen, i.e., have relatively high scores. In general, a measure has to have 17 or more total ratings or points in order to pass this screen.

Figure 3-5 Water-saving fixture—waterless urinal

EVALUATION OF WATER SAVINGS

Estimated water savings are useful to help utility planners forecast how future demands may be impacted by water conservation. Savings normally develop at a measured and predetermined pace, reaching full maturity after full market penetration is achieved. This may occur three to ten years after the start of implementation, depending on the implementation schedule.

Methodology

The basic method for estimating water savings is typically expressed as follows:

$$\text{Water savings, } gpd = \text{No. accounts targeted} \times \text{market penetration } (\%) \times \text{unit water savings, } gpad \quad (3\text{-}7)$$

There are a number of ways to express the unit water savings. These include gallons per fixture replaced and percent of end use reduced. Equation 3-7 can be adapted to suit available water savings data.

Sources of Data

Data necessary to forecast water savings of measures include baseline water use, end uses of water use, demographics, market penetration, and unit water savings. These are described as follows:

Baseline water use. Baseline water use (without conservation) projections are usually developed for 20 to 30 years into the future. It may include water losses or just be based on water sales, depending on the needs of the water planner. The baseline water use includes the effects of the current plumbing and appliance codes.

The savings caused by the effects of plumbing code can be estimated given assumptions about unit water savings and rate of natural replacement of old fixtures with new, efficient fixtures. The customer response to future rates and rate structures should also be included in the baseline use.

End water uses. The base water use or water sales by customer class can be portioned into end uses using the seasonal pattern and research such as the Residential End Uses of Water [10]. An example of end use for single family is shown along with a customer class breakdown in Figure 3-6.

Unit water savings. Units can be individual product units (such as toilets) or groups of products (such as household retrofits), as long as the analysis is consistent. A unit estimate may not be appropriate for each measure, in which case total program water savings and costs for the measure can be used.

Demographics. Service area population, total dwelling units, and residential and nonresidential demand are normally used to evaluate measures.

Market penetration. The market penetration for existing customers is the estimated percentage of customers that will be participating in the measure when completed. Estimates are based on measure design and experience from similar measures implemented by other water agencies (see Figure 3-7).

The concept of market penetration can be explained using an example utilizing residential water surveys. If approximately 10,000 residential dwellings exist when a measure begins, and the ultimate penetration rate of 10 percent will be reached after three years, 1,000 customers would have participated by the third year. Each year 333 new dwellings would be surveyed until all 1,000 had been audited. Certain measures require maintenance or repetition. For example, surveys would need to be done every year in order to maintain savings because the effects of the surveys may have a limited life. Thus, if water savings from the surveys are assumed to last five years (the life of the measure), then additional surveys (in this case 333) or other appropriate follow-up with prior surveyed homes should be done every year to ensure that water savings are permanent.

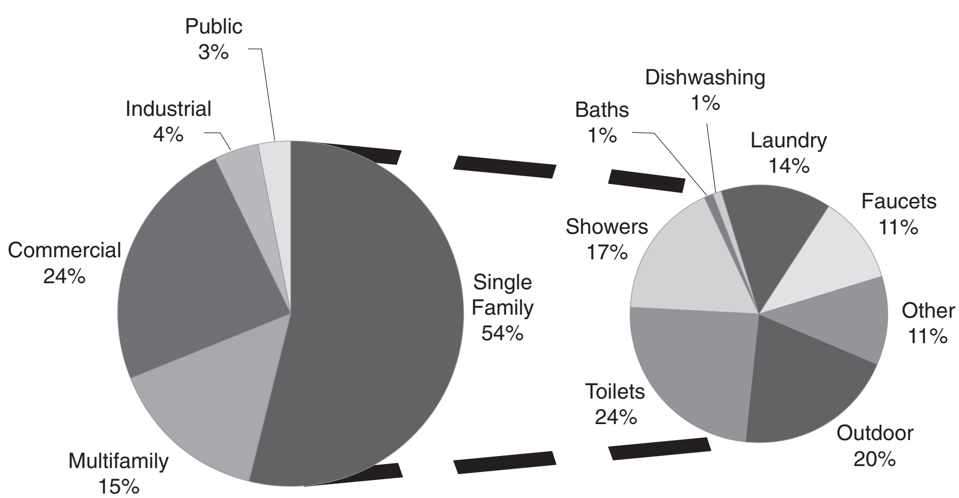

Figure 3-6 Typical water sales breakdown and single-family end uses

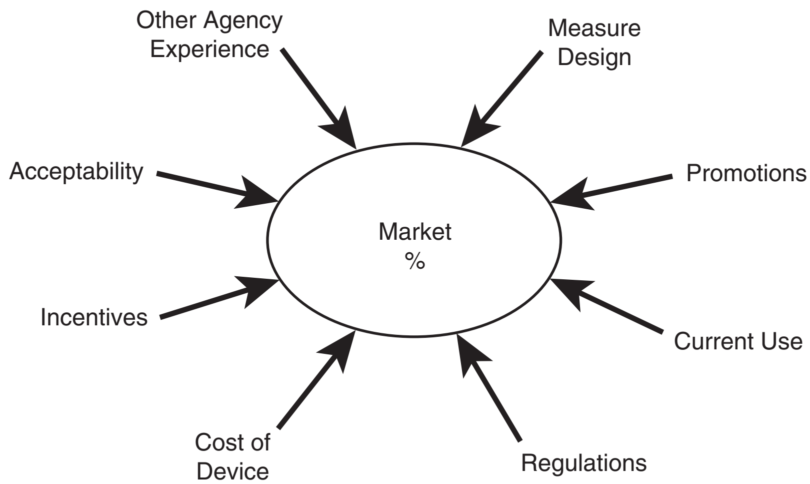

Figure 3-7 Assess market penetration

Errors in market penetration estimates for each measure can be significant because they are based on previous experience, chosen implementation methods, and projected effort and funds allocated to the measure. The potential error can be corrected, through reevaluation of the measure, as the implementation of the measure progresses. For example, if the market penetration required to achieve the needed savings is more or less than predicted, adjustments to the implementation efforts can be made. Larger rebates or more promotions may be used to increase the market penetration, for example. The process is iterative to reflect actual conditions and helps to ensure that market penetration and needed savings are achieved regardless of future variances between estimates and actual conditions.

In contrast, market penetration for mandatory ordinances can be more predictable. An Ultra-Low-Flush Toilet Program could be adopted by ordinance requiring that plumbing is retrofit within a set time or on resale. The program can ensure an almost 100 percent market penetration for affected properties. An example of market penetrations for conservation measures used on an example project are shown in Table 3-8. The market penetration is based on the factors previously described and is inherent in the measure design and cost. Table 3-8 shows illustrative values only and may not be more generally applicable.

EXAMPLE OF UNIT WATER SAVINGS EXPRESSED ON AN END USE BASIS

An example of end-use water savings, presented in Table 3-8, is expressed as a percent reduction in water use per end use. The percentages only apply to the amount of water identified as the end use, not the entire category of use. Long-term savings are those that are sustainable. Measure life is also shown in the table. When the measure life is exceeded, the water savings erode, unless steps are taken to maintain them, such as replacing an expiring water audit with a new one. Again these percentage water use reductions are illustrative only and should not be considered generally applicable.

Table 3-8 Example of end-use water savings and market penetration of conservation measures

	Measure	Applicable Customer Classes	Water Use Reductions for Targeted End Use(s)	Program Length (yr)	Market Penetration by End of Program	Measure Life (yr)
1.	Toilet Retrofit on Resale	RSF, RMF	~50% of Toilet use, varies with current toilet stock	Varies with resale rate ~10 years	~100% (varies by county ~7%/yr)	Permanent
2.	Clothes Washer Rebates	RSF, RMF	35%–Laundry	5	12%	Permanent
3.	Distribute Retrofit Kits	RSF, RMF	21%–Shower	5	75% of existing non-low-flow (varies by county)	Permanent
4.	Residential Water Audits	RSF, RMF	5%–internal, 10%–leaks & exterior	Indefinitely	10%	5
5.	Increase Public Education	RSF	2% all end uses	Indefinitely	100%	2
6.	Submeter Multifamily	RMF	15% indoor uses	5 for exist., Indefinite for New	25% Exist., 50% New	Permanent
7.	Irrigation Controller Rebates	RSF, COM, INS	15% irrigation	10	25% of [10–25%]	Permanent
8.	Rain Sensor Regulations	RSF, RMF, COM, INS	20% irrigation	Indefinitely	75% of [10–25%]	Permanent
9.	Landscape Requirements	RMF, COM, INS	20% irrigation	Indefinitely	50–75%	Permanent
10.	Commercial Water Audits	COM, INS, IND	15% all end uses	10	30% of Top 40%	Permanent
11.	a. Commercial Toilet Rebates	COM	50% of toilet use	5	40%	Permanent
12.	b. Commercial Urinal Rebates	COM	50% of urinal use	10	50%	Permanent
13.	Rebates for Coin-op Efficient Clothes Washers	RMF, COM	35%–laundry	5	25% of number in county	Permanent
14.	Cooling Tower Meters	COM, INS, IND	20% of cooling use	5	25% of number in service area	Permanent
15.	Restaurant Low-Flow Spray Nozzles	COM, INS	50% of kitchen spray use	5	25% of number in service area	Permanent
16.	Hotel/motel Water Audits	COM	15% hotel/motel end uses	10	25% of number in service area	Permanent

Table continued next page.

Table 3-8 Example of end-use water savings and market penetration of conservation measures—*continued*

	Measure	Applicable Customer Classes	Water Use Reductions for Targeted End Use(s)	Program Length (yr)	Market Penetration by End of Program	Measure Life (yr)
17.	Capacity Buy-Back for ICI Process Improvements	COM, INS, IND	15% of process use	10	25% of top 10%	Permanent
18.	Rebate for X-ray Water Recycling Units	COM, INS	90% of X-ray use	5	25% of number in service area	Permanent
19.	Self-Closing Faucets on New ICI Buildings	COM, INS, IND	25% of faucet end use	10	90%	Permanent
20.	Efficient Process Equipment	COM, INS, IND	10% of all end uses	Indefinitely	50%	Permanent
21.	Require 0.5 gpf Urinals in New ICI	COM, INS, IND	50% of urinal use	Indefinitely	90%	Permanent
22.	Irrigation Audits of Large Turf Areas	COM, INS	15% irrigation	Indefinitely	Top 25% (varies by service area)	5
23.	Xeriscape City/County Buildings	INS	30% of City, County irrigation	3	Varies by service area	Permanent
24.	System Water Audits	SYS	10% of UFW	Indefinitely	All for UFW > 10%	2
25.	Leak Detection	SYS	Reduce UFW to 15%	Indefinitely	All for UFW > 15%	5
26.	Conservation Rates	ALL	Convert to seasonal rates; indoor elasticity–0.05, outdoor elasticity–0.2	Indefinitely	100%	Permanent

NOTES: RSF = Residential Single Family
RMF = Residential Multifamily
COM = Commercial
IND = Industrial
INS = Institutional
ALL = All customer types
SYS = System
ICI = Industrial/Commercial/Institutional

Source: Reference 10

Example Comparison of Water Savings by Measure

The examples in this chapter are intended to show the general screening process. When resources allow, utilities should seek out additional tools to assist them. The water savings screening analysis can be performed using an end use evaluation model, such as the DSS model[11] or IWR MAIN[12], BMP Cost-Effectiveness Spreadsheets[13], or custom made spreadsheets.

Table 3-9 shows an example of what a completed first screen of measures might look like, prior to any detailed economic analysis. The determination of the economic feasibility of water conservation programs depends on comparing the costs of the

Table 3-9 Example results of a conservation-measure savings evaluation

	Conservation Measure	30-Year Average Water Savings (percent of 2020 water needs)
1a	RSF ULFT Retrofit on Resale	1.32
1b	RMF ULFT Retrofit on Resale	0.51
2	Residential SF Washer Rebate	0.07
3	Residential Shower Retrofit	0.33
4	Residential Water Audits	0.24
5	Public Information	0.57
6	Multifamily Submetering	0.36
7	Irrigation Controller Rebate	0.07
8	Rain Sensor Regulations	0.10
9	Non-RSF Landscape Requirements	0.20
10	Commercial Water Audits	0.22
11a	Commercial ULFT Rebates	0.44
11b	Commercial Urinal Rebate	0.22
12	Commercial Washer Rebate	0.07
13	Cooling Tower Meter Rebate	0.04
14	Commercial Kitchen Spray Wash	0.03
15	Hotel & Motel Water Audits	0.02
16	Capacity Buy-Back for ICI	0.01
17	Rebates for X-ray Recycling Units	0.04
18	Require Self-Closing Faucets for New ICI	0.15
19	Efficient Process Equipment for New ICI	0.09
20	Require 0.5 gpf Urinals for ICI	0.21
21	Irrigation Audits for Large Turf Areas	0.11
22	Xeriscape of Public Areas	0.00
23, 24	Water Losses Reduction (Audits & Leak Detection/Repair)	3.18
25	Conservation Pricing	2.18

NOTES: RSF = Residential Single Family
RMF = Residential Multi Family
ICI = Industrial/Commercial/Institutional
ULFT = Ultra Low Flush Toilets

Source: Reference 10

programs to the benefits provided. The example in Table 3-9 is from the Atlanta, Georgia, region. Savings are averaged over a 30-year analysis period. And expressed as a percentage of the region's water needs in 2020. This table presents how much water the measures would save, if the measures were run on a stand-alone basis, i.e., without interaction or overlap from other measures that might address the same end use(s).

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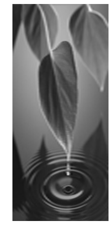

Chapter 4

Evaluation of Benefits and Costs

INTRODUCTION

Water conservation planners often rely mostly on cost-effectiveness analysis to compare water conservation measures. This type of analysis is a systematic way to evaluate benefits and costs associated with measure implementation. A conservation measure is said to be cost-effective if the present value of the benefits exceeds the present value of the costs. In this manual, the terms cost-effectiveness analysis and benefit–cost analysis are used interchangeably. Other less common methodologies may also be considered, such as life-cycle cost analysis.

The planner may use cost-effectiveness analysis to educate the public and decision makers to enable informed decisions. An example case study of a benefit–cost evaluation for a residential survey efficiency measure is provided at the conclusion of this chapter. Performing a benefit–cost analysis sets the stage for the monitoring and future evaluation of the program over time.

The first step in evaluating benefits and cost is to determine the perspective of the accounting to which the benefit or costs accrue. There are three basic perspectives:

- Water utility
- Utility customers (conservation program participants and nonparticipants)
- Community as a whole (social or external)

In other words, the planner must establish the basis for who receives the benefit or must pay the cost and be consistent in the perspectives to have an accurate analysis. Additionally, benefits and costs may be determined separately for the customer and the water utility and then combined for the community as a whole.

The following chapter will outline the methodology for performing a benefit–cost analysis to compare the value of conservation measures (through demand management) between themselves and compared with water supply augmentation (increased system capacity, new supply projects). Planners may use this analysis to assess the ability of a conservation program to defer, downsize, or potentially eliminate the near-term need for new water supplies. The outcome of this benefit–cost analysis can allow for more accurate planning for future water supply facilities requirements. Quantifying the benefits (cost savings) from a conservation program will also help justify budget requests to fund the program.

OVERVIEW OF BENEFIT–COST ANALYSIS METHODOLOGY

Benefit–cost analysis is a very useful screening tool, but the results depend on an accurate forecast of the water savings, costs, and benefits. This manual describes the process to estimate costs and benefits using either a simplified approach (suitable for small utilities) or a detailed methodology.

Many water utilities use benefit–cost analysis to evaluate and select a conservation program best suited to local conditions. This type of analysis requires locale-specific data about water use and demographics. Collect forecasted demographic data from local planning agencies or the US Census (www.census.gov) that can be used to forecast water account growth. The detailed methodology for benefit–cost analysis (Figure 4-1) may be described by the following numbered steps (which are further discussed in this chapter):

1. Develop a baseline projection of water use without conservation.
2. Based on the water use profile, identify applicable water conservation measures.
3. For each measure, estimate the market penetration (the percent of accounts that will participate in the measure).
4. Estimate the average and peak day water savings by multiplying the affected number of accounts by the measure's unit water savings.
5. Estimate the measure costs by multiplying the number of accounts participating by the incremental unit costs.
6. Identify the types of benefits of customers and the utility (water, wastewater, energy).
7. Identify planned capital projects that might be delayed or downsized by reduced water use and/or wastewater flow.
8. Determine the avoided costs associated with the planned water supply projects.
9. Determine the O&M cost savings associated with reduced water use and wastewater flows.
10. Combine the avoided capital cost and O&M cost savings into the marginal costs.
11. Use the water savings and marginal costs to compute the measure benefits.
12. Compute present worth of time stream of benefits and costs.
13. Divide the benefits by the costs and express as a ratio.
14. Accept the measure if benefit–cost ratio is greater than 1.0.

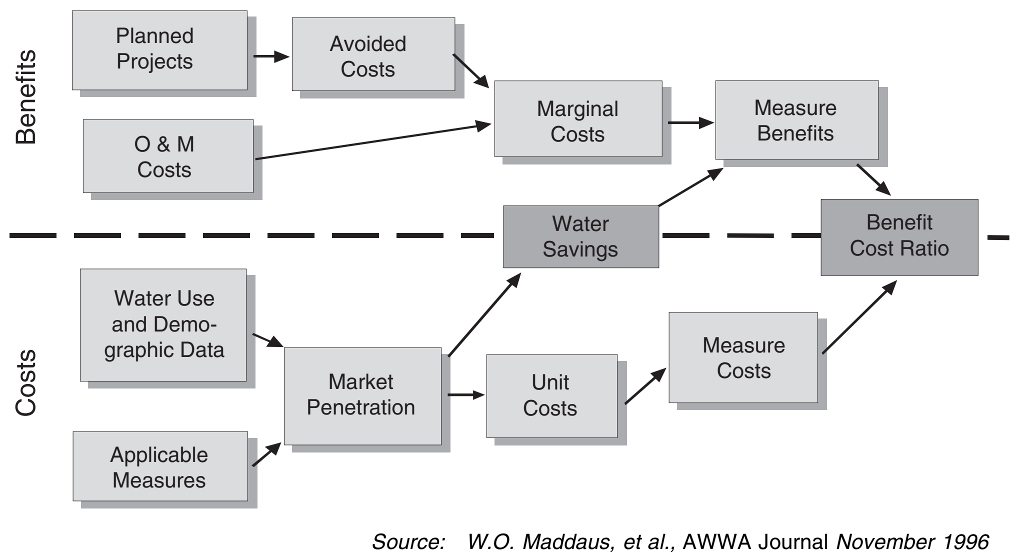

Figure 4-1 Benefit–cost analysis methodology

After benefit–cost is determined, some utilities also add a percentage bonus for benefits, which are difficult to quantify, such as environmental, socioeconomic, and consumer relations. Thus, a measure with a benefit–cost of slightly less than 1.0 might still be undertaken if it is believed that it will result in additional unquantified benefits.

Simplified Approach for Small Utilities

For small utilities (less than 10,000 connections), a streamlined approach to benefit–cost analysis may be appropriate. While a more detailed evaluation is helpful for informed decision making, especially when a large budget increase is requested, it is not necessary for a successful program. A more informal comparison of benefit and costs may be adequate for the utility to make comparisons and decisions.

The streamlined approach is to compare a planned program measure with another utility's program with similar goals and objectives. The simplified approach can build a budget based on a scaled level of effort such as dollars per person cost. For example, take a successful program's annual budget and divide by the corresponding service area population, then multiply the dollars per person cost for the same planned efficiency measures by the service area population to determine an estimate for an annual budget request. For example, a neighboring utility has 10,000 connections and a successful school education program for \$20,000 per year. The planner may estimate, based on a ratio of 7,500 connections, to budget (10,000/7,500) × \$20,000 = \$15,000.

This straightforward approach works well when the number and types of utility connections is similar. However, if the neighboring utility has several large industrial customers and many commercial connections, the focus of their program may be on nonresidential efficiency measures. It would be shortsighted to then directly compare their efforts to another service area, which is predominately residential. The straightforward approach will likely underestimate costs if the number, general pattern of use, and type of connections (residential, commercial, industrial, institutional) are more than 10 percent different from the comparison utility.

TYPICAL BENEFITS AND COSTS

The following section summarizes the major types of benefits and costs from water efficiency to the water utility, whose perspective is the focus of this manual. However, some utilities may also wish to consider customer and society benefit–cost discussed later in the section, "Other Perspectives on Benefits and Costs." If the measure has a positive (greater than 1.0) benefit–cost ratio for the customer, the customer may be more likely to implement the measure. In addition, benefits accrue from reduced wastewater flows (e.g., lower cost of treatment and delayed facility construction). While these impacts need not be included in the benefit–cost analysis for the water utility, they can be counted for utilities that provide both water and wastewater services. Many water conservation measures also save energy and/or have other benefits. All benefits should be recognized and discussed during the public review phase of efficiency planning. Partnering with wastewater and energy agencies may assist with funding efficiency programs.

Important factors to consider besides a formal benefit–cost analysis are other noneconomic impacts (e.g., water quality improvements caused by less runoff from irrigated landscapes that carry pesticides and fertilizers through stormwater systems, which discharge these contaminants directly to streams and rivers). Quantifying social and environmental benefits so they can be included in the quantitative benefit–cost analysis has long been problematical. They should be considered at least qualitatively. Reduced water production will allow the utility to save costs from

- reduced water purchases from wholesale water agencies;
- reduced O&M costs (energy from pumping [production, treatment, and distribution] and lower chemical use);
- reduced or deferred treatment plant capital expansion costs;
- reduced water storage costs; and
- reduced wastewater processing costs.

Water utility cost savings can be significant. The cost of water depends on source and necessary treatment, however costs commonly range between $1.00 to $4.50 per 1,000 gallons. These benefits (cost savings) are based on combined short-term and long-term water savings.

Short-term savings are those that are not related to capital facilities and tend to result immediately from efficiency activities. These include the reduced costs of treatment chemicals, energy, and labor and materials required to handle reduced water production.

Long-term savings are those associated with capital facilities (i.e., deferred, downsized, or avoided water and wastewater facilities because of reduced demand) or reduced water purchases. These facilities savings include not only the obvious new sources of supply, but also distribution improvements needed for increments of that new supply (e.g., replacement requirements to increase size of distribution system pipelines).

Cost of efficiency programs fall into three broad categories:

- Implementation costs (paid by the utility) such as staff time, hardware costs, and public and school education materials, and the cost of any monetary incentives that may be offered.

- The cost to the utility from reduced revenues resulting from decreased demand.
- Other costs that accrue to customers or other agencies to install and maintain water-efficiency measures (e.g., Xeriscape™ demonstration gardens, irrigation system improvements).

HOW TO CALCULATE WATER SAVINGS

The following guidance provides details for estimating water savings. An example of estimating water savings from specific measures was provided in chapter 3, specifically in Table 3-2. The following formulas give specific details on how to calculate water savings, which will result in cost savings (or benefits) from water conservation. These calculations show how to calculate rate of water savings (mgd) and may also be performed to volume of savings (e.g., acre-feet) using life cycles of measures.

Estimating Water Savings

To calculate estimated water savings, baseline water use must first be determined for the group of users targeted (e.g., use by residential customers). Water savings resulting from efficiency measures will depend on (1) the reduction in water use as a result of implementing the measure; and (2) the degree of coverage that the measure can achieve (also known as *market penetration*). The following formula may be used to estimate how effective a specific efficiency measure may be in a given year:

$$E = R \times C \times V \tag{4-1}$$

Where:

E = estimated reduction in water use as a result of the measure, in million gallons per year (mgy), for the year of interest.

R = reduction in water use as a result of the measure for all customers, expressed as a fraction of 1.

C = percent coverage of the measure for the group of water users under consideration (market penetration) for the year of interest. Also called the *installation rate*. For mandatory measures (e.g., plumbing efficiency standards), the C factor is considered 100 percent. For voluntary measures, the C factor is much lower. Once resource for estimating this value is from other utility's experience. Another approach is to set a value for C based on the desired coverage for the program. For example, the utility may decide that a coverage of 20 percent is the goal for the implementation of the measure (e.g., home water surveys), and the efficiency program will be designed to achieve this goal. In this example, the C factor is 20 percent or 0.20.

V = volume of water use without the water-efficiency measure, in million gallons per year (mgy).

The fractional water use can be estimated by the formula:

$$R = S / W \tag{4-2}$$

Where:

R = fraction water reduction for the year of interest
S = water savings resulting from the measure, in gpd
W = average water use without the efficiency measure in place (in gpd), for the year of interest.

How to determine *P*, percentage overall expected reduction in water use. The factors R and C that have been determined estimate the expected water reduction from a given measure for a particular user group, when these factors are multiplied,

$$P = (R \times C) \times 100 \tag{4-3}$$

For example, if the fractional reduction in water use resulting from installing water-efficient showerheads is 0.094, and the estimated coverage is 100 percent given the mandatory national plumbing efficiency standards,* the overall percentage reduction will be

$$P = (0.094 \times 1.0) \times 100 = 9.4\% \tag{4-4}$$

To design for maximum effectiveness, the expected impact of each efficiency measure should be assessed individually and combined for an estimate of total expected water savings. The expected water savings can be estimated by multiplying by V, for each efficiency measure expected reduction, E. For example, if the baseline water use (without conservation) for the users group of interest is 1,000 mgy, the reduction in water use from installation of water efficient showerheads is

$$E = 0.094 \times 1.0 \times 1{,}000 = 94 \text{ mgy} \tag{4-5}$$

To compute the benefits of water conservation using these formulas, the planner will need to estimate the water savings that may result from the efficiency measures. There are numerous resources to assist with estimating water savings including

- *Residential End Uses of Water*, American Water Works Association, 1999.
- *Commercial End Uses of Water*, American Water Works Association, 2001.
- *Best Management Practice (BMP) Costs & Savings Study: A Guide to the Data and Methods for Cost Effectiveness Analysis of Urban Water Conservation Best Management Practices*, California Urban Water Conservation Council, December 2003.
- *Handbook of Water Use and Conservation: Homes, Landscapes, Businesses, Industries, Farms*, Amy Vickers, WaterPlow Press, 2001.
- WaterWiser Web Site, www.waterwiser.org, American Water Works Association.

*1992 Energy Policy Act, National Plumbing Efficiency Standards for showerheads maximum flow rate is 2.5 gpm.

- Water Saver Home Web Site, www.h2ouse.org developed by the California Urban Water Conservation Council and funded by the US Environmental Protection Agency and US Bureau of Reclamation.
- Full program savings assessments and pilot test results that are published in AWWA Journals and Annual and AWWA Water Sources Conference Proceedings.
- Data from other nearby water utilities or the state agency tasked with overseeing urban water demand (e.g., California Department of Water Resources).
- Data from USGS Water Use Survey, (http:/water/usgs.gov/pubs/circ/2004/circ12681).
- *Evaluating Urban Water Conservation Programs: A Procedures Manual*, AWWA, 1993.

HOW TO DETERMINE THE BENEFITS OF EFFICIENCY MEASURES

Savings to the utility result from avoided costs (the benefits from implementing efficiency measures that achieve water savings). The following section describes the three principal ways that avoided costs accrue: (1) reduced water purchases (if the utility is a wholesale customer of another water purveyor); (2) lowered O&M expenses; and (3) delayed, downsized, or eliminated capital facilities.

Cost Savings From the Reduced Purchase of Water

A straightforward calculation results in the average annual unit cost of purchased water from a wholesaler using the following expression:

$$AWC = UPW \times UCPW \tag{4-6}$$

Where:

AWC = annual water cost
UPW = units purchased annually
$UCPW$ = unit cost of purchased water

The planner can calculate the amount of cost savings by multiplying the unit cost of purchased water by the units of water savings estimated from efficiency measures. An added level of detail can be used if a higher cost is charged in peak-use period (e.g., high irrigation season). Then, the average cost during this period (typically a few months time) is divided by the units of purchased water over the same time span. This unit cost of peak-period purchased water is multiplied by the water savings from efficiency measures targeting water reductions during that period (commonly outdoor irrigation efficiency measures).

Cost Savings From Reduced Operation and Maintenance (O & M) Expenses

Because lowering demand results in less water produced, efficiency measures can reduce expenses dependent on amount of water produced or variable costs for utility operations, such as energy and chemical costs. In addition, some fixed costs may be associated with these variable costs of energy and chemical usage and may be included, if warranted. Only the variable costs that are attributed to water efficiency activities are included in the calculation of avoided costs shown here.

To estimate the variable cost of energy ($/unit of water), use the following formula:

$$VUCE = [AEC - (12 \times MFEC) - (ECNP)] / UWU \tag{4-7}$$

Where:

VUCE = variable unit cost of energy
AEC = annual energy bill (cost)
MFEC = monthly fixed charges for energy
ECNP = energy costs not related to water production are those costs independent of actual water production, such as building heating, cooling, lighting, and process equipment use. These costs should be included unless the water production is lowered to the extent that facilities (e.g., certain buildings or pieces of equipment) are not used, which would rarely be the case.
UWU = annual units of water used

Cost savings are calculated by multiplying the variable unit cost of energy by the units of water saved per year as a result of an efficiency measure.

In most cases, costs associated with chemicals are variable because the chemicals are added based on flow with very few fixed costs. To calculate the variable cost of chemicals ($/unit of water), use the following formula:

$$VUCC = [ACC - CCNP] / UWU \tag{4-8}$$

Where:

VUCC = variable unit cost of chemicals
ACC = annual chemical bill (cost)
CCNP = chemical costs not related to productions (e.g., delivery charges unless reduced)
UWU = annual units of water used

Cost savings are calculated by multiplying the unit cost of chemicals by the units of water saved per year as a result of a conservation measure. The benefits derived from wastewater operations for energy and chemical savings can be calculated in a similar manner.

Cost Savings From Delayed, Downsized, or Eliminated Capital Facilities

Water efficiency can affect both the requirements for current operations, expansion of existing facilities, and planned new facilities. Most capital facilities are designed to meet peak demands in some future year. Typical design horizons are 10 to 20 years. Although indoor conservation measures will reduce average day and peak day demands, savings in landscape, cooling water, and other summer uses will have greater effects on reducing the peak. In cities with hot or arid climates, peak to average day ratios of 2.0 to 3.0 are common. In humid or colder climates, peak day ratios of 1.2 to 1.7 are common. The peak-day ratio can be determined by comparing utility water production records using the following formula:

$$\text{Peak-day ratio} = \text{highest day production} / \text{average day production} \quad (4\text{-}9)$$

The timing of capital facilities depends on the rate of growth in peak demand and the capacity of existing facilities. If the planned facilities are dependent on the growth of water demand, reduction in future water use can affect the timing of construction of these facilitates. Figure 4-2 illustrates an example of how water conservation could affect the timing of capital facilities. In this case, a water treatment facility needed in 2020 could be delayed about 7 years. In the example shown, demand reduction would reduce peak-day demands by about 20 percent. The resultant dollar savings to the utility are the difference in the present value of the costs associated with building the facility in 2027 instead of 2020.

A utility's efficiency program would reduce peak-day water use by 15 percent. Cost savings to the utility are the difference between building the plant at two different points in time (less debt service), plus the elimination of operating expenses for the years of delayed construction.

If demand is leveling off as growth slows down, reducing demand may reduce the need for the last expansion. In this case, the last expansion can be downsized. The capital cost savings associated with a smaller facility can be converted to present worth and added to other conservation benefits.

Information on the timing and sizing of capital facilities can often be found in the utility's capital facility plan, water supply plan, and/or water master plan. Unfortunately, sometimes the capital facilities are only identified a few years in advance, and projections of needed facilities must be made using demand projections and the design criteria.

To evaluate the impacts of efficiency, both peak-day and average-day water use must be considered. Peak-day water use usually occurs on or near the warmest day of the year for the community when outdoor irrigation has the highest demand of the season.

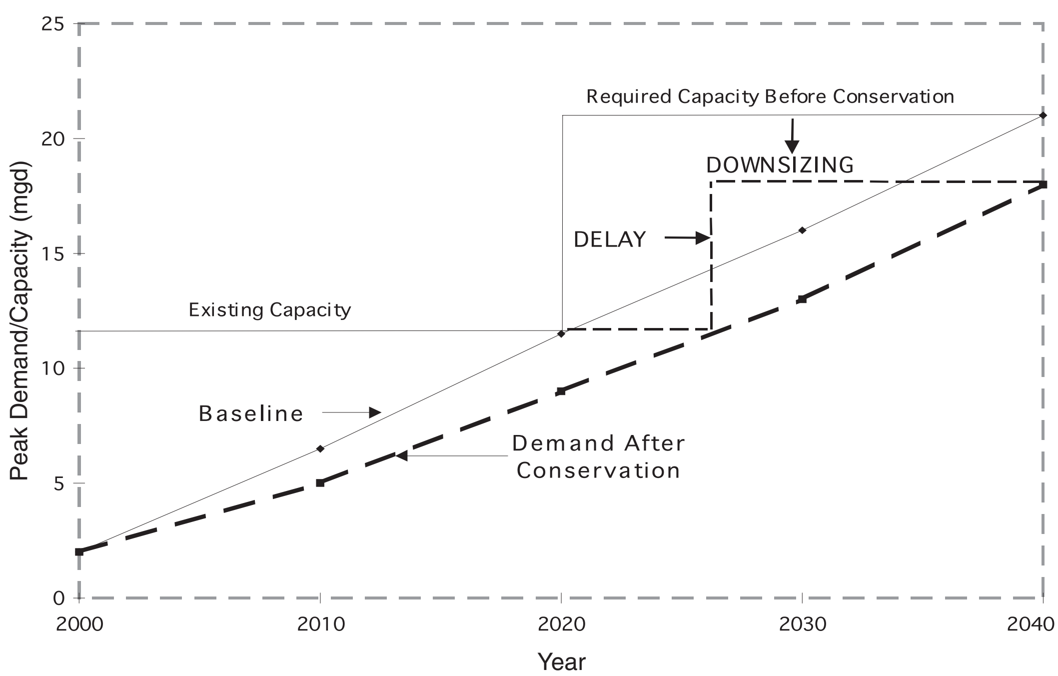

Figure 4-2 Example of delaying and/or downsizing a capital facility

Water System Design Criteria

New water facilities present an opportunity to downsize or postpone expansions. This can occur if the design of the facility is dependent on water flows. Table 4-1 shows typical design criteria for water facilities that may be affected by reduced consumption. Reduction in average day demand affects how much water must be developed, or imported and stored, prior to treatment and use. Reduction in peak day demand affects the sizing and timing of water treatment plant expansions and treated water storage. Water pipelines and pumping stations are affected by peak hour pumping. Peak hour is dependent on customer peak hour demands plus required fire flows. The latter is based on the type of land use to be protected.

Wastewater System Design Criteria

Table 4-2 shows the impacts of conservation (wastewater flow reduction) on design of new facilities. Design criteria for land disposal systems are volume dependent. Most facilities are based on peak wet weather flow, which can benefit from infiltration/inflow (I/I) control programs but are little affected by conservation programs, which save much less water than I/I contributes.

Table 4-1 Water system elements affected by conservation

	Design Criteria Based On			
System Element	Average Day	Peak Day	Peak Hour	Fire Flow
Source Water Acquisition	√			
Raw Water Storage	√			
Water Pipelines		√*	√	√
Water Treatment Plants		√		
Pumping Stations			√	√
Treated Water Storage		√		√

*Source and transmission pipelines

Source: W.O. Maddaus, *Estimating the Benefits for Water Conservation*, AWWA Conserv Conference Proceedings, 1999

Table 4-2 Wastewater system elements affected by conservation

	Design Criteria Based On		
System Elements	Average Dry Weather Flow	Peak Wet Weather Flow	Solids Loading
Collection Systems		√	
Interceptors		√	
Treatment Plants		√	√
Disposal to Receiving Water		√	
Land Disposal	√	√	

Source: W.O. Maddaus, *Estimating the Benefits for Water Conservation*, AWWA Conserv Conference Proceedings, 1999

Other Benefits

Other benefits that sometimes are significant and possibly can be quantified:

- Lower withdrawals from supply sources (more water remains in rivers and aquifers)
- Lower discharges of treated wastewater to receiving waters
- Lessened construction environmental impacts
- Creation of water conservation jobs
- Customer savings in utility bills

In-depth descriptions of the methodology for calculating the economic benefits that the utility will realize from the delay, downsizing, or elimination of capital facilities is available in the American Water Works Association Research Foundation (AwwaRF) publication, *Economic Impacts from Water Demand Reductions* (AwwaRF, 1996).

How to Calculate Avoided Costs From Downsizing, Delaying, or Eliminating a Water Supply Capital Project

The basic methodology below illustrates the economic benefit from the following simplified formulas:

If the project is downsized:

$$\text{Cost savings} = (\text{Cost at original size}) - (\text{Cost at reduced size}) \qquad (4\text{-}10)$$

Cost in the above equation includes both capital and life-cycle operations and maintenance costs.

If the project is delayed:

$$\text{Cost savings} = \frac{(\text{Cost in original year})}{(i+1)^m} - \frac{(\text{Cost in delayed year})}{(i+1)^n} \qquad (4\text{-}11)$$

Where:

m = number of years until the original project is built
n = number of years until the delayed project is built
i = discount rate used in present value calculation
Note: $n–m$ is the delay in years.

Cost in the above equation includes both capital and life-cycle operations and maintenance costs.

If the project is eliminated:

$$\text{Cost savings} = \text{capital cost (in net present value (today's) dollars)} \qquad (4\text{-}12)$$

HOW TO DETERMINE THE COSTS OF CONSERVATION MEASURES

This section describes the following two principal types of costs to the utility for undertaking efficiency programs: (1) direct utility costs for implementation, such as in-house staff costs and any contracted costs (where a private contractor performs some of the work); and (2) cost of decreased water revenues.

Direct Utility Costs are the sum of in-house staff costs and contracted costs (if work is contracted out) and can be calculated as:

$$\text{Direct utility costs} = \text{In-House costs} + \text{contract costs} \tag{4-13}$$

Where:

In-House costs = Administrative costs + {field labor hours × hourly rate (including overhead)} + {unit costs × number of efficiency measures or devices} + publicity costs + evaluation (or follow-up costs)

Contract costs = Administrative costs + {number of events (or sites) × unit cost per event (including program unit costs)} + publicity costs + evaluation (or follow-up costs)

Administrative costs include the staff time required to oversee field staff, contractors, consultants, or contracted field labor. Administrative costs will be higher when launching a new program or with large consultant contracts. Administrative costs are typically 5 to 15 percent of total program costs.

Field labor costs include staff time to conduct efficiency program work in the field, such as water audits/surveys, leak repair, and fixture installation, follow-up site visits, and door-to-door canvasing.

Unit costs are based on cost per device or measure basis or as a cost per participant. Examples include retrofit kits, water audit programs, and rebate programs. Small programs typically have higher unit costs than larger programs because of bulk purchase discounts and a smaller number of participants.

Publicity costs are the costs of a public outreach to educate customers through local media, including radio and television spots, local newspaper advertisements, flyers, bill inserts, billboard and bus advertising, theater slides, customer workshops and seminars, and special demonstrations (booths at community events). Larger utilities often employ public relations professionals to handle this aspect of their efficiency program for maximum effect, but this is not necessary for smaller programs. Costs will be roughly proportional to the number of customers contacted.

Evaluation and follow-up cost includes two types of follow-up: (1) the utility must keep records of the impact of the conservation measure(s) is having (to quantify the water savings from these activities); and (2) monitoring how well the measures are performing through follow-up contact with participants to assess if program goals are being achieved. Costs from these follow-up activities may include staff time, conducting public surveys assess customer participation and satisfaction (including changes from a baseline survey on attitudes and also market penetration studies (more common among larger utilities) to assess future means for better targeting implementation of the measure).

The best sources of information are from the experience of other utilities that have conducted similar programs. Costs can be expressed on a unit basis (for example, $ per dwelling unit, or $ per survey/audit) and then transferred to another utility's service area, accounting for economies of scale (e.g., any bulk purchase discount or larger number of participants that would drive costs down) for different size programs.

Costs of Decreased Water Revenues

Less revenue is a primary concern of utility decision makers and should be assessed carefully and explained fully. Decreased water revenues can mean less funding for new capital facilities operation and maintenance, but these costs are often offset by a reduced need to build, operate, and maintain future facilities.

There is a direct correlation between lower water use and less revenue. The cost of decreased water revenue is the cost per unit of water multiplied by the units of water conserved. Generally, this revenue reduction is small and occurs over a long period of time, allowing for the utility to incorporate these changes into budget forecasts and redesign rate structures. Typically, cost-effective (benefit–cost ratio above 1.0) efficiency programs save ½ to 2 percent of annual water use, and by the same accord, reductions in water revenues per year are the same over the life of the program. This amount has historically been less than inflation in other utility costs. The short-term savings from efficiency measures that reduce production costs (energy, chemical, and treatment costs) help to offset revenue decreases. Periodic rate adjustments can recover the inflation in utility costs in addition to recovering any less revenue, thus the actual economic impact is insignificant. The primary concern of utility decision makers over reduced revenue can frequently be avoided by incorporating estimated conservation program savings into future demand forecasts and rates prior to program implementation.

HOW TO PERFORM A BENEFIT–COST ANALYSIS

Up to this point, the planner has gathered information on how to calculate benefits and costs. The goal now is to combine this information into a formal benefit–cost analysis from the perspective of the water utility. For guidance, Tables 4-3 through 4-5 provide an actual example of how to perform a benefit–cost analysis for a residential water survey efficiency measure.

Benefit–cost analysis will tell the planner, decision makers, and the public whether the proposed measures are economically efficient, or if the benefits are greater than the costs. The larger the water savings and the smaller the costs of the measures, the more economically attractive the measures are to the water utility. Later in this chapter, immediately following determination of benefit-to-cost ratio from a utility perspective, is a more detailed discussion of other perspectives and considerations.

Benefit–cost analysis requires careful attention to detail and is a central responsibility of planners at medium-sized and large utilities. Planners perform benefit cost analysis to justify significant budgets or as part of an effective water supply planning process. Smaller utilities may elect to calculate the cost of water saved, as described below, and select measures based on only costs.

A positive benefit cost ratio will not always be the final deciding factor. Some measures are implemented independent of an economic evaluation. A good example is public education programs, which are often thought of as the "glue" that holds the efficiency program together. When performing a financial assessment, public education is difficult to quantify in terms of direct water savings and as a result rarely has a positive benefit–cost ratio. However, public information and education programs are critical to assist with the success of all measures by building the conservation ethic in customers. In general, most utilities will ramp up their efficiency program over time and package education costs with other cost effective measures so that the total combined conservation program has a positive benefit to cost ratio.

How to Determine the Benefit-to-Cost Ratio

This is a standard means of analyzing different alternatives, and numerous economics textbooks present several methods for estimating the costs and benefits of a potential alternative, in this case an efficiency measure. One resource is the *Cost Effectiveness Guidelines for Evaluation Urban Water Conservation Best Management Practices* (California Urban Water Conservation Council, 1998).

As an overview, the method calculates the ratio of the present value (today's dollars) of benefits to the present value of costs. Present value of a future cost or benefit (payment) is the amount of money needed today to make that payment in a future year, given that today's money will earn interest between today and when the payment must be made. It is a similar concept to buying a US Savings bond today at a discounted amount that will mature to the face value in some specified future year.

If the ratio is greater than 1.0, the benefits outweigh the costs and the measure is considered feasible (or economically efficient). The following formula shows the basis for benefit to cost ratio:

$$\text{Benefit–cost ratio} = \frac{\dfrac{\text{sum of benefits (\$) in year } (t)}{(1+i)^t}}{\dfrac{\text{sum of costs (\$) in year } (t)}{(1+i)^t}} \tag{4-14}$$

Where:

i = selected discount rate, as a decimal (5% = 0.05)
t = year in evaluation period

Simplified Approach—Estimating the Cost of Water Saved

The cost of water saved is a useful number that is relatively easy to calculate. It is commonly expressed as dollars per million gallons, cents per 1,000 gallons, or dollars per acre-feet. These are common denominations of new water supply, and it is a simple comparison to see if efficiency measures are less expensive than new sources of supply. Although somewhat simple, the reader is cautioned that the lifetime of each conservation measure and the lifetime of a water supply project are usually different, and thus these should be normalized prior to comparison. This can often be done by renewing the shorter lifetime measure until it approximately equals the lifetime of the longer one. There is no standardized formula for calculating the unit cost of water saved, but the following is suggested:

$$\text{Unit cost of water saved (\$/unit of water)} = TC/V \tag{4-15}$$

Where:

TC = present value of the total efficiency program costs over planning period (dollars)
V = total volume of water saved (units) over the planning period (e.g., acre-ft or 1,000 gal)

OTHER CONSIDERATIONS

Looking only at the economic benefits and costs to the water utility may lead the planner down the path of selecting measures only with very high benefit–cost ratios. However, it is vital to keep the big picture in mind and make sure that the overall water savings goal of the program is met. High benefit–cost ratios may only lead to small total water savings and result in using available dollars that would be better expended on implementation of measures that achieve more total water savings or save on peak-day water savings, depending on program goals. Often, packaging measures that target certain customer sectors provide economies of scale in marketing and administration, making the package more cost-effective than the individual components would appear. Combining measures with high benefit-to-cost ratios with some that produce more savings but have lower benefit-to-cost may in some cases make an attractive option.

OTHER PERSPECTIVES ON BENEFITS AND COSTS

It is crucial to review the efficiency measures from other perspectives, namely the customer and other organizations (e.g., wastewater, stormwater, or energy utilities). For example, for efficiency measures that result in hot water savings, such as efficient showerheads, customers receive significant cost savings on their energy bill in addition to savings on their water bill (if metered). In this case, secondary beneficiaries result from cost savings to the wastewater and energy utilities.

Where potential efficiency measures benefit more than one utility, the cost savings to each may be quantified and used as means for negotiating a partnership to co-fund efficiency programs. At a minimum, combined messages are especially effective when trying to stretch public information campaign dollars. Some example partnerships include the following:

Stormwater Utilities

Reductions in outdoor irrigation that prevents runoff containing pesticides and fertilizers are beneficial to stormwater utilities that are governed by discharge water quality limits (sometimes difficult to meet in dry seasons). Irrigation peak-day water use is also the most significant capital cost to water utilities given system capacity expansions are commonly triggered when demand reaches 90 percent of peak system capacity.

Solid Waste Utilities

Less irrigation and appropriate (more native) and dense landscapes result in less green waste, which saves on trucking and disposal costs. In some cases, solid waste utilities have bioreactors that use green waste to generate energy, and this lowers the benefit to these utilities.

Wastewater Utilities

Reductions in indoor water use leads to generation of less wastewater, which results in cost savings to wastewater utilities (e.g., lower energy and chemical usage on the average dry weather flow that is mostly indoor water use). Given that new wastewater treatment facilities are hydraulically sized to meet wet season conditions, and mechanically to treat the workload, water efficiency usually does little to assist in deferring wastewater capital projects. There are exceptions to the general rule where the volume discharged matters (disposal limitations). Also, many wastewater utilities are looking to recycle by irrigating landscapes with reclaimed versus potable water. This allows for water utilities to reduce peak-day irrigation demands, conserve system capacity, and potentially serve additional customers.

Energy Utilities

These benefits may be twofold. Water utilities that produce less treated water conserve energy and can pump more water during off-peak times. In addition, customers that install more efficient fixtures and appliances that use hot water (i.e., showerheads, faucet aerators, clothes washers, dishwashers) also assist with reducing energy usage, which, if used during peak use periods, allows energy utilities to defer building new capacity.

Customer Benefits

The following discussion focuses on how to estimate savings to the customer that will result from lower utility bills for water, wastewater, and energy.

Water utility bill savings. Assuming the customer is metered with a volumetric billing rate, the estimated customer water savings from implementing different efficiency measures can be multiplied by the customer's water billing rate. This calculation can become complicated, depending on the type of water rate system in place. In cases where the customer pays a regular fee for water service regardless of usage, there is no economic incentive to conserve water.

When utilities charge different rates to different customer classes, the water savings need to be calculated for each customer class (e.g., residential, commercial, industrial, institutional). In the case of different rates within customer cases, the simplest procedure may be to find the "average" customer in each class and calculate the "average" customer in each class. To determine the average billing rate, the total water consumption for the customer class should be divided by the number of customers in the class. When matched to the appropriate rate, multiplying by the corresponding water savings estimate gives the cost savings for the "average customer." This can be done for the peak month usage (commonly July–August) and the minimum month (commonly January–February) to estimate a range of average cost savings for an "average" customer. This information can be useful in public education efforts, for example, as content for bill inserts. However, the combined cost savings with other utility bills will make a stronger case for efficiency.

For the customers throughout the service area, the average water savings per customer class multiplied by (1) the total number connections for that type of customer; and (2) the unit cost per 1,000 gallons will provide the total estimated cost savings to "average" customers for the efficiency program as a whole.

Wastewater utility bill savings. Customers that are billed based on a flat rate will not realize any benefits from efficiency measures that generate less wastewater. Residential customers will benefit from conservation if billed according to a fixed monthly charge plus a unit charge per unit of water use. If this billing method is used, wastewater bill savings can be estimated by multiplying indoor residential water savings estimates by the unit charge. This method is appropriate because reduction in wastewater flows is approximately equal to reductions in indoor water use. Nonresidential customers are typically billed with a fixed charge and unit charge based on water usage, so the same method for estimating cost savings is appropriate.

Energy utility bill savings. Reductions in hot water use translate into direct energy savings from less water heating. These cost savings are significant for both residential and nonresidential users. Most energy utilities charge a basic rate followed by "block" rates for higher energy usage. The marginal energy cost for different customer classes can be found by contacting the local energy provider and asking for the rate of the highest block for the "average" customer, or, alternatively, the *marginal cost* for energy for that customer class. The average customer probably uses energy at all block levels and so energy saved will be at the highest rate, but this assumption should be verified with the local energy provider. Additional information on the type of energy (electricity, natural gas, or propane) most commonly used will lead to the fuel efficiency of the water heating unit and the resultant water heating capacity in each gallon of water. An assumption for an average length of shower will provide a volume of heated water saved. Similarly for clothes washing, an average number of loads washed and savings from a water-efficient machine will lead to energy savings. The local energy provider can assist with this evaluation. The energy units saved can be multiplied by the cost per unit energy (highest rate) to determine the total cost savings to customers.

Solid waste and stormwater savings. Because customers typically pay a flat fee for solid waste disposal service and do not pay directly for stormwater service, neither may provide savings on customer utility bills. In areas where customers pay by volume of "green" waste, some reductions in volume can produce savings. Nonutility savings from less investment in these types of services is not considered economically significant to include in this analysis of customer savings.

Tax credits. Certain states, including Texas, offer sales tax and property tax exemptions for installation of certain water conservation equipment such a rainwater harvesting and water reuse.

Environmental and Other Benefits

Environmental benefits can take many forms and be direct or indirect. Examples of direct benefits include the lessened impact on endangered species or biological diversity from reduced water withdrawals from a surface water supply. Examples of indirect or less obvious effects include reduced greenhouse emission from power plants because of less pumping energy to extract groundwater. Other benefits can include secondary employment for recreation, aesthetics, and conservation services that benefit the local economy. Some of these environmental and social benefits are now beginning to be better quantified.[*]

Customer Costs

There will typically be costs incurred by customers to become more water efficient. These costs commonly include an incremental increase in cost to purchase more efficient appliances (e.g., clothes washers). For example, a customer may replace a clothes washer at the end of its useful life. It may cost $200 more to purchase a more efficient machine. The cost to the customer in this example is not the full cost of the washer, but the incremental cost of a more efficient model. Some utilities offer incentives to customers who purchase more efficient fixtures or appliances to reduce or eliminate the cost difference between less and more water-efficient models. In addition, incentives may assist with the customer making a purchase of a new more efficient model in lieu of continuing to repair an old inefficient model. Incentives sometimes help offset installation costs as well (e.g., a plumber's installation of a water efficient toilet). Obviously, if costs are too high, customers may not be willing to participate.

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*Postel, S. and Richter, B. *Rivers for Life, Managing Water for People and Nature*. Island Press, 2003.

Increased costs may also occur for commercial or industrial facilities where installation of water saving equipment increases operation and maintenance expenditures. These customers normally use a simple payback analysis on the time to receive a return on an investment.

CALCULATION EXAMPLE: BENEFIT–COST CASE STUDY FOR A RESIDENTIAL SURVEY MEASURE

In this example, a trained water utility surveyor (or auditor) visits single-family homes and conducts tests and recommends ways to save water (the water-saving measure). The homeowners take voluntary actions to conserve water based on these recommendations.

This case study is from a water utility's perspective and is simplified to evaluate only one efficiency measure and a one-year investment in that measure. The benefits (water savings) over the life of the measure are evaluated against the one-year cost of implementing this measure. If the benefit–cost ratio is greater than 1.0 (that is, the benefits are greater than the costs), the measure can be considered cost-effective and a good investment for the utility.

The water utility and the impact of the water saving measure in this example has these characteristics:

Total Daily Water Produced (gal) = 18,500,000
Average Daily Total Single Family Residential Water Use (gal) = 8,400,000
Number of Single Family Homes = 28,000
Average Water Use per Home (gpd) = 300
Number of homes per year implementing the water saving measure = 1,000
Program length is 10 years
Each participating home saves 10% due to the water saving measure
Each participating home saves 30 gpd due to the water saving measure
Each participating home will implement the measure for five years
Planning period for data analysis is 25 years

Step 1—Lifetime Water Savings

The first step is to calculate the lifetime water savings from implementing this water saving measure. Use Eq. 4-1 to calculate the estimated annual water savings. In this case, calculate the savings in gpd rather than million gallons per year by using this value in the formula.

$$E = R \times C \times V$$
$$R = 0.1$$
$$C = 1{,}000/28{,}000 = 0.0357$$
$$V = 8{,}400{,}000 \text{ average daily water usage in gal}$$
$$E = 0.1 \times 0.0357 \times 8{,}400{,}000 = 30{,}000 \text{ gpd}$$

Calculate the total savings at the end of the measure life (five years) = 150,000 gpd

The total savings in the last year of the program (tenth year, see Figure 4-3) = 150,000 gpd

The total annual savings decay after the end of the program (after year ten, Figure 4-3) = 150,000/5 = 30,000 gpd.

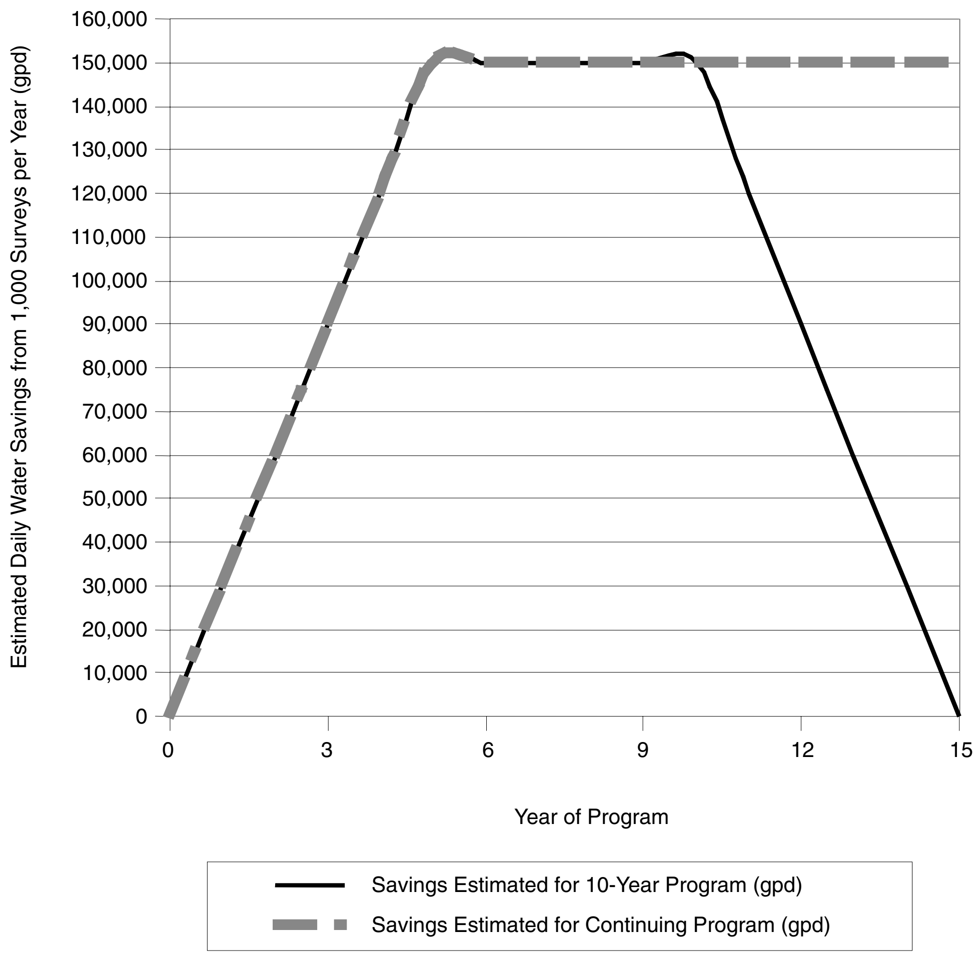


Figure 4-3 Estimated water savings for a 10-year versus ongoing residential water survey program. Note that the savings decay at the end of the 5-year measure life, unless the program continues

The lifetime savings is calculated based on a 25-year planning period that was chosen for the example analysis.

Lifetime savings,
million gallons (mg) = ($E \times 365/1{,}000{,}000$) / (1/measure life)
= (E, gpd $\times$ 365 day/yr)/1,000,000 gal/mg/(1/5yr)
= 54.75 mg

Step 2—Costs to Develop and Implement the Water-Saving Measure

Calculate the direct utility costs using Equation 4-16 as follows:

$$\text{Direct Utility Costs} = \text{In-House Costs} + \text{Contract Costs} \qquad (4\text{-}16)$$

Where:

In-House Cost = Administrative costs + {Field labor hours × hourly rate (including overhead)} + {Unit costs × number of efficiency measures or devices} + Publicity costs + Evaluation (or follow-up costs)

Contract Costs = Administrative costs + {number of events (or sites) × unit cost per event (including program unit costs)} + Publicity costs + Evaluation (or followup costs)

Table 4-3 Summary of Direct Cost Calculation Example

			Value (Example)
1.	Administration Costs	a. Staff Hours	150
		b. Hourly Cost, $/hour	50
		c. Annual Cost, $/year Line 1a times 1b	7,500
2.	Field Labor Costs	a. Staff Hours	500
		b. Hourly Cost, $/hour	30
		c. Annual Cost, $/year Line 2a times 2b	15,000
3.	Materials Costs	a. Unit Cost per Participant	20
		b. Number of Participants/year	1,000
		c. Annual Cost, $/year Line 3a times 3b	20,000
4.	Total Service Area Population		100,000
5.	Targeted Population	Percent	10
6.	Targeted Population (line 4 × 5)	Number Customers Contacted (assume 10% positive participation response)	10,000
7.	Publicity Costs	a. Marketing Cost, $/year	5,000
		b. Advertising Costs, $/year	10,000
		c. Annual Cost, $/year Line 7a plus 7b	15,000
8.	Evaluation and Followup Costs	a. Labor & Consultant, $/year	5,000
		b. Annual Cost, $/year Line 8a	5,000
9.	Total Costs (Line 1c+2c+3c+7c+8b)		62,500
10.	Program Cost Sharing (e.g., 25% grant funds, partnerships with wastewater, stormwater, or neighboring water utilities) (Line 9 × cost share percentage)	Cost Share From Other Organizations (assume 25%)	15,625
11.	Net Agency Annual Cost, $/year (Line 9 minus Line 10)		46,875

Step 3—Benefits of Water-Saving Measure

The value of the benefits of the water saving measure are the sum of the avoided costs. There are three main cost categories that comprise this total: reduced water purchases; lower operation and maintenance expenses; and delayed, downsized, or eliminated capital facilities. In this example the need for a new reservoir can be avoided. The volume of water that is not needed also affects the wastewater volume and, therefore, the cost of collection and treatment. The variable chemical and energy cost savings are added to the total.

Table 4-4 Summary of Utility Benefits Calculation

		Value (Example)
1.	Next source of water	Our New Reservoir
2.	Average Annual (Discounted) Avoided Supply Acquisition Cost, $/mg	0
3.	Average Annual (Discounted) Avoided Water Treatment and Distribution Costs, $/mg	1,250
4.	Average Annual (Discounted) Avoided Wastewater Capacity Costs, $/mg	500
5.	Avoided Variable Treatment and Distribution Costs (water plus wastewater if measure reduces both, otherwise just water costs)	
5a.	Chemical Costs	
	1. Total Annual Chemical Costs, $/yr	500,000
	2. Annual Costs for Chemicals not related to Water Production, $/yr	200,000
	3. Avoided Chemical Costs, $/yr Line 5a.1 minus Line 5a.2	300,000
	4. Total Annual Treated Water Produced, mg (18.5 mgd × 365)	6,750
	5. Unit Cost of Chemicals, $/mg Line 5a.3 divided by Line 5a.4	44
5b.	Energy Costs	
	1. Total Annual Energy Costs, $/yr	2,000,000
	2. Annual Fixed Costs for Energy $/yr	1,000,000
	3. Annual Energy Costs Not Related to Water Production, $/yr	500,000
	4. Avoided Energy Costs, $/yr Line 5b.1 minus Line 5b.2 minus Line 5b.3	500,000
	5. Total Annual Treated Water Produced, mg (18.5 mgd × 365)	6,750
	6. Unit Cost of Energy, $/MG Line 5b.4 divided by Line 5b.5	74
6.	Avoided Unit Variable Treatment and Distribution Costs, $/mg Line 5a.5 plus Line 5b.6	118
7.	Total Average Annual Unit Supply and Treatment Benefits, $/mg Line 2, plus Line 3, plus Line 4, plus Line 6	1,868

NOTE: Lines 2,3,4 discounted and converted to equivalent annual cost

Step 4—Benefit–Cost Ratio Calculation

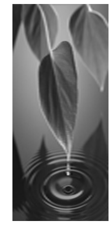
The benefit–cost ratio is calculated using the equation as shown below.

$$\text{Benefit–cost ratio} = \frac{\text{sum of benefits (\$)}}{\text{sum of costs (\$)}}$$

The benefit–cost ratio is 2.2 for this example and, therefore, the program can be justified on a cost basis.

Table 4-5 Summary of Utility Benefit–Cost Ratio Calculation

1. Present Value of Costs	
a. Total Annual Costs, $/yr** (Costs Summary in Step 2)	62,500
b. Cost Share from Others, $/yr	15,625
c. Total Program (Net) Costs, $/yr (Line 1a–Line1b)	46,875
2. Present Value of Benefits	
a. Unit Water Supply and Wastewater benefits, $/mg (Benefits Summary in Step 3)	1,868
b. Lifetime Water Savings, mg (Water Savings Calculation in Step 1)	54.75
c. Total Utility Benefits, $/yr Line 2a times Line 2b	102,273
Benefit–Cost Ratio Line 2c divided by Line 1c	2.2
Benefit–Cost Ratio is greater than 1.0. Program design for this measure is cost-effective	



Chapter 5

Creating a Formal Water Conservation Program Plan

INTRODUCTION

This chapter describes the process to develop a utility conservation plan. It begins by using the cost-effectiveness techniques described in chapter 4 to establish and evaluate alternative packages of measures. Also, a comparison of alternatives is made. An example outline for a water conservation plan is provided. Implementation issues are covered including budget setting, staff scheduling, partnering, and training. Plus, a method to track and evaluate program water savings is shown.

USE BENEFIT–COST ANALYSIS TO EVALUATE PACKAGES OF POTENTIAL MEASURES

Chapter 4 shows how to evaluate the benefits and costs of water conservation measures, individually. This analysis shows how much water the measures would save, how much they would cost, and what the benefit–cost ratios are if the measures were run on a stand-alone basis, i.e., without interaction or overlap from other measures that might affect the same end use(s). It should be noted that measures with benefit–cost ratios less than 1.0 have a negative net utility benefit.

Most water conservation programs consist of multiple water conservation measures. Therefore, it is customary to combine measures into alternative programs and reanalyze the benefits and costs for the alternative programs. When deciding which measures to include in an alternative package, the following factors are normally considered:

- Water savings over the planning period: These can be averaged over thirty years or water savings calculated in a particular year, such as 2020, can be the focus.
- Utility benefits and costs: Those benefits and costs that the utility would receive or spend.
- Community benefits and costs: Community benefits equal utility benefits plus customer energy (cost to heat water) benefits. Community costs include utility and customer costs.
- Water benefits: These are based on the avoided cost of new treated water expressed as $/mg and avoided wastewater costs (wastewater benefits) also expressed as $/mg dry-weather flow reduced.
- Required initial year(s) budget for the utility: Costs can include measure setup, annual administration, and payment of rebates or purchase of devices or services as specified in the measure design.
- Customer costs: These costs may affect the measure acceptance and normally include costs of implementing the measure and maintaining its effectiveness over the useful life.

In constructing alternatives, it is useful to develop three to four alternatives of increasing effectiveness, which could be named, for example, Program A, B, and C. An example array of programs:

- Program A could include the most cost-effective measures and be a small increase from current efforts. For example, it could include three measures: public education, water losses reduction (where needed), and residential retrofit.
- Program B normally includes Program A measures plus additional measures. It can be designed to be the midpoint, and generally consists of 5–10 measures, all relatively cost-effective, but less aggressive, yet still able to save significant amounts of water.
- Program C often includes 10–30 measures. It normally includes Program A measures and usually all of Program B measures, plus additional measures. Measures that either saved a small amount of water or were not cost-effective (benefit–cost ratio less than 1.0 and a high cost of water saved) are usually eliminated. Aggressive regulatory measures are often included in this program.

In this way, the three programs represent the range of options from a low impact program to a very aggressive program. Although this can be done with three programs, in some cases four to five alternatives may be needed to represent a full range of choices. Sometimes the water conservation advisory committee may suggest an additional alternative, after reviewing the results of the evaluation of the first three.

Example of an Alternative Packages Evaluation

Table 5-1 presents an example of key evaluation statistics for the water service area. Assuming all measures are successfully implemented, projected water savings and wastewater reductions for 2030 in mgd are shown, as are the costs of achieving this reduction. The costs can be expressed in three ways. Shown in the table are the total

Table 5-1 Results of an example alternative packages evaluation

Conservation Alternative Package	Water Utility Benefit Cost Ratio	2030 Water Savings (*mgd*)	2030 WW Generated Reduction (*mgd*)	2030 External Water Savings (*mgd*)	Present Value of Water Utility Costs ($1,000)	First Five Year Total Utility Costs ($1,000)	Cost of Water Saved ($/*mg*)
A	2.8	52.1	9.0	1.9	$139,300	$42,200	$331
B	4.7	117.7	49.9	26.7	184,900	52,100	203
C	4.4	131.3	60.3	29.9	224,400	71,800	218

NOTES: Present Value is determined using an interest rate of 3%
Cost of water saved is present value of water utility cost divided by total thirty-year water savings.

present value over the thirty-year period, the money utilities would need to budget in the first five years to get the program under way, and the cost of water saved.

Figure 5-1 is an illustration of the relationship between the water savings at the end of the planning period (in this case 2030) versus the present value of costs to achieve those savings. Water savings are cumulative in that Program A is plotted at the Program A plus plumbing code savings, B is A plus the water savings from B, etc. This figure shows an example where the marginal returns first increase and then decrease as more money is spent to achieve savings. The cost of water saved decreases from $331/mg with Program A to $203/mg with Program B, and increases to $218/mg with Program C. The benefit–cost ratios increase from Program A to B, and the ratio for C is a little lower than for B (all packages are cost-effective). The increasing effectiveness in moving from Program A to B is because of the inclusion of relatively low cost but effective measures in Program B. Program C has more aggressive and costly measures and so the slope of the curve begins to decrease. In this example, one would be inclined to select Program B as the most cost-effective. It can also be said that Program B represents the point of diminishing returns; that is, further investments in conservation beyond Program B achieve further savings, but at a higher unit cost ($/mg).

PLAN SELECTION CRITERIA

At this stage in the process, the plan is merely a package of conservation measures. Later the plan will include a budget, staffing, and implementation requirements and schedule. Before this additional effort is expended, the alternative packages should be narrowed to a preferred option or recommended plan.

The job of water conservation planners is to present information needed by decision makers who will select the final water conservation plan. In some cases, the planner will be asked for a recommendation; in other cases only an evaluation of alternatives and suggested plan selection criteria will be requested. Focusing on an appropriate set of plan selection criteria is important whether making a decision or just presenting technical and nontechnical information concerning alternative plans. There is no one list of criteria that fits all situations. Presented below are criteria that the planner may deem appropriate for the local situation.

- **How well does the alternative plan meet goals?:** Goals were discussed in chapter 2. How well the plan will meet those goals should be quantified.
- **Cost-effectiveness:** Alternative plans can be evaluated for cost-effectiveness using such measures as the benefit–cost ratio or the cost of water saved in

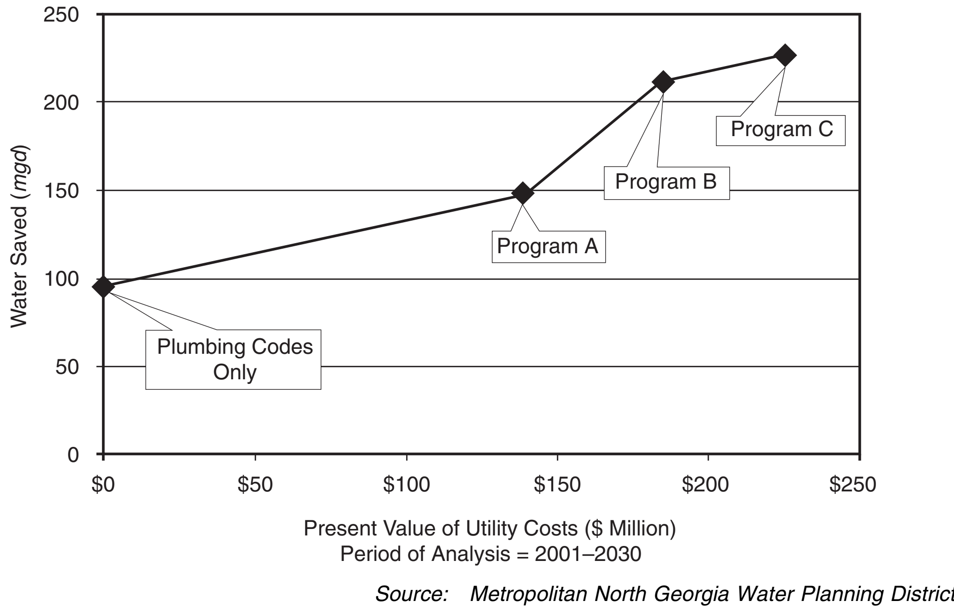


Figure 5-1 Example of the relationship between present value of utility costs and water saved in a future year

$/mg. The higher the benefit–cost ratio or the lower the cost of water saved, the more cost-effective is the alternative. Small differences in these parameters should be ignored because they must be prepared with estimated water savings and costs. The plan should clearly show the best value for the conservation dollars expended.

- **Effect on long- versus short-term supply situation:** In some cases, the plan may obviate the need to expand a water supply or water treatment plant. If the plan can do this in the short term, it will produce more immediate benefit for the agency than deferring a capital project that is not needed for 10 to 20 years. In some cases, a conservation program can stretch an existing supply until a more permanent long-term supply can be developed.

- **Regulatory requirements:** A number of states require that water conservation plans be prepared, often by a certain date. Such requirements generally specify the contents of the plan; with few exceptions the level of aggressiveness of the plan, i.e., the amount of water that must be saved, is left to the discretion of the local water agency. In some cases, the measures that must be evaluated are specified, such as customer metering, leak reduction, and public education.

- **Public input:** Public participation in the plan selection process is to be encouraged. Various AWWA publications and the following text can be used as a guide on how to conduct an effective public participation program. Many utilities have a water conservation advisory committee that provides at least part of the needed process. Public support for the plan is important and when choices are involved, it can be ensured that the public will weigh in on which alternative is preferred.

- **Environmental benefits:** Nonquantified benefits to the environment (such as less water withdrawn from a stream or lake important to an endangered species of fish) can be an important consideration. This type of information may be found in reports and environmental studies by the water utility and others when expansion of a source of water was being considered. At a minimum, the less environmental impact arising from selecting a more aggressive conservation plan can be described.

- **Partnership opportunities:** Some conservation measures offer more of a potential for partnering with other funding agencies. Energy companies will often cosponsor rebate programs for measures that save hot water, such as efficient clothes washers. Wastewater agencies sometimes will cosponsor measures that reduce wastewater flow, such as low-flush toilets or efficient commercial process equipment. In other instances, in-kind services can be arranged or cost sharing of a regional public education program among local water agencies. Pooling of resources may allow access to more effective and more expensive means of reaching the public, such as paid television advertisements.

- **Budget and staffing requirements:** No matter how cost-effective a program is, if the agency cannot afford it, it is unlikely to be implemented. Oftentimes realizing the program benefits requires upfront financing of the program to save the amount of water needed to defer the capital project at a future date. Many water agencies are reluctant to ramp up conservation program funding for a promised future benefit. Other factors to consider include the following: Who will do the work? Will in-house staff supplemented by contractors do the additional work, or will new staff be hired? How difficult is it to hire new staff? Rectifying budget and staff imbalances requires skillful marketing of agency decision makers by conservation staff.

- **Community impacts:** Depending on the extent of the public participation program, the community impacts may be identified during process and mitigation strategies developed. In other cases, the community impacts can and should be assessed early on. How will the community react to restrictions on where and how much turf can be planted? Will the community object to bans on nonrecycling car washes (which may raise the price of car washes), or decorative fountains, or other water uses? In these situations, public opinion surveys are an effective means of gauging public support or resistance to specific measures.

- **Other criteria:** The process should be open, and the public and other stakeholders should be encouraged to submit their own list of criteria for plan selection. This could include other benefits and costs not included in the evaluation. In some cases, the agency board of directors will be very explicit in this regard; in others, they will look to staff and to consultants to provide direction through the process.

SELECT THE PROGRAM

There are several steps involved in selecting a recommended plan:

1. Finalize the list of selection criteria
2. Develop and use a public participation program
3. Rate the alternatives
4. Make a formal selection

Finalize Criteria

The plan selection criteria suggested earlier in this chapter should be considered as a starting point. Customized changes are encouraged, and they should be used to develop a final list.

Set Up a Matrix

Shown in Table 5-2 is an example evaluation matrix that planners may find useful. The general approach is to compare alternatives. This can be done with short word statements, a +/– system, or ratings on a scale of 1 to 5 where 5 is the highest rating. In the example shown, Program B is superior because it has the most total points.

Staff can do the rating, or they can use a water conservation advisory committee to rate some of the alternatives against some or all of the criteria.

Table 5-2 Example of a rating matrix for comparing alternative conservation plans

	Comparison or Rating		
Criteria	Program A	Program B	Program C
Meet Goals	3	4	5
Cost-Effectiveness	5	4	3
Supply Benefits	3	4	5
Regulatory	5	5	5
Public Support	4	5	2
Environmental Benefits	3	4	5
Partnership Opportunities	5	5	3
Budget	5	4	3
Staffing	3	4	5
Community Impact	4	5	5
Other (Specify)			
TOTAL	40	44	41

EXAMPLE OF A CONSERVATION PLAN REPORT'S CONTENTS

The state of California has one of the most detailed requirements for a water management plan (of which water conservation is an integral component). The following example shows the contents of a plan report. Figure 5-2. is an example table of contents for a water conservation plan report

I. Service Area, Climate, and Demographics

   A. Describe service area and climate of service area, including current geographic boundaries of service area, current and projected population (5-year intervals projected out 20 years, the suggested time frame for a plan), and other demographic factors affecting water planning.

II. Source of Water

A. Identify and quantify existing and planned sources of water. Describe the water treatment that is or will be required to make the water potable.

III. Supply Vulnerability

A. Describe reliability of water supply and vulnerability to seasonal and climatic shortage, examining an average water year, a single dry year, and multiple dry years. Complete this Section only if Section VII is also included in the plan.

B. For any water supply not available at a consistent level of use (taking into account specific legal, environmental, water quality, or climatic factors), describe plans to replace that source with alternative sources or water demand management measures

IV. Water Transfers/Exchanges

A. Describe opportunities for exchanges or transfers of water on a short-term or long-term basis.

V. Existing and Projected Water Use

A. Quantify past and current water use (five-year intervals).

B. Project future water use (five-year intervals projected out 20 years) by water use sectors or customer classes, if data is available from the water billing system (suggested sectors could be single-family, multifamily, commercial, industrial, institutional/government, landscape, sales to other agencies, saline water intrusion barrier use/groundwater recharge/conjunctive use, or any combination thereof, and agricultural use).

C. Project the timing of the need for more water supply and additional water treatment capacity, in the absence of additional water conservation.

VI. Demand Management Measures

A. Provide a description of each water demand management measure that is currently implemented or is scheduled for implementation detailing the dates that the program went into effect, the affected customer classes, and the number of affected units (persons or accounts). The plan will describe the steps necessary to implement any proposed measures, including, but not limited to, the following suggested list of conservation measures (also called *best management practices*):

1. Water survey programs for single-family and multifamily residential customers

2. Residential plumbing retrofit

3. System water audits, leak detection and repair

4. Metering with commodity rates for all new connections and retrofit of existing connections
5. Large landscape conservation programs and incentives
6. High-efficiency washing machine rebate programs
7. Public information programs
8. School education programs
9. Conservation programs for commercial, industrial, and institutional accounts
10. Wholesale agency assistance programs
11. Conservation pricing
12. Conservation coordinator
13. Water waste prohibition (an ordinance that prohibits water waste)
14. Residential ultra-low-flush toilet replacement programs

B. A schedule of implementation for all measures proposed or described in the plan.

C. A description of the methods, if any, that water supplier will use to evaluate the effectiveness of measures implemented.

D. An estimate, if available, of existing conservation savings within the supplier's service area and effect of such savings on the supplier's ability to further reduce demand.

E. An evaluation (that could take into account each of the following items) for each of the 14 measures listed that is not currently being implemented or scheduled for implementation:

1. Economic and noneconomic factors, including environmental, social, health, customer impact, and technological factors
2. Cost–benefit analysis, identifying total benefits and total costs
3. Description of funding available to implement any planned water supply project that would provide water at a higher unit cost
4. Description of the water supplier's legal authority to implement the measure and efforts to work with other relevant agencies to ensure the implementation of the measure and to share the cost of the implementation. The objective of the evaluation is that the utility must demonstrate the reasons for not implementing specific conservation programs.

VII. Detailed water shortage contingency analysis and drought/emergency action plan (including draft implementing ordinance). Drought/emergency plans are useful, and most states that now require conservation plans also require a drought plan as an element of the long-term plan.

VIII. Detailed information on recycled water and its potential, including coordination with local sewer service agency.

IX. Recommended long-term conservation plan.

A. Include a summary of the measures selected and their implementation schedule.

B. Project the required budget and staffing over the life of the plan.

C. Discuss the monitoring and reporting that will be done to ensure that the water conservation goals are being met.

D. Provide a resolution or other evidence of official plan adoption by the utility containing a statement of intent to implement the plan.

IMPLEMENTATION CONSIDERATIONS

Formal Adoption of the Plan

Some regulators require the utility to formally adopt the plan before the plan is considered "official" and is used to meet other obligations, such as water right permits, to qualify for state grant and loan programs, etc. Once adopted, it is often filed with the state water agency, which oversees utility planning requirements.

The public participation program goal is to inform the public, seek community input, and ultimately to obtain approval of the water agency decision makers. The process should involve a public meeting so that all stakeholders receive a chance for input.

Budget

The plan should lead to a budget request to support plan activities. This can involve hiring additional staff to run programs or contracting out certain programs to private companies. The latter approach is often preferred when the plan requires the use of specialists for a limited amount of time. In addition, adding staff is often a long and difficult process.

The budget could be formatted as shown in Table 5-3, with the particular details depending on the local agency needs.

Prioritizing

The budget may require establishing priorities because:

- Only part of the funds requested were approved
- Preferences stated by agency management
- Staff limitations
- Need to hire staff and/or contractors
- Time of the year or other sequencing considerations for measures
- Cash flow

Schedule

A schedule for plan element implementation should be created as a part of the conservation programs annual work plan. The schedule will put the priorities and available budget onto paper to focus staff on what should be done and by when. The schedule can be shown graphically such as in Figure 5-3. Staff assigned to activities could be noted, as well as milestones or deadlines.

Section 1 Introduction and Summary
- Purpose and Scope of Plan
- Plan Submittal Requirements
- Plan Development and Public Participation
- Plan Elements
- Resolution for Adopting the Plan

Section 2 Study Area Characteristics
- History of Water System
- Demographic Forecasts

Section 3 Analysis of Historical and Projected Water Demand
- Historical Water Use
- Analysis of Water Use by Customer Group
- Summary of Historical and Projected Demand, Without Conservation
- Impact of New Plumbing Code on Water Use

Section 4 Water Supply
- Sources of Water
- Groundwater
- Surface Water
- Overall Supply and Demand Balance

Section 5 Reclaimed Water Plan
- Results of Previous Studies
- Plans for Reuse

Section 6 Current Water Conservation Program
- Measures Implemented by Water Wholesaler and the City
- Management of Unaccounted-for Water

Section 7 Alternative Water Conservation Measures
- List of Conservation Measures Considered

Section 8 Evaluation of Long-Term Water Conservation Measures
- Menu of Water Conservation Alternative Programs
- Estimated Water Savings
- Costs of Measures
- Results of Benefit–Cost Analysis

Section 9 Recommended Plan
- Selection Criteria
- Description of Recommended Plan
- Projected Water Savings
- Benefits
- Implementation Schedule
- Budget and Staffing

Section 10 Water Shortage Plan
- Worst Case Water Supply
- Plan Elements
- Water Use Restrictions
- Water Supply Emergency
- Water Rate Structure

Appendix A State Water Management Planning Requirements

Appendix B Detailed Description of Selected Water Conservation Measures

Appendix C Benefit–Cost Model Output

Appendix D Drought Shortage Ordinances

Figure 5-2 Example water conservation plan report table of contents

Table 5-3 Example of a detailed budget for first two years of implementation (in $)

Plan Element	Staff Labor	Contract Labor	Materials and Publicity	Incentives (Rebates)	Total
Public Education	25,000	5,000	5,000		$35,000
Fixture Rebate	5,000	20,000	2,000	50,000	77,000
Residential Water Audits	10,000	50,000	5,000	5,000	70,000
Totals	40,000	75,000	12,000	55,000	$182,000

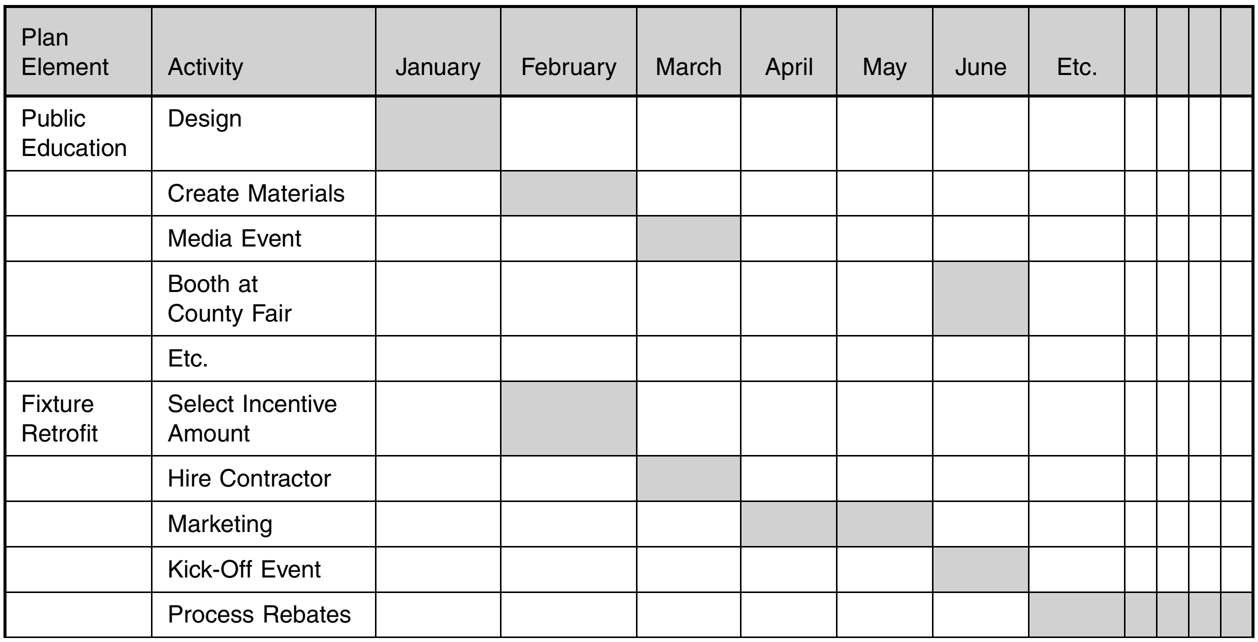


Figure 5-3 Example of a plan element implementation schedule for first year of implementation

Agreements and Partnering

Many agencies that implement programs that can or should be done on a regional scale partner with other water, wastewater, energy, stormwater, and solid waste recycling agencies. Each plan element should be reviewed for partnering opportunities. Examples include

- Public information programs with other water and wastewater agencies
- School education programs with a general environmental theme cosponsored by water and wastewater and solid waste recycling agencies
- Regional efficient clothes washer rebate programs with other water agencies and energy companies
- Regional residential and/or commercial toilet rebate programs with wholesale and retail water agencies and wastewater agencies
- Regional residential water audit programs with other water agencies
- Regional landscape audit and efficiency programs with other water and stormwater agencies

For a partner to enter into an agreement to provide in-kind services or funding, there should be a clear statement of purpose and enumeration of benefits to the partners. For example, a toilet replacement program should identify the water savings to the water agency and the wastewater flow reduction to the wastewater agency for every toilet replaced. This will enable the avoided costs to be calculated and used to establish the amount of the rebate. The water savings and benefit–cost analysis should be able to provide this information. In each case, there should be a lead agency to perform the job, rather than trying to do the work by committee. A memorandum of agreement can be signed to identify responsibilities and commitments.

Adopt Ordinances and Other Tools

Some measures are regulatory in nature, such as toilet retrofit on resale or landscape requirements on new development. For these measures, the utility may need to seek adoption of requirements by other authorities, such as a city or state law. There are many examples of ordinances written by other agencies to accomplish most regulatory programs. A literature search should be conducted prior to initiating preparation of a program.

Training

Experienced water conservation staff is often hard to find. Often the manager may be recruited from another agency, but the staff may need to be trained. Water conservation is not a technically difficult subject, but certain basic business and communication skills are often required, even for technicians who implement programs such as water audits. Many papers have been published in AWWA Conference Proceedings on "how to" water conservation topics (www.awwa.org). Some statewide groups or water associations offer training for staff. The California Urban Water Conservation Council, www.cuwcc.org, offers a several-day training course. The Irrigation Association trains technicians to do landscape water auditing and budgeting, www.irrigation.org. Many of the larger water agencies with trained staff are usually willing to help other agencies that currently lack staff expertise. A considerable amount of information is available through AWWA, such as this manual and other publications (see www.waterwiser.org and the Internet).

PROGRAM MONITORING AND EVALUATION

A conservation program should be regarded as dynamic. Changes to the program should be expected based on how well the program meets the goals developed according to guidance provided in the previous section. The consulting team fully expects water utilities to not only tailor programs to their individual needs, but to periodically change the program to keep it effective and economical. Observations concerning the water supply situation, growth projections, customer participation and satisfaction, and water savings achieved should be made. The water conservation industry is changing rapidly, and the program should be reviewed periodically to take advantage of new devices and measures to save water.

Typically, four types of program follow-up need to be performed.

1. The utility must keep good records of the impact that the conservation program is having (i.e., measure water savings). Water use data before, during, and after implementation of a measure is essential to evaluating water savings.

2. The utility should monitor how well the program is performing and whether it is achieving its program goals (which may need to be revised).
3. The program actual costs should be compared to planned costs.
4. How well the various plan elements are being received by customers should be monitored. Examples of program evaluations:

   East Bay MUD's Water Conservation Division annual reports, Saving Water Partnership (Seattle) Conservation Accomplishments report, see Table 5-4 below for an example. (http://www.ci.seattle.wa.us/util/RESCONS/accmpReport/default.htm)

   Evaluating Urban Water Conservation Programs: A Procedures Manual, AWWA, 1993.

Program Evaluation and Performance Tracking

One method to track water use and overall water conservation savings is to create a conservation performance model. Such a model can track monthly water use, in gallons per day per account (gpd/a), for each customer class. The model can identify trends in water use and reductions as a result of water conservation programs or other reasons.

An example from the Tualatin Valley Water District in Oregon is given in the following section, and the process to set up such a model is described briefly as follows:

- Obtain monthly water sales and number of accounts billed for each billing period, and each customer class to be analyzed, going back at least three years, preferably 10 years.
- Put the data in a preprogrammed spreadsheet model, which computes the monthly water use, in gpd/a and a weighted moving average (WMA) of the gpd/a.
- Develop a seasonal index from the data (ratio of each month's water sales to the average month).
- Separate total gpd/a into indoor and outdoor water uses.
- Calculate a preconservation level of water use (baseline) and project through the current period (month).
- Perform a regression analysis using the seasonal index and weather departures from normal to normalize consumption for weather. (Optional)
- Calculate conservation performance (difference between baseline and actual consumption) in gpd/a and percent.
- Update the model graph that tracks actual and forecasted consumption with WMA.
- Incorporate results of naturally occurring (plumbing code) and specific program analyses to help explain overall water use reduction. (Optional)
- Use the model to forecast future water use, as needed. (Optional)

Table 5-4 New water savings achieved in 2003 (mgd)

	New Long-Term Customer Savings						Transitory Savings			
	1% Conservation Program									
	Hardware	Behavior	Rates	Code	Seattle Low Income	Total	Curtail-ment & Economy	System	Total	**Total**
Residential Indoor	0.29	0.1	0.3	0.5	0.3	1.5	0.7	–	0.7	2.1
Residential Landscape	<0.01	0.3	0.1	–	–	0.4	0.6	–	0.6	1.0
Commercial Domestic	0.04	0.2	0.0	0.3	–	0.5	0.9	–	0.9	1.4
Commercial Process	0.15	0.1	0.1	–	–	0.4	1.6	–	1.6	2.0
Commercial Landscape	0.01	<0.1	<0.1	–	–	0.1	0.2	–	0.2	0.3
2002 Total	0.5	0.7	0.5	0.8	0.3	2.8	4.0	2.0	6.0	8.8

Courtesy of Al Dietemann.

- Update the model with new data on a quarterly or annual basis to track water use (reductions).
- Summarize the results for all customer classes for the water utility.

Example: Tualatin Valley Water District, Oregon

The overall conservation performance model previously described was applied to analyze single-family customer water use in the Tualatin Valley Water District, Oregon. The model shows that customers have been saving water since 1995. This was the year after multitier rates were introduced. Further research is needed to identify the complete cause of the decline. Note how the weighted moving average has remained lower than the baseline level.

The use of this model would allow the development of graphs such as that shown in Figure 5-4, for each customer class. The vertical axis is gpd/eru (gallons/day /equivalent residential unit). Because the "gap" (apparent water savings or conservation performance) between the historical average water use per account and current levels may be caused by more than one factor, appropriate statistical methods (such as cross-sectional regression analysis) would be used to evaluate completed programs, to explain the gap. Weather normalization, use of engineering estimates, and other methods would define additional segments of the gap. Some portion of the gap would remain that cannot be attributed to specific conservation measures.

The advantages that the model described above include the following:

1. Capturing the overall effects of conservation programs that cannot be effectively monitored individually
2. Ensuring uniformity of method and results
3. Providing total gallons saved and percentage performance for all measures together

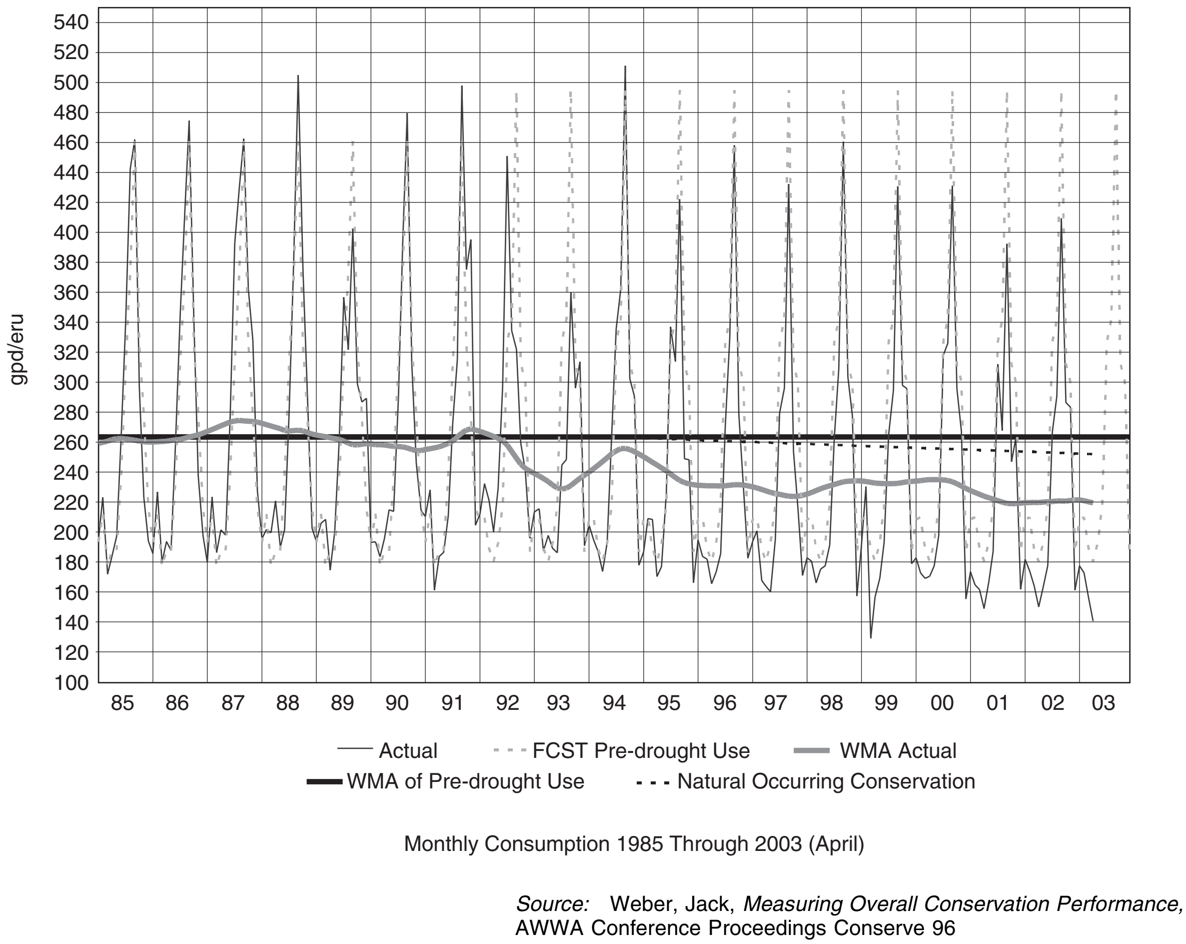


Figure 5-4 Example of a conservation performance model

4. Providing indoor and outdoor performance
5. Tracking monthly performances (short-term) and providing ability to extend to any time horizon (long-term) with continuity of method while adjusting for weather variations
6. Readily adaptable to setting sector water use reduction targets

Implementing the use of such a model would obviously require considerable technical skill that many utilities may not have. Consultants can be utilized for technical assistance and training and to set up and maintain models to evaluate program effectiveness.

Simplified Version of Model. To see trends in water use by customer class, it is not always necessary to prepare a regression analysis of past water use. The following steps can be done at a minimum to identify trends.

1. Acquire monthly water sales and number of accounts billed for each billing period and each customer class to be analyzed, going back at least three years, preferably 10 years.

2. Put the data in a spreadsheet and compute the monthly water use, in gpd/a and a moving average trend line of the gpd/a.
3. Examine trends in three parameters:
   - Average use (from the moving average trend line), and if it is rising or falling, it may indicate that new or remodeled accounts have a different water use than the existing accounts.
   - Low point of the graph, which shows trends in the indoor use
   - High points in the graph, which indicates trends in irrigated landscaping and watering practices.

Employing Statistical Methods

Existing statistical methods were reviewed for their applicability to the project's goals. Methods were reviewed for two types of evaluation: (1) tracking overall water use and (2) measuring water savings from specific conservation programs. Methods included several types of regression analysis, use of significance testing such as Chi-Square, factor analysis such as ANOVA, and engineering estimates. A description was developed for each candidate method; then the methods were subjected to a screening process to identify which best met a specified set of criteria. The methods were matched up with the following applications, including their subelements:

- Tracking overall monthly conservation performance model by customer class and provider including:
  — Seasonality
  — Baseline demand
  — Indoor and outdoor consumption and performance
  — Weather normalization
  — Naturally occurring conservation (due to existing laws and codes)
  — Savings from programmatic conservation measures
- Analysis of specific conservation programs (compiled or survey data)
  — Before and after analysis
  — Control versus test group analysis
  — End use information
  — Customer attitude surveys
  — Use of engineering estimates
- Peaking analysis
- Evaluation of drought/restriction periods
- Measuring response to water price changes (elasticity)

Further descriptions are available in *Forecasting Demand and Measuring Price Elasticity, AWWA, Journal*, May 1989, and *Forecasting Urban Water Demand*, R. Bruce Billings and L. Vaughan Jones, AWWA 1996, *Evaluating Urban Water Conservation Programs: A Procedures Manual*.

Meeting Goals

Goals can be qualitative and quantitative. For each goal that is adopted, a method of measuring performance should be developed when the goal is formulated. This will simplify the process of tracking progress versus goals. Tracking can be done using tables or matrices so performance is readily evident. If the goal is not being met, either the plan element should be changed, or if the goal was unrealistic or inappropriate, the goal should be revised. Comparison of performance versus goals should be done at least annually, prior to the utility's annual budget-setting process.

Tracking Actual Costs

The water conservation group should set up an accounting system that allows costs to implement plan elements separately accounted for. This would include labor, contracts, materials, and other expenses, accounted for in the same way the plan element is budgeted, see Table 5-3. Costs should be accumulated monthly and reported annually.

REEVALUATE PROGRAM COST-EFFECTIVENESS

Water utilities should periodically evaluate water savings from selected completed programs. This information should be routinely used to recalculate the cost of water saved and compare to original cost, savings, and measure lifetime estimates. The cost of water saved can be expressed as dollars per 1,000 gallons saved. In most cases, the programs should continue until the costs, implementation rates, water savings, or other factors change and cause the cost of water saved to rise above some predetermined threshold. This threshold could be the cost of meeting objectives or new water supply by some other means. When a program is no longer cost-effective, it should be terminated and resources placed elsewhere. Water utilities should always be given the flexibility to tailor and revise programs to fit current local conditions.

Progress Versus Planned Schedule

The planned schedule for implementing plan elements shown in Figure 5-3 can be used to track progress. Milestones of when activities were actually completed will show where the utility is falling behind. This may be indicative that costs are also rising above planned levels or that staffing is inadequate to complete all activities assigned to certain individuals. Tracking progress at least quarterly will allow adjustments to be made before more serious problems develop.

Monitoring Customer Feedback

Customer surveys are often used to identify customer motivations and barriers to various conservation measures. Statistically significant customer surveys by mail or telephone are fairly inexpensive, costing about $10,000. Professional survey companies are very good at preparing unambiguous questions that can be answered in a limited amount of time. The maximum time or number of questions varies but is about 15–20 minutes and about 30 questions. Surveys are a common way to track and monitor progress of public information and education programs whose water savings are difficult to measure. Most large utilities have completed a number of surveys and will usually share the questions with others. If customer feedback is negative, it is indicative of needed changes in plan elements. If the feedback is positive, it reinforces that the program is succeeding.

In summary, the questions that should be periodically asked are

- Are the measures being achieved? If not, why not?
- Is public response positive? If not, why not?
- Are the specific efficiency measures contained in the program effective? If not, why not?

If negative responses are received to any for these questions, consider revising the program by

- evaluating alternative efficiency measures
- modifying existing measures to increase participation
- focusing efforts on other potential water-saving ideas

EXAMPLES OF SUCCESSFUL PROGRAMS

Appendix B presents case studies of successful programs. Current programs can be researched on the Internet or by direct contact of utilities with leading programs.

Internet Resources

It is recommended that planners review programs of other utilities and states to identify measures worth considering. State sources include

- California Urban Water Conservation Council's list of 14 Best Management Practices, see www.cuwcc.org
- Arizona Department of Water Resources list of Reasonable Conservation Measures, see www.water.az.gov
- State of Texas, Texas Natural Resources Conservation Commission (http://www.tnrcc.state.tx.us/permitting/waterperm/wrpa/conserve.html)

Leading water utilities include

- Denver Water Department's Program (http://www.denverwater.org/conservation/conservframe.html)
- EBMUD, California—see http://www.ebmud.com/conserving_&_recycling/
- City of Austin, Texas, see http://www.ci.austin.tx.us/watercon/
- City of Phoenix, Arizona, see http://www.ci.phoenix.az.us/WATER/wtridx.html
- City of Cary, North Carolina, see http://www.townofcary.org/depts/pwdept/water/waterconservation/overview.htm
- Los Angeles Department of Water and Power, see http://www.ladwp.com/water/conserv/
- City of Seattle, see http://www.ci.seattle.wa.us/util/RESCONS/wst/wst_ctip.htm
- Cobb County, Georgia, see http://www.cobbwater.org/conservation/watersmart.asp

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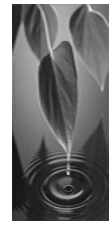


Chapter 6

Conservation Plan Development and Implementation: Dealing With Perceptions, Barriers, and Obstacles to Effective Water Conservation

INTRODUCTION

The implementation of water conservation programs requires a dedicated staff and budget, plus several other positive aspects such as willing customer participants. This chapter explains what can be done to overcome constraints to program implementation and improvements in water use efficiency.

MITIGATING REVENUE IMPACTS

Utility rates can be an important tool for encouraging efficiency in customers' use. The result of increased customer efficiency is reduced revenue, which can lead utility decision makers to be less supportive of conservation programs. There are three possible ways in which a utility's revenue needs and implementation of a conservation program can interact:

1. When the water rates remain unchanged but an aggressive conservation program is started, there may be *revenue impacts*. The key to managing revenue impacts of a conservation program (lower water sales) is to predict those lower sales and account for them in the rate setting process.
2. Water rates can also be used to encourage conservation. Various rate types send price signals to the customer, encouraging him or her to reduce water use. In this case, lower water sales are not an unwanted or unexpected outcome of the program but rather part of it.
3. A utility can use both of the previously mentioned techniques to reduce water use. An aggressive conservation program will include effective programs that reduce water use in a measurable way. An aggressive water rate structure will also encourage water conservation. Following implementation of both, it is difficult to separate the effects and ask "How much of the reduction was due to programs and how much was due to raising the price of water or changing the form of the rate structure to encourage conservation?" This is a difficult question, and there are no easy answers.

Because the price charged for the water and the nature of the utility's conservation programs are often intertwined, it is important to understand how to analyze water savings as a result of programs and price changes separately. The former was covered in chapter 5; the following will help the planner understand the price impacts.

Types of Rate Structures

Impacts are a function of the type of rate structure employed by the utility. Traditional objectives in rate structure design include (a) basing the rates on the actual cost of service, (b) providing adequate and stable revenues, (c) providing fairness or equitability among customer classes and volume users, and (d) ease of implementation and administration.

Nonpromotional water rates. These rates provide a financial incentive for customers to reduce water use, usually by applying a surcharge on peak-month usage or by charging a higher unit rate for water as the number of units used increases. Conservation rates must be fair; it is therefore essential that conservation rates be developed through a public process that ensures acceptance of the purpose and design of the rate structure. It is important that regardless of the conservation rate structure selected, greater control can be achieved from a combination of pricing with indoor and outdoor conservation programs than from pricing alone. Conservation pricing as part of a broad demand management program is the most logical approach. Types of nonpromotional conservation water rates include

- A combination of low rates for baseline minimum water quantity (the same fixed charge every billing cycle for the baseline volume) and high volumetric charges for the amount that the customer uses above the baseline volume
- Inclining tier rates with volume amounts (or blocks) where higher unit charges are triggered at higher levels of use to encourage conservation
- Seasonal rates or excess-use surcharges
- Marginal cost pricing

- Water budget rate structures where tailored allocations are developed for each customer and rates increase as the allocation is used or exceeded

Other rate structures. In some cases, it is easier to envision what types of rate structures do not encourage water conservation. The following rates are the most common types of rate structures:

- A declining block structure
- A flat rate structure (a fixed fee regardless of water use)
- A uniform rate structure (the same unit charge for water regardless of how much is used)

These types of rate structures, especially the first two, offer little incentive for customers to improve water use efficiency. A useful reference for current water rates in place around the US is the biennial *Water and Wastewater Rate Survey* published by Raftelis Financial Consulting, PA, located in Charlotte, North Carolina.

Price elasticity. When water rates are raised significantly (beyond an inflationary response), water use often declines. The amount of the decline in demand is called *price elasticity*, which is the percentage change in consumption per percentage change in price. Price elasticity is normally expressed as a fractional reduction (i.e., an elasticity of –0.1 means that a one percent increase in price will stimulate a 0.1 percent decrease in consumption).

It is difficult to predict changes in water use caused by changes in price. Definitions and methods for assessing the response to rate change are covered in numerous reference texts and need to be considered when deciding whether and how to implement water rate changes. It is critical for planners to have an understanding of price elasticity concepts, because they may greatly influence the revenue generated and thus the financial situation of the utility if water rate structures are not applied correctly. However, as this aspect is not covered by this publication, the authors recommend the use of more in-depth reference material on the subject, such as *Principals of Water Rates, Fees and Charges* (M1) by the American Water Works Association (see www.awwa.org).

Funding a Conservation Program With a Water Bill Surcharge

The city of Albuquerque, New Mexico, has an overall budget of $2.4 million for water conservation generated by a water rate surcharge, with over 50 percent of the revenue generated given back to the customers in the form of incentives. Rebates include residential and commercial landscape rebates that are based on the area retrofitted. For approved landscaping projects, the rebate rate is $\$0.25/\text{ft}^2$ (approximately $\$0.75/\text{m}^3$) that is replaced. The rebate maximum is $500 for residential customers and $750 for commercial customers. Other conservation programs funded by the surcharge include public education through workshops and demonstration gardens.

The city of Pleasanton, California, used a $0.05/ccf surcharge on water bills for irrigation accounts to create a fund to sponsor irrigation equipment upgrades. Eligible equipment included low-volume spray heads, drip irrigation, and irrigation controllers. The size of the irrigation meter was used to set the maximum amount of the rebate. The rebate was $60 for a ⁵⁄₈ in. meter, increasing to $3,000 for a 6 in. meter.

Billing Cycle Considerations

For water rates to form an effective deterrent to wasteful water use, the rate structure should be designed to have an impact on the potentially wasteful customer categories and the deterrent rates must also be effectively communicated to customers so that informed choices can be made on whether or not to use the water. There are two important aspects in communicating these rates:

1. The shorter the billing cycle, the more frequent the reminder to customers of the cost of water. Where there is a chronic shortage of water, utilities can move to monthly meter reading and billing. During prolonged drought periods, monthly billing takes on even greater importance. Quarterly billing, in contrast, has minimum communication with customers and defeats the purpose of conservation rates. For example, a higher bill for the dry season might have been sent to customers during the wet season.
2. The bill sent to water users should clearly show the amount and cost of water used separately from wastewater and other charges. It is also useful to provide consumption history and other comparative data.

Integration of Conservation and Rates

In evaluating the relationship between water price and water use, the following should be considered:

- In the case of interior water use, which is largely nondiscretionary, customers are unlikely to engage and persevere in water-saving habits, such as shorter showers, fewer number of toilet flushes, and larger laundry loads, on the basis of cost alone. However, higher cost may encourage leak repair. The more efficient water-preserving approach is to install fixtures that will ensure water savings. It might be argued that higher water costs will prompt the use of efficient fixtures, but experience with attempts to reduce interior water use through pricing alone suggests that utility education programs stressing the necessity for water savings and give-away/rebate programs are more effective. In addition, it is difficult to increase water costs for interior water use and to maintain volumetric revenue neutrality;
- In a two-tier rate structure, there is little latitude for setting a high second-tier rate without reducing the first-tier rate or changing the balance between fixed and volumetric derived revenue. Consequently, in using a two-tier rate structure, it is difficult to address outside water use even with differentials for dry/wet-season use patterns. It is more effective to engage in conservation programs related to landscape design, irrigation methods and practices, and incentives for reductions in use, rather than to rely solely on water pricing to obtain water-use conservation improvements;
- By using a rate structure of three or more tiers, the high end users can be targeted with high water rates for assumed wasteful water use. This can affect the top 5–10 percent of customers with the highest water usage rates. However, the majority of customers receive bills for unchanged or lower amounts.

Building Ongoing Conservation Into Rate Setting

Water rate setting and conservation program implementation are linked, either by design or inadvertently. When rates are used as a part of the process to encourage conservation, it is hard to separate the effects. Setting up a tracking model as described in chapter 5 will show the reductions, *regardless of their origin*. Because the goal is to reduce water use, it is essential to know how the total reduction is achieved and how the components that contribute to the total are estimated.

A by-product of the water use forecasting (chapter 3) and benefit–cost analysis (chapter 4) is the ability to forecast future water savings. The forecast of water use can be translated into a forecast of water revenues. This may be simple for some rate structures and more difficult for multitier rates. Using this forecast of lower water sales, the future rate increases can be designed to accommodate lower sales. The lower sales are usually rather small, when viewed on an annual basis, usually between one-half to one percent per year, and are probably more predictable than the effects of inflation in costs, which also must be factored into the rate-setting process. As most utilities review rates about every three years, it becomes evident that revenue losses caused by a conservation program are very manageable.

MAINTAINING AN ADEQUATE BUDGET

Water conservation programs are often viewed as a cost center. Sometimes the benefits produced by the program are misunderstood. A good water conservation plan should include a five-year budget, justified by a cost-effectiveness analysis. There are steps the conservation manager should take to ensure adequate funding.

Marketing Program Success and Needs to Finance Managers

Because water conservation is budgeted annually or every two years, along with other utility departments, and sometimes because of the lower revenue issues, obtaining an adequate budget to carry out planned programs can be difficult. The process can consume a significant amount of the water conservation manager's time. It is especially difficult to increase budgets dramatically year after year or to add staff. Therefore, when the plan is adopted, the required staffing and budget must be highlighted to decision makers, rather than hidden.

The water conservation manager should try to market the program to senior management, because they may not retain prior agreements on budget and staffing. One way to do this is to publicize the program's successes. This can be done through a number of techniques and venues:

- Involve political officials in program kick-offs
- Conduct water savings analyses and public opinion polls to document success
- Quickly terminate program elements that are not meeting expectations
- Do not have too many programs going at once; successfully complete programs before starting new ones
- Brief senior management on program progress at least monthly
- Routinely report (i.e., every six months) to the board of directors about program progress and successes
- Stretch the utility's dollar by leveraging partnerships into financial or in-kind contributions to the program costs
- Garner public support for the program (see the following section)

INVOLVE THE PUBLIC IN SUPPORT OF THE PROGRAM

The public participation program can vary from a public hearing at a single water agency board meeting to a full-scale public involvement program. The former may be all that is required to secure plan adoption, but it is unlikely to develop the type of support necessary for the program to be successful. To build and maintain a grassroots support for the program, it is important to involve key stakeholders in developing and implementing the plan. Below are some general guidelines for conducting an effective program that will involve the public and build support for the programs the utility wishes to carry out.

The American Water Works Association Research Foundation has developed a helpful handbook entitled *Public Involvement Strategies: A Manager's Handbook* (see www.awwa.org). The handbook describes the steps involved to design an effective program, with most of the steps related to the upfront research needed to develop an effective plan. The overall process is described in the following ten steps, the first eight of which relate to developing the work plan:

1. Frame the problem—focus on issues and boundaries, describe the project need
2. Identify constraints—determine issues to be negotiated with the public and those that cannot, such as regulatory or political mandates, spending limits
3. Identify and describe decision steps and project milestones—develop a schedule that shows public input decision points
4. Identify and understand potentially affected stakeholders—identify the groups that should be involved
5. Determine vulnerability and must-resolve issues—focus efforts on issues and groups likely to generate the most conflict
6. Determine the appropriate level of public involvement—establish what level of involvement is needed to address stakeholder concerns
7. Select processes and techniques—by completing the above six steps first, the agency can save time and money by selecting from many available techniques
8. Develop a public involvement work plan—using information developed in Step 7, the agency develops a schedule, budget, and staffing needed to carry out the plan
9. Implement and monitor the work plan—periodic monitoring is needed to ensure
   - the time frame of the problem has not changed;
   - the issues and stakeholders remain valid; and
   - the techniques used are effective.
10. Manage change—the process must be flexible enough to adapt to changes in schedule, political climate, staff, or critical issues

Identify Target Audiences

Every planning process will have a unique list of target audiences that should be involved. The following identify participants:

- The general public
- Elected officials

- Utility managers
- Community leaders
- Environmental groups
- Economic development and business organizations
- Wholesale water customers
- Local and regional agencies
- State and federal regulatory agencies
- Developers
- Neighborhood and community associations
- Large water users
- The media

Through contacts and interviews, this list can be used to identify stakeholders and specific group representatives that should be invited to participate.

Addressing Inequities

When deciding on which target groups to focus, those who might be impacted by proposed conservation measures should be considered. Ask "Who will feel left out of the process or feel unfairly treated?" For example, if a rebate program is targeted to only single-family homes, apartment manager associations should be contacted so they can be apprised of why this decision was made. If clothes washer rebates are targeted to single-family homeowners, only then should other ways be found to communicate with and involve apartment residents. Finally, if commercial programs are targeted to high water users, small business owners should be approached in other ways.

Forums for Consensus Building

A wide variety of consensus-building techniques exist. Once the above first seven steps have been conducted and the stakeholders identified, the nature of the specific techniques can be selected. Some available techniques:

1. Public meetings—although they are difficult to arrange, they provide a very open, informal, and participatory forum that can enhance the utility's relation with its customers but may be too unstructured for consensus building.
2. Citizen advisory committee—these committees allow a broad range of stakeholder input on a regular basis over the duration of the project.
3. Workshops—these can provide a participatory process for exchanging ideas and information. By bringing interested parties together, they can focus on specific issues and concerns and build consensus.
4. Task forces—such groups are more formalized and exclusive groups that are usually charged with the task of devising and recommending solutions to specific problems.

Tools for Consensus Building

In addition to the procedural models listed above, there are a wide variety of methods that can be used in conjunction with and to support the selected model. These methods include

1. Participant surveys—these can provide a knowledge basis by cataloging participants' basic concerns and expectations. This can be used to highlight divergent views on key issues that will need to be resolved. These can be random telephone surveys of the general public or one-on-one interviews with key stakeholders.
2. Issue or discussion papers—these help define the issues and provide a common basis of knowledge about an issue or set of issues. While they do not attempt to resolve issues, they can be the catalyst for educating and starting discussions with stakeholders.
3. Position papers—members of groups can state broad positions on policy issues that can be helpful in finding common ground among groups with diverse perspectives.
4. Policy statements—these go further by committing participants to a specific position. Draft statements are circulated until consensus on a final version can be reached. They reinforce the outcome of the consensus-building process.
5. Memoranda of understanding (MOU)—these are particularly appropriate for regulatory agencies needing to clarify roles and improve coordination. By signing an MOU, different groups can commit to a process to resolve a specific issue or agree to take unilateral action in support of the consensus.

Guidelines for Conducting a Successful Process

In addition to maintaining an honest and open participatory atmosphere, the following are some general tips to ensure success:

- Set realistic goals. Organizers and participants must bring realistic goals to the table. This process will not solve all problems. Stay focused on the key issues that require consensus and ignore other issues.
- Optimize participation. Only the stakeholders that need to be involved should be involved. Smaller groups of 25 or fewer can be more efficient in making decisions and reaching consensus.
- Discourage hidden agendas. Special interest groups to further their cause, which can undermine the process, sometimes use planning processes.
- Create access and openness. Many potential participants will expect the process to be open and resources, such as key staff, available during and between meetings. Information germane to the process should not be privileged. Participants should not feel inhibited by the nature of the proceedings.
- Allow due process. All affected parties have the right to be heard.
- Sense the need for closure. It is important to know when to close the process because of diminishing returns. It may be necessary to settle for consensus on a limited number of issues and resolve the remainder in a more

traditional forum. In some cases, when competitive solutions are available, consensus may not be desirable. In other words, it is acceptable to disagree on certain issues and to clearly state positions so that ultimate decision makers can appreciate the different points of view as they try to balance water issues.

Public participation (Figure 6-1), in particular consensus building, is one of the key features of water conservation planning and program implementation. Public input can result in a better plan. If the public is involved from the beginning, the support for new programs, including the staffing and budget, are more likely to be forthcoming.

OVERCOMING OBSTACLES

There are a number of hurdles that the program planner may face when preparing a conservation plan for the first time. In addition to those previously mentioned, other reasons could include a lack of knowledge about the planning process, where to learn about conservation measures, where to get data to make a water savings forecast, how to get data needed to evaluate cost-effectiveness. The following guidelines are offered:

Knowledge of Conservation Measures

Water conservation planners are often hampered by a general lack of knowledge about water-saving devices and measures. Good sources of information are the conservation plans of agencies that have a conservation program as well as Internet sites of water utilities that are active in the conservation field. Guidebooks and manuals have been written on the topic and they can serve as a resource for those new to the field. Some are available from AWWA, others are on the Internet. Many

Figure 6-1 Seattle Area Utilities *Saving Water Partnership* sponsored vendor fair for landscape contractors featured efficient weather-based irrigation technologies

new professionals start by accessing information from local and regional information networks (see chapter 5).

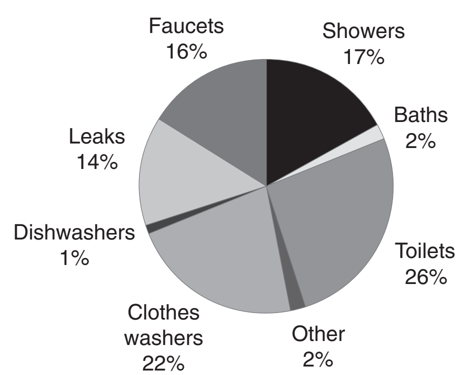
DATA NEEDS

The following best available data are needed to enable conservation plans to be prepared:

- Demographic data and projections
- Monthly water production data
- The number of water accounts by customer class
- Monthly water sales (usage) data by customer class

If certain types of data are not available or are inadequate, estimates must be used. Data gaps can be filled by using data from similar water utilities or research projects. Figure 6-2 shows how water is generally used in single-family homes in the United States. Outdoor use (primarily for landscape irrigation) is highly variable and depends on rainfall and temperatures during the growing season.

If a utility buys water from a wholesaler and has no sources itself, the supply-side benefits to the utility from saving water is trivial. If the utility needs less, it buys less, and the benefits can be readily determined from purchase agreements. For the wholesaler that provides the water or for utilities that make their own water, deferring or downsizing projects is a major source of potential benefits for the conservation program. If water use is growing and will exceed the capacity of supply sources and water treatment and distribution facilities, capital expansion projects will be needed. Unfortunately, the cost–benefit analysis is often hindered by the lack of long-term water supply capital facility plans (giving types of projects and cost estimates). Sometimes capital facility plans are only determined three years in advance to correspond to water rate reviews. Large water supply projects normally require a long lead time to go through environmental review, obtain permits, funding, engineering, etc.



Source: AwwaRF Residential End Use Study, 1999.

Figure 6-2 Average indoor end uses of water in single-family homes in the United States

If capital facilities appear to be needed and the plans do not cover the normal conservation planning period (usually 20 years), the costs of these unplanned facilities should be estimated. Supply projects are normally designed to provide for growth over a 20- to 50-year period. Similarly, expansion of water treatment projects is designed for growth over approximately 10 years. There are general cost guidelines available from various sources for estimating project costs sufficiently and accurately for conservation planning. For example, US water treatment plants cost between $500,000 and $1 million for a capacity of 1 mgd. In this way, the costs to accommodate planned growth for 20–30 years can be estimated, and the conservation analysis can proceed.

SUMMARY OF RECOMMENDATIONS

The top five key points from this chapter that can help the planner create and implement a successful conservation plan can be summarized as follows:

1. Identify obstacles to plan preparation early on and take steps to mitigate them.
2. Use rates as a conservation tool and factor conservation into the rate-setting process to avoid reduced revenue surprises.
3. Use the conservation plan process to set priorities, justify an adequate budget, and maximize benefits at the lowest cost (fund programs that are cost-effective to the utility).
4. Use public participation to garner public support for the plan and its programs.
5. Communicate with key stakeholders inside and outside the utility to ensure smooth implementation, including adequate staff and budget.

REFERENCES

Chesnutt, T. W. *Designing, Evaluating, and Implementing Conservation Rate Structures*, California Urban Water Conservation Council (see www.cuwcc.org).

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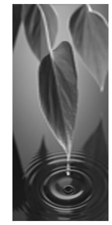

Appendix A

Case Studies

CASE STUDY A—CITY OF AUSTIN: ALTERNATE WATER SOURCES SAVE MONEY AND WATER

City of Austin, Texas, metro area population—1,249,763; Austin 2001 population—656,562; utility service area—450 square miles.

Total savings of 73 million gallons a year with an investment by the city of $150,000 in rebates and approximately half a man-year of effort.

The city of Austin is one of the few cities in North America with a longstanding program to promote the use of alternate water resources such as rainwater harvesting, the use of air conditioner condensate, French drain and groundwater infiltration water, and water captured from other nonconventional sources. Promotion of these sources of water serves to both supplement conventional potable water resources and to provide an excellent way of educating the public about the dynamics and limited availability of these resources. Incentives include 75-gallon rain barrels that can be purchased for $45; residential whole rainwater-harvesting system one-time rebates of up to $500 for the purchase of system components; and a commercial rebate of up to one dollar for every one gallon per day saved on an annual average basis. Additionally, commercial entities that can provide 100 percent of their outdoor needs from alternate sources can be exempt from installing an irrigation meter, which can save many thousands of dollars in tap fees.

The largest example is the University of Texas at Austin that utilizes many different alternative resources: rainwater harvesting, collection of French drain water, water from laboratory equipment cooling systems, and air conditioner condensate. Other nonresidential examples include Advanced Micro Devices that collects seepage water from a French drain system; Samsung and Motorola that collect stormwater runoff for use in landscape irrigation; two ready-mix concrete plants that collect at least half of their annual operational water needs for making concrete and washing trucks from stormwater collection systems; and a major state facility that collects its air-conditioning condensate for cooling tower makeup. A local veterinarian has installed a state-of-the-art air-conditioner condensate recovery and stormwater harvesting system that, along with a very well-designed xeriscape, has completely eliminated the need for potable water for landscape irrigation. Combined average savings for these commercial examples exceeds 180,000 gallons per day.

At the city level, the new city hall will provide all landscape irrigation needs from a French drain recovery system, and the newest city clinic and homeless shelter and a new EMS–Fire station will employ rainwater harvesting. Other municipal opportunities are being investigated.

Many of the residential customers have participated in collecting alternative resources of water, as well, to supplement their outdoor water use — the single largest use of water during the summer months is for landscape irrigation. Currently, over 3,000 homes have installed rainwater-harvesting systems to supplement their outdoor water use. Thirty of these homes have installed systems that collect over 300 gallons. While the remaining 2,900 homes have installed over 3,500 75-gallon rain barrels.

Contact Person: William de Herrera; City of Austin, Texas; Water Conservation; (512) 974-3542 or e-mail William.deherrera@ci.austin.tx.us.

CASE STUDY A—CITY OF AUSTIN (CONTINUED): APARTMENTS CUT WATER USE BY 25% THROUGH PLUMBING RETROFITS

Water savings for all multifamily retrofitted bathrooms is about one million gallons per day. The total cost has been about $2.7 million.

The city of Austin's water conservation program has actively worked with the multifamily sector for the last ten years to encourage them to retrofit their plumbing fixtures. Efforts include annual workshops for apartment managers, multiple mailings to managers, owners, and apartment management firms, direct phone calls, site visits, a quarterly industrial, commercial, and institutional Water Conservation Newsletter to all commercial entities in Austin, advertising in apartment management newsletters, etc. To date, over 30,000 toilets and showerheads and over 60,000 faucet aerators have been replaced.

In 2001, city conservation staff conducted a study of actual water bills from 45 apartment complexes that have retrofitted their toilets, showerheads, and faucet aerators as part of the city's water conservation program to determine the effectiveness of the program in reducing billed water use. The study examined water bills for 3,463 toilets that were replaced in 2,902 separate apartments. This represents about 11 percent of all toilets replaced in apartment units. The results showed a 25 percent reduction in water use overall with some apartment complexes reducing use by as much as 50 percent. This is a collective savings of almost 3.5 million gallons a month that translates to an annual water and wastewater bill saving of $245,000. This is equal to savings of 14,500 gallons per apartment per year—and this does not include energy savings as a result of reduced hot water use for showers and faucets.

The city offers free showerheads and faucet aerators, and either *free* toilets plus $30 towards installation, or a *rebate* of up to $100 for the purchase and installation of a toilet. This means that out-of-pocket cost to apartment owners for the program is minimal to none in many cases. Payback is in months, not years (Figure A-1).

Contact Person: Jessica Woods; City of Austin, Texas; Water Conservation; (512) 974-3535 or e-mail Jessica.woods@ci.austin.tx.us.

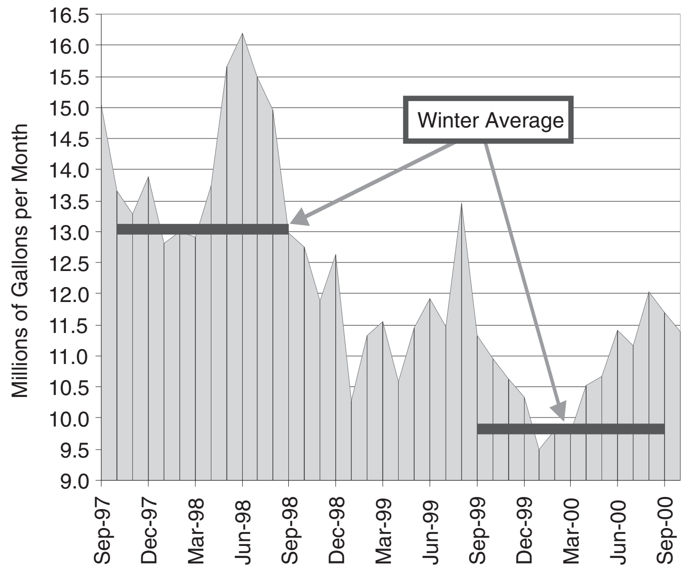

Figure A-1 Retrofit of 45 apartment complexes in Austin, Texas

CASE STUDY A—CITY OF AUSTIN (CONTINUED): VOLUME PURCHASE CLOTHES WASHER PROGRAM

In 1997, the City of Austin Water Conservation Program began researching different means to promote high-efficiency clothes washers. These washers, mostly front-loaders, use 40 percent less water and energy than traditional machines, but cost $200–$900 more than comparable conventional machines. While some of that cost differential is offset by lower utility costs, it was recognized that steps needed to be taken to reduce the upfront price differential. In March 1998, Pacific Northwest National Laboratories and Battelle Laboratories, under contract from the Department of Energy as part of the Energy Star Program, solicited bids from washer manufacturers and distributors on supplying these washers in truckload lots at reduced prices, which could then be passed on to consumers. The program was open to any utility that wished to take part. Only one distributor submitted a bid to provide a qualifying washer at a low price. Sides Distributing of San Antonio agreed to offer the Gibson machine at reduced truckload prices if retailers agreed to charge no more than $599 for the machines.

This program, called the volume purchase program, seemed to meet Austin's needs. Austin solicited local retailers to see if any were interested in participating in this volume purchase program. A rebate program for a wider selection of high-efficiency washers was introduced at the same time, which in partnership with Austin Energy and Southern Union Gas, offered rebates of up to $150. To make the volume purchase program more attractive, Austin offered to provide advertising and an additional rebate of $30 to buyers of the Gibson machines.

The program was introduced through a stakeholder meeting with local appliance retailers. However, the appliance retailers were not interested. Few carried the Gibson brand name, and none were willing to begin carrying it just to participate in the program. Gibson was considered too down-market, with a low consumer profile and an undistinguished track record. This was in spite of the fact that the Gibson machine was made in the same factory and was nearly identical to machines being made under the Frigidaire, GE, and Kenmore brand names.

After failing to interest any appliance retailers in carrying the Gibson machines, the Water Conservation Program researched selling the machines themselves. A number of issues immediately became apparent. The city did not have a suitable storage or sales facility for large numbers of washers, lacked experience in dealing with the idiosyncrasies of the appliance retail business, and lacked delivery and repair services. Nor were appliance retailers happy about the prospect of having the city compete with them.

After assessing these difficulties, staff decided to resolicit participation from the retailers. After this second round, two local retailers agreed to participate in the program. These retailers were key to the early success of the program. In the first 18 months of the program, 925 machines were rebated. Of that total, 429 machines, or 46 percent, were Gibson models purchased under the volume purchase program. Although the contract with Sides has lapsed, the volume purchase program was instrumental in giving the high-efficiency washer program an early boost. In the five years since the rebate program has been running, over 8,500 washers have been rebated.

CASE STUDY A—CITY OF AUSTIN (CONTINUED): WATER CONSERVATION CUTS WATER USE AND MORE

Reducing water use can have many benefits, including reduced demand on natural resources, extending limited water supplies, and reducing demand during drought. Identifying the dollar side of water conservation, both costs and benefits, is harder to do, and many benefits can be missed. Austin, Texas, has many economic reasons to conserve water. These include

- reduced treatment costs
- reduced electric energy use with resulting reduced air pollution
- deferred capital cost for new water and wastewater facilities
- Austin-specific water supply contract savings
- savings to the end user with resultant benefits to local economy

National data shows that between four and five percent of electricity consumed in the US is for water and wastewater operations. In a typical city that operates its water and wastewater systems, about half of the electricity the city government uses is for water and wastewater operation. In Austin, water and wastewater treatment and pumping accounts for 58 percent of all electricity used by the city government. That comes to 3.9 kWh per 1,000 gallons of water. This includes treating and pumping potable water and wastewater treatment and collection. Nonvolume-related uses, such as aeration at wastewater treatment plants, account for about 40 percent of the electric energy use, thus water conservation alone saves about 2.3 kWh per 1,000 gallons or about 16 cents per thousand gallons. Total saving per thousand gallons for other variable operational costs plus energy costs is about 20 cents. In addition, air pollution is reduced because less electricity has to be generated.

The capital cost of new water and wastewater treatment facilities continues to rise. For example, a new 50 million gallon a day (mgd) water treatment plant now under construction will cost approximately $200 million or $4/gpd of capacity when completed. Because this is a totally new location, costs for site development, intake structure, and connection to major distribution lines make the cost high. More typical costs for additions to existing plants are half that cost, or $2/gpd of capacity.

Wastewater treatment capacity costs are about $3/gpd of capacity, bringing combined water and wastewater costs to $5/gpd of capacity. Amortized debt service on $5 is about 40 cents per year, so deferring construction by ten years will save about $4 per gallon/day capacity over that time. Thus, delaying a 25 mgd for ten years could save $20 million in payments during that period. It is beyond the scope of this discussion, but in the final analysis, future inflation and present value of future savings will have to be taken into account.

Table A-1 shows the annual savings to end users (customers) by measure for both water and wastewater costs and for electricity where applicable and also shows the amount of bonded indebtedness deferred and savings in O&M costs. Table A-2 shows the impact various conservation measures will have on air pollution avoided from the electricity saved by the water and wastewater utility.

Table A-1 End-user and utility savings for various conservation measures

	Savings by the End User				Utility Savings $/Yr	
	gpd	$/Yr water*	$/Yr Electricity†	$/Yr Total	Capital $ deferred‡	O&M $ Saved/Yr§
Residential Programs						
Free Toilets	25	$73		$73	$125	$3
Toilet Rebates	25	$73		$73	$125	$3
Clothes Washer Rebates	15	$44	$42	$86	$75	$2
Irrigation Rebates	30	$38		$38	$150	$3
WaterWise Rebates	30	$38		$38	$150	$3
Aerators	4	$12	$3	$15	$20	$0.4
Showerheads Picked Up	7	$20	$11	$31	$35	$1
Irrigation Audits	30	$38		$38	$90	$3
Rainwater Rebates	79	$101		$101	$237	$9
Rain Barrel Rebates	6	$7		$7	$17	$1
Indoor Audits	20	$58		$58	$100	$2
Hose Timers	3	$4		$4	$9	$0
Rain Shutoffs	20	$26		$26	$60	$2
Multi-Family Programs						
Free Toilets	30	$66		$66	$150	$3
Toilet Rebates	30	$66		$66	$150	$3
Clothes Washer Rebates	45	$99	$140	$239	$225	$5
Commercial Programs						
Toilet Rebates	34	$87		$87	$170	$4
Free Toilets	34	$87		$87	$170	$4
Irrigation Audits	250	$274		$274	$750	$27
Indoor Audits	100	$256		$256	$500	$11
Clothes Washers	45	$115	$140	$255	$225	$5
Dental Vacuum Pumps	720	$1,840	$123	$1,962	$3,600	$79
Pre-rinse Spray Valve	200	$511	$306	$817	$1,000	$22
Remove Garbage Grinder	400	$1,022	$612	$1,634	$2,000	$44

*Based on appropriate rate for user class and for inclusion of wastewater where applicable
†Assumes electric water heater where applicable—Vacuum pump and garbage grinder include electricity for electric motor
‡Capital cost delayed. With growth, this cost will be incurred at some future date but is delayed because of conservation. Actual savings will have to be adjusted for present value and inflation to time of construction of new capacity
§Based on O&M costs of 30 cents per 1,000 gallons

Table A-2 Air pollution reduction through water conservation measures

	Savings per Measure, *gpd*	Water Savings, *gpy*	Water Energy Savings, *kW–h/yr*	Other* Energy Savings, *kW–h/yr*	Total Energy Savings, *kW–h/yr*	Grams per Year: SO_2 1.58 *g/kW–h*	NO_x 1.22 *g/kW–h*	Particulates 0.13 *g/kW–h*	CO 0.16 *g/kW–h*	CO_2 540 *g/kW–h*
Residential Programs										
Free Toilets	25	9,125	21		21	33	26	3	3	11,432
Toilet Rebates	25	9,125	21		21	33	26	3	3	11,432
Clothes Washer Rebates	15	5,475	13	600	613	968	747	80	98	330,859
Irrigation Rebates	30	10,950	25		25	40	31	3	4	13,718
WaterWise Rebates	30	10,950	25		25	40	31	3	4	13,718
Aerators	4	1,460	3	50	53	84	65	7	9	28,801
Showerheads Picked Up	7	2,555	6	153	159	251	194	21	25	85,801
Irrigation Audits	30	10,950	25	25		40	31	3	4	13,718
Rainwater Rebates	79	28,835	67		67	106	82	9	11	36,124
Rain Barrel Rebates	6	2,008	5		5	7	6	1	1	2,515
Indoor Audits	20	7,300	17		17	27	21	2	3	9,145
Hose Timers	3	1,095	3		3	4	3	0	0	1,372
Rain Shutoffs	20	7,300	17		17	27	21	2	3	9,145
Multi-Family Programs										
Free Toilets	30	10,950	25		25	40	31	3	4	13,718
Toilet Rebates	30	10,950	25		25	40	31	3	4	13,718
Clothes Washer Rebates	45	16,425	38	2,000	2,038	3,220	2,486	265	326	1,100,577
Commercial Programs										
Toilet Rebates	34	12410	29		29	45	35	4	5	15,547
Free Toilets	34	12410	29		29	45	35	4	5	15,547
Irrigation Audits	250	91250	212		212	334	258	28	34	114,318

Table continued next page.

Table A-2 Air pollution reduction through water conservation measures—*continued*

	Savings per Measure, *gpd*	Water Savings, *gpy*	Water Energy Savings, *kW–h/yr*	Other* Energy Savings, *kW–h/yr*	Total Energy Savings, *kW–h/yr*	Grams per Year				
						SO_2 1.58 *g/kW–h*	NO_x 1.22 *g/kW–h*	Particulates 0.13 *g/kW–h*	CO 0.16 *g/kW–h*	CO_2 540 *g/kW–h*
Indoor Audits	100	36500	85		85	134	103	11	14	45,727
Clothes Washers	45	16,425	38	2,000	2,038	3,220	2,486	265	326	1,100,577
Dental Vacuum Pumps	720	262,800	610	1,750	2,360	3,728	2,879	307	378	1,274,236
Pre-rinse Spray Valve	200	73,000	169	4,370	4,540	7,173	5,538	590	726	2,451,457
Remove Garbage Grinder	400	146,000	339	8,741	9,079	14,346	11,077	1,180	1,453	4,902,914

	Grams of Pollutant Generated Based on Austin Power Generation Mix				
Pollutant	SO_2	NO_x	Particulates	CO	CO_2
Grams/kW–h†	1.58	1.22	0.13	0.16	540
Grams/1,000 Gal†	6.2	4.8	0.5	0.6	2,277

*Additional energy savings due to reduced hot water, decreased dryer energy use, and increased motor efficiency assuming heating of water done with electricity.
†Based on Austin, Texas Power Generation Mix

Other supply savings unique to Austin involve the contract with the Lower Colorado River Authority (LCRA) for water. Once 201,000 acre-feet a year (179 mgd) is exceeded, 5 to 10 million dollars a year will be paid in additional charges. It is important to remember that O&M savings will continue to occur each year, as will payments to LCRA, while deferred capital cost savings will only exist until the new capacity must be built. The bottom line is that these combined savings can be significant. For example, since 1991, the City of Austin Water Conservation staff estimates that the cumulative water savings is approximately 10 mgd and from the programs beginning in 1984, overall use would be 25 mgd higher if per capita water use typical in the early 1980s had continued. A savings in O&M costs of 20 cents per thousand for 25 mgd in savings is equal to $1.8 million per year, and the capital cost for that much water and wastewater treatment plant capacity would be over $120 million and would have a debt service of approximately $10 million a year, but this does not take into account present value of a future debt. Conservation can create tremendous savings.

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CASE STUDY B—LANDSCAPE AND AGRICULTURAL AREA MEASUREMENTS AND WATER USE BUDGETS

The Santa Clara Valley Water District (District), in California, encompasses all of Santa Clara County and serves the area's 15 cities, 1.7 million residents, and more than 200,000 commuters. In 2001, the District was awarded CalFed grant funds to accurately measure the classified large landscape areas of urban parcels and agricultural farmland within Santa Clara County. The project, which began in June 2002 and will be completed by June 2003, will acquire multispectral images of Santa Clara County, will perform image analysis (classification) to identify the areas of turf, other landscaping, water features, bare ground, and hardscape for each parcel (site), and will prepare a database of these areas to support Landscape Water Budgets as well as support the Irrigation Technical Assistance Program Landscape Survey and Agricultural Mobile Lab Programs. Currently, this is the largest mapping project of its kind.

In 2000, the District completed a pilot study to examine the feasibility of such a project. The pilot study, which covered the city of Mountain View's (one of the District's retailers) service area, used similar techniques to generate the area measurements for each parcel. The District is confident that the results are promising and is currently working with the city of Mountain View to develop a landscape water budget system.

The goal of the water budget program is to calculate (using the aforementioned grant funding) the irrigated landscape area for approximately 50,000 irrigation-only and mixed-use commercial accounts that are distributed over a 900-square-mile area representing Santa Clara County. The irrigated landscape area will be used along with real-time evapotranspiration rate (ETo) data to calculate a water budget (recommended landscape irrigation water use).

The District will routinely update each budget using ETo data from the California Irrigation Management Information System (CIMIS) so that the budgets reflect actual site irrigation demands during the most recent billing cycle. Concurrently, the District is developing a database-backed Web site (webITAP) to deliver real-time landscape water budget information to property and landscape managers via the Web. It is projected that these landscape water budgets will reduce water use for these sites by at least 10 percent (or 5,000 acre-feet per year for the entire county).

The project will also classify into multiple crop categories approximately 200 square miles of agricultural lands within the District's service area. Orchards and alfalfa fields can be easily indexed to ETo, and mobile lab investigations will provide appropriate compensation factors for distribution uniformity in these cases. Vegetable crops present a greater challenge because of planting date variation. The high-resolution image will provide a valuable teaching tool for irrigation system distribution uniformity at the levels of District meetings and the individual irrigator. Potential savings are forecast at 0.3 acre-foot per acre. The project contract was for $386,000, and approximately 500 staff hours have been spent so far.

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CASE STUDY C—WATER SMART TECHNOLOGY PROGRAM: INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL WATER CONSERVATION CASE STUDY

Saving Water Partnership (the Seattle, Wash., regional utility conservation program)

Background

The Water Smart Technology program provides free technical assistance and financial incentives to reduce water use at commercial, industrial, and institutional facilities. The program has been operating with great success for the past ten years. Conservation opportunities include replacing toilets and urinals, converting ice machines and refrigeration equipment from water to air-cooled, other types of pass-through cooling, installing high-efficiency commercial clothes washers, upgrading air compressors and other medical equipment, process water recycling and reuse, cooling tower improvements, and other water use efficiency technologies. Program staff and consultants provide efficiency solutions through on-site assessments, technical review, product evaluation, fact sheets, and case studies. Program financial incentives provide standard rebates or custom incentives of up to 50 percent of the installed costs of any utility cost-effective measure. Utility cost-effectiveness is determined based on a model, which considers the utility's marginal cost of new supply sources plus a 10 to 15 percent bonus for environmental externalities. From a customer perspective, most program participants have a simple payback of less than two years on their investment.

Goals of This Project

The Water Smart Technology Program has a specific water-saving target each year, with a goal of saving 5.7 million gallons per day of peak demand reduction by the year 2010. To put this goal in perspective, it represents over a 3 percent reduction in peak season regional water use (using the years 1994 to 2000 as an average baseline).

In 2003, the program had a savings goal of 540,000 gpd, including information and outreach activities, with a budget of $1.3 million. Of this total, over 430,000 gpd of savings came from replacement and upgrades of equipment, where the pre- and post-water use can be measured. Program delivery and outreach focused on four strategies.

1. Vendor driven incentives initiated primarily by service and equipment providers
2. Partnerships with trade groups, energy utilities, agencies, and other service providers
3. Targeted recruiting of select business categories, emphasizing large customers such as hospitality, medical facilities, schools, and institutions
4. Outreach and information by the Chamber of Commerce's Resource Venture, including workshops designed to address selected end uses

Project Implementation Risks

Instead of free business audits by utility staff, which proved to be a poor strategy to achieve project implementation, the Water Smart Technology Program offers financial incentives for installed and completed projects. Vendors and service providers use the incentive program as sales leverage as they contact their potential customers. A single utility staff person administers the program with the assistance of consultants. Program efficiency is maintained by only paying incentives for projects that are installed and saving water. This eliminates most of the utility risk of obtaining actual water savings, because funds are only provided for completed projects. Over 80 percent of the program budget goes to paying incentives for projects and not for program staff, planning, administration, and audits. The risk of completing enough projects each year has not been a great concern, with the annual budget usually obligated well before the end of the funding year. Finding enough cost-effective projects has not been a serious problem in the past ten years of the program, although it is widely recognized that more marketing effort should be made in future years as more and more of the most cost-effective and easy projects are completed.

The risk of losing savings over time can be significant. A fine line exists between encouraging customers to undertake conservation projects and ensuring ownership and maintenance of completed projects. Program experience to date suggests that water customers need to invest at least 50 percent of the total project costs with "their" money. If more than this percentage is invested, the project is sometimes not taken very seriously (it becomes a "utility" project). Because the basis of the program is long-term utility savings, customer maintenance is key to long-term success. The risk of revenue disappointment has been mitigated by building the anticipated water savings and program budget into the demand forecast in advance of rate setting.

Budget

By 2010, the Water Smart Technology Program will spend $18 million to obtain approximately 6 million gallons per day in peak season savings. To reduce utility revenue fluctuations and continue program continuity without large peaks and valleys, annual funding has been maintained at approximately 1 to 1.5 million dollars per year. Much of this funding comes from the sale of long-term bonds, similar to how pipeline and other utility facilities are funded. Because this program will produce reliable and measurable long-term savings, it is financed similarly to a new source of supply, such as a well. Only the "soft" information and education portion of the conservation budget is funded from operating revenues. This financing strategy reduces the program's impact and competition for annual operating revenues, which in some years can be very tight. To put this program into a utility and customer perspective, annual expenditures on this program make up about 4 percent of the annual revenue collected from the nonresidential customer class.

Stakeholders

Large water-using businesses (key accounts) are contacted every few years to review potential projects. Frequently it takes several years for large businesses and institutions to budget their share of project costs and to justify projects to their decision makers. Partnerships with energy utilities have leveraged water utility funding. Often projects will have energy savings associated with water savings, and the customer can "double dip" on both energy and water rebates. Using the Resource Venture, a nonprofit affiliate of the Chamber of Commerce, for program promotion, leverages business-to-business contacts, testimonials, and success stories. The Resource Venture is also involved in many other business activities, such as recycling of solid waste, waste prevention, drainage, sustainability, and hazardous waste. Adding water conservation to this menu of business services through the Chamber of Commerce has proved to be a powerful program-marketing tool.

Program Techniques Used

Some business customers will implement conservation without utility rebates. So in addition to rebate incentives, the program uses a variety of other motivational techniques to reach customers. This includes workshops and seminars, which have proven very popular when coupled with case studies and testimonials from local businesses. In 2003, outreach included direct business mailings in cooperation with energy providers, cooperative restaurant prerinse spray head replacement of over 1,200 units, and a workshop on no-water and reduced water urinals. Also, a number of trade group and facility manager presentations were made, as well as a major vendor luncheon to launch a special incentive promotion. An annual Business for an Environmentally Sustainable Tomorrow (BEST) awards ceremony provides for business recognition for their environmentally beneficial accomplishments, including water and energy conservation. The awards are sponsored by the utility partnership, the Resource Venture of the Greater Seattle Chamber of Commerce, and Seattle City Light. The awards draw attention to businesses' success in resource conservation.

Program Evaluation

The water smart technology program is evaluated annually to ensure that actual savings are being achieved. In 2002, the program saved 490,000 gpd. For recent examples of this evaluation, see the following Web reference.

All projects are evaluated prior to authorization for rebates. For some projects like coin-op washers, a standard rebate is provided based on measured savings from a large sample of customers. For more unique projects, a portable flowmeter or standard flowmeter is installed for pre- and postevaluation. Site inspections are done for all large projects and many smaller ones. Long-term tracking is done from billing records and periodic checkups with facility managers and vendors. Payment and process procedures are checked by independent auditors to ensure accuracy.

References and Contact

Water Smart Technology Program Web page:
    http://savingwater.org/business.htm
Chamber of Commerce Resource Venture Web site:
    http://www.resourceventure.org/rv/issues/water/introduction/index.php
Annual Evaluation Report:
    http://www.ci.seattle.wa.us/util/RESCONS/accmpReport/default.htm
For additional information, contact Philip Paschke, program manager, at (206) 684-5883

CASE STUDY D—EVALUATING CONSERVATION PROGRAM IMPLEMENTATION, TAMPA BAY WATER, FLORIDA

Tampa Bay Water is Florida's largest wholesale water provider and supplies potable water to over two million residents in the Hillsborough–Pasco–Pinellas tri-county areas. The agency provides water to six member government utilities, including the three counties mentioned and the cities of Tampa, St. Petersburg, and New Port Richey. As a part of its water conservation planning and coordination role, the agency, with input of its member governments, developed a series of water conservation best management practices (BMPs) for reducing interior and exterior potable water demand and a water savings tool allowing members to compile and evaluate various scenarios for implementation, review, and documentation of implemented measures.

The member government utilities are required annually to develop five-year water conservation plans. These plans are required to quantify active conservation programming under a partnership agreement with the Southwest Florida Water Management District.

In 2003, Tampa Bay Water evaluated the selection of BMPs previously provided to and used by member governments over the past five years. Existing BMPs were updated and reclassified with respect to water savings rates, implementation costs, and interactions with other BMPs. New water-saving BMPs that could be applicable to the Tampa Bay region were identified and included in a BMP implementation plan.

A water savings calculator software product was developed to enable members to easily evaluate water savings and cost associated with various BMP implementation scenarios. The program allows for regional compilation of member government five-year water conservation plans, maximum conservation potential by member and the region, and the ability to track BMP implementation on an annual basis. The program and BMPs were upgraded in 2004.

Following the submittal of individual five-year plans, they were compiled into a regional "Compilation of Five-Year Conservation Plans." This document provides an evaluation of savings occurring historically, currently, and through a five-year planning horizon, based on best available savings data. According to member government actual and projected five-year water conservation plans, the region will cumulatively save approximately 33 mgd by the end of FY 2008.

Tampa Bay Water is currently working with its members to establish conservation-related fields in their billing systems. The agency is proposing to develop standardized evaluation functions allowing members to statistically determine actual savings from conservation and reuse programs implemented to date.

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CASE STUDY E—BLOCK LEADER PROGRAM OVERVIEW, TOWN OF CARY, NORTH CAROLINA

Begun in 1998, the Town of Cary's Block Leader Program is one of many educational initiatives to inform citizens about water conservation. Since its inception, over 275 residents have volunteered to learn about water conservation and distribute information and special promotional items to their neighbors. Block Leaders are grassroots environmental educators—resources for their neighbors—not extensions of the water conservation enforcement staff. They do not enforce ordinances nor do they solicit anything from their neighbors; instead, they keep neighbors well informed and up-to-date on water conservation issues and methods. Currently, approximately 18 percent of the town's solid waste customers are served by nearly 150 Block Leaders.

Each year, in the spring or early summer, new and established Block Leaders attend an hour-long training session to learn about the town's summer water conservation campaign, new water conservation initiatives, and the status of relevant utility projects. During the training session, volunteers also pick up materials to distribute to neighbors within their "block." Town staff customizes blocks for each volunteer based on volunteer's time availability and level of commitment. Some Block Leaders are responsible for the half-dozen homes within their cul-de-sac. Others have agreed to be responsible for up to 200 homes within their entire subdivision. Staff encourages and appreciates participation at whatever level the volunteer is willing to give. Each year volunteers commit to a time obligation of one hour plus whatever time it takes each Block Leader to distribute their materials. Throughout the year, town staff maintains regular contact with Block Leaders through e-mail messages and *The Network News*, a semiannual newsletter. Furthermore, the Town of Cary sends out regular news releases and any pertinent releases (for example, landscaping workshops, irrigation restrictions, recycling information) are forwarded to Block Leaders, providing them with additional opportunity to communicate with their neighbors, either in person or via e-mail if they have a neighborhood mailing list.

The Town of Cary is committed to reducing per capita water consumption by 20 percent by 2015. Block Leaders are helping to make a difference in protecting and preserving the finite natural resources and in achieving this goal. As an indicator of its effectiveness, staff has recently identified a difference in water consumption during the drought of 2002 between areas of town that are covered by Block Leaders and the average overall consumption. Staff is closely monitoring the effectiveness of the Block Leader Program as it expands to include a greater percentage of utility customers.

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CASE STUDY F—CASE STUDY: CITY OF FORT COLLINS UTILITIES (FCU)

Residential Landscape Measures:

In 1992, Fort Collins, Colo., City Council passed a water demand management policy, Resolution 92–63. Since then, this policy has been the foundation of the city's water conservation program. The resolution set two goals for lowering demand and twelve measures for achieving those goals. FCU is examining this policy to determine if any improvements could be made or if new goals should be set.

- A Sprinkler System Audit Program for residential customer and homeowner associations has been in place for three years. Customers request water audits on a volunteer basis. Last year FCU performed 200 audits. The audits are performed during the summer months by a part-time employee hired specifically for this water-efficient landscape measure. Auditors evaluate the sprinkler systems for proper coverage and damaged or misaligned heads. Homeowners learn how to program their controllers and to prepare watering schedules based on weather conditions.
- A Soil Moisture Sensor Research Study performed last year consisted of one case study. There is no write up available for this study, however FCU assessed that the soil moisture sensor worked well as long as it was appropriately placed out of reach of the sprinkler system.
- During the watering season, FUC provides a daily Lawn Watering Guide to the local newspaper, showing how much water a lawn might need if it had not been watered for three, five, or seven days.
- Landscape seminars on sprinkler system design for water efficiency and xeriscape are provided about three times per year.
- A Xeriscape Demonstration Garden is displayed for public education at the City Hall. Provided maintenance and tours are offered on request.
- FCU is a participant in the Bureau of Reclamation Yields and Reliability Demonstrated in Xeriscape (YARDX) for the Fort Collins area. YARDX is a study to analyze the water and maintenance savings of xeriscape compared to traditional landscaping. The landscapes were completed in 1998, and meter reading continued through 2002 for participants and control homes. This is a study based on four years of measuring water use of specified landscape designs each summer.
- Review of landscape plans and irrigation plans for new development are required by the city. During 2000, FCU reviewed 79 landscape plans. Landscape plans for new development are reviewed for compliance with the Land Use Code's water conservation standards. The plan review is part of the review process prior to city approval for new developments.
- Water Conservation Education is an ongoing part of FCU's landscape. Xeriscape and lawn-watering techniques are popular topics for inquiries. Lawn-watering efficiency and water use estimates are also available for homeowners' associations, businesses, and homeowners. Articles, brochures, fact sheets, and other materials are distributed at various city locations and through newspapers, newsletters, and the Internet. The outreach program for residential customers emphasizes watering practices and xeriscape because half of the home's annual water use goes for lawn watering.

Commercial Landscape Measures

Review of landscape plans and irrigation plans for new development are required by the city. FCU developed minimum water conservation standards for irrigation systems associated with landscape plans for all development that is subject to city review and approval. This does not include the irrigation systems of single-family residences. During 2000, the FCU reviewed 24 irrigation plans. Irrigation plans for new development are reviewed for compliance with the Land Use Code's water conservation standards. The plan review is part of the construction permit review process before a final building permit is issued.

Key Residential Program Strengths and Weaknesses

Water use overall has decreased in the FCU service area. The sprinkler system audits have received a good response, especially because they are based on volunteer response from customers. The sprinkler system audits also allow for further water conservation education of the customer.

It is difficult to measure water savings from these sprinkler system audits and the other water conservation activities, because in part of the fact that the system is not completely metered. FCU compares annual average water use from year to year, but because weather patterns vary from year to year, it is difficult to make a comparison.

A weakness of the irrigation plan and approval process is that the city does not always actually require a permit applicant to be in compliance with the landscape requirements. This measure is difficult to enforce.

CASE STUDY G—WATER LOSS CONTROL IN PHILADELPHIA

Philadelphia's Water Supply: A History of Firsts

The city of Philadelphia has been a leader in water supply technology in the US for over two hundred years. By 1822, a dam and water-driven turbines were incorporated into the Fairmount Water Works, which was widely recognized as both an engineering marvel and a place of architectural splendor. The distribution piping of this early system consisted of bored wooden logs joined by iron bands and caulking. The city's first water loss problem was realized as these pipes leaked badly. Philadelphia began to import British-made cast iron pipe to expand its water distribution system. The longevity of iron pipes—in use in Europe for hundreds of years—has been confirmed in Philadelphia, where several thousand feet of pipe segments installed in the 1820s still provide reliable service.

Philadelphia continued to demonstrate innovation by becoming one of the first large cities in the nation to construct water filtration plants between 1903 and 1911. More recently, the city installed the largest automatic meter reading (AMR) system in the US, with over 400,000 residential units outfitted between 1997 and 1999. At the start of the new millennium, Philadelphia continued its tradition of firsts by becoming the first US water utility to initiate use of the progressive water loss management methods and technology developed internationally during the 1990s.

Despite a number of early water conservation efforts, the city has not historically operated with a high level of water efficiency. With water resources relatively abundant and inexpensive, Philadelphia's primary water supply goals were to provide a safe, sufficient supply of water for industrial, residential, and fire protection needs, and the city has continuously met these goals for over two centuries.

Philadelphia began reviewing its water loss status in 1980 when an "Unaccounted-for" Water Committee undertook a comprehensive study to identify sources of lost water and propose loss reduction actions. Improvements, including master meter calibration, expanded leak detection, and meter replacement soon followed. Still, nonrevenue water (NRW)—the difference between the water put into the distribution system and customer-billed consumption—remained at levels well above 100 million gallons per day (mgd) in the decade following this work. Water loss was scrutinized in 1993 after a proposed 30 percent water rate increase was rebuked; instead a series of single-digit increases was implemented totalling 7 percent over three years. A permanent Water Accountability Committee was established to pursue sustained water loss reductions. Further expansion of the main replacement and leak detection programs and a switch from quarterly to monthly billing were implemented shortly thereafter. Figure A-2 reveals a notable decline in NRW after 1994. NRW routinely averaged between 120 and 130 mgd prior to this year but stood at just under 87 mgd for the business year ending June 30, 2003.

This success in cutting water loss is attributed to reductions in both *real losses* (leakage) and *apparent losses* (missed billings, meter inaccuracy, and unauthorized consumption). Real losses have been reduced by a combination of increased leak detection effort, improvements in leak repair job routing, and pipeline replacement. Apparent losses have been reduced using new residential meters (installed with AMR), large meter right-sizing, recovery of missed billings, and establishing accounts for city-owned properties.

Thwarting unauthorized consumption from fire hydrants has also been successful. While these improvements are significant, city managers recognize that the current level of NRW water remains excessive and reduction efforts should continue.

In Search of Best Management Practices for Water Loss Control

During the 1990s, Philadelphia's Water Accountability Committee began participation on AWWA's Water Loss Control (formerly Leak Detection & Water Accountability) Committee. Initially, Philadelphia developed a water audit based largely on the AWWA M36, *Water Audits and Leak Detection*. To stay abreast of current developments, Philadelphia became the first American water utility to employ the

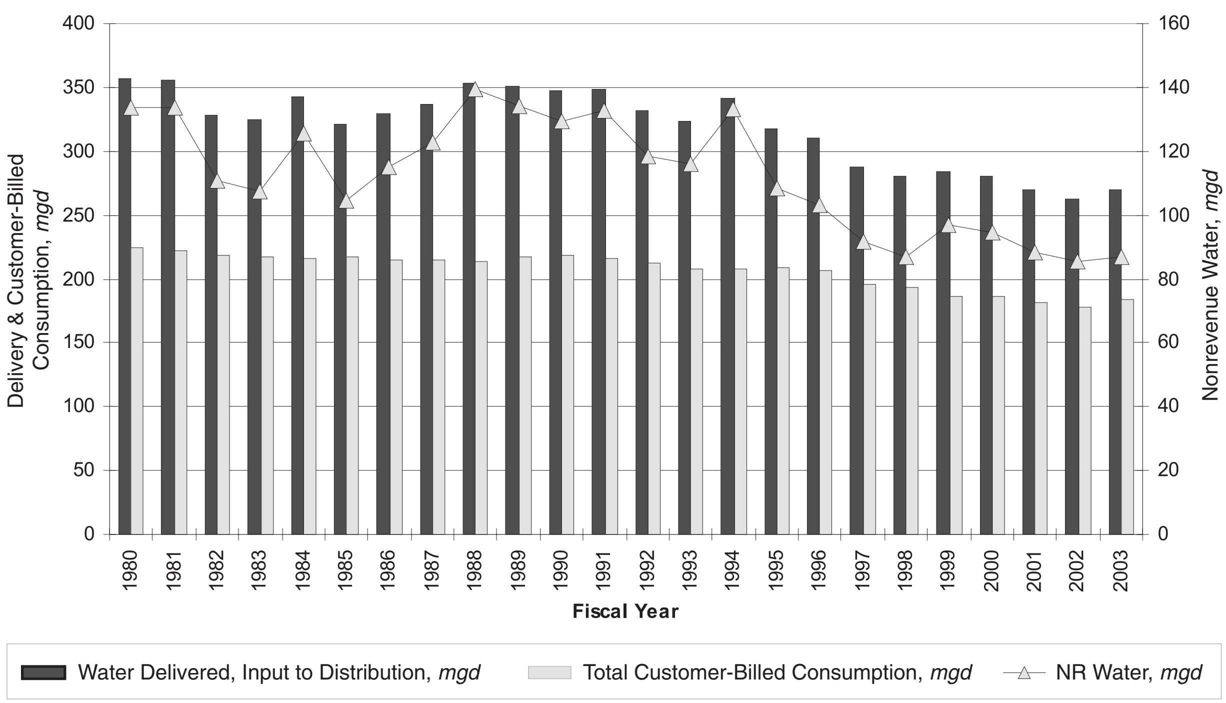

Figure A-2 City of Philadelphia—water delivery & nonrevenue water

water audit method issued in 2000 by the Water Loss Task Force, a five-country committee formed by the International Water Association (IWA). The Task Force included AWWA participation.

By compiling its initial IWA/AWWA water audit, the city was able to utilize the robust performance indicators included in this method. Its initial infrastructure leakage (ILI) index—the ratio of current vs. best achievable leakage levels—was calculated at 12.3, meaning the city's leakage stood at 12.3 times the technically achievable low level. This level benchmarked high among a dataset of international utilities, but it is likely a reasonable level for an older US city that is just starting a progressive leakage management program. With water relatively available and inexpensive, Philadelphia does not have an economic justification to attain technically low leakage levels, or an ILI close to 1.0. It should, however, seek to determine an appropriate economic leakage target that is based on the city's direct and indirect costs of water. While an economic assessment of leakage has not yet been performed, Philadelphia can follow guidelines published by AWWA in 2003 (Kunkel 2003) that suggest an ILI of 8.0 as a maximum allowable level. In following this guideline, the city could seek a reduction of 23.5 mgd; reducing its current level of 70.5 mgd to 47 mgd. Such a reduction is being forwarded in planning efforts and could occur during an initial 5–10-year period of stepped-up leakage management interventions. By the year ending June 30, 2003, Philadelphia had reduced its ILI to 11.9, which indicates a slight improvement from the initial water audit in 2000. The city's water audit report summary for the year ending June 30, 2003, is given in Table A-3.

Managing Real Losses: The Leakage Management Assessment Project & Beyond

In addition to the implementation of the IWA/AWWA water audit, Philadelphia also contracted with international leakage experts in 2000 to conduct the Leakage Management Assessment (LMA) project, which evaluated the city's leakage standing and control practices. Consultant services funded at roughly $60,000 were utilized as part of this effort.

A comprehensive assessment of Philadelphia's active leakage control practices was conducted as part of the LMA. General conclusions recommended that Philadelphia improve its leak repair activities by better work order management that emphasizes timely reporting and repair execution. Refinements to its leak survey scheduling were also suggested along with considerations to modify its capital planning for water main rehabilitation, with less emphasis on full trench pipe replacement and greater emphasis on infrastructure downsizing and investigation of trenchless technologies. Moderate potential was found to exist to control water pressure to prevent surge-driven ruptures and to reduce background leakage; i.e., weeps at pipe joints. An important policy recommendation was also forwarded to reassess Philadelphia's regulations requiring customers to bear full responsibility to arrange repairs of leaks found on their customer service line piping. The worldwide practice of customer-arranged leak repairs has been found to be inefficient, as many customers are slow to implement repairs, resulting in long leak run times and mounting losses. Philadelphia is now in the process of implementing changes to accommodate this shift in responsibilities.

The LMA also included analysis of data from four pilot District Metered Areas (DMAs) using the Bursts and Background Estimates (BABE) leakage modeling concept. These four areas were selected to provide a variety of conditions, including different levels of water pressure, leakage histories, demographics, and infrastructure age. The DMAs were created by closing pipeline valves to surround a single

Table A-3 City of Philadelphia annual water balance in IWA/AWWA format

Fiscal Year 2003—July 1, 2002 to June 30, 2003		
	Water	Costs
Corrected System Input Volume		
Water Delivery	271.500	
Master Meter Adjustment	–1.300	
	270.200	
Authorized Water Usage		
Billed Metered	182.800	
Billed Unmetered	0.593	
Unbilled Metered	0.582	$26,894
Unbilled Unmetered	2.456	$153,482
	186.431	$180,376
Water Losses	83.769	
Apparent Losses		
Customer Meter under-regis.	0.210	$277,394
Bypassed Flow—Fire System	0.100	$4,621
Unauthorized Consumption	5.256	$1,645,207
Data/SCADA System Error	0	$0
Customer Meter Malfunction	0.136	$176,027
Meter Read/Estimating Error	0.971	$1,301,570
Accounts Lacking Billing	2.250	$3,014,809
City Properties	4.000	$3,091,514
Billing Adjustments/Waivers	0.375	$502,468
Apparent Loss Total	13.298	$10,013,610
Real Losses		
Operator Error/Overflows	0.649	$30,004
Unavoidable Ann. Real Loss	5.926	$273,845
Recoverable Leakage		
Active Service Line Leaks	16.418	$758,655
Abandoned Service Leaks	14.207	$656,478
Distribution Main Leaks	31.692	$1,464,454
Measured Leakage — DMAs	0.209	$9,648
Main Breaks (Bursts)	0.108	$4,991
Other	1.262	$58,299
Indemnity Costs		$425,884
Real Loss Total	70.471	$3,682,258
Water Losses Totals		$13,695,868

Water Data Shown in mgd

Fiscal Year 2003 Financial Data	
$3,856	Apparent Losses per mg—Small Meter Accounts ($^5/_8$ in. & $^3/_4$ in.)
$3,369	Apparent Losses per mg—Large Meter Accounts (1 in. and larger)
$3,312	Apparent Losses per mg for City Property Accounts
$3,671	Apparent Losses—Overall Average Customer Rate
$126.60	Real Losses—Marginal Cost per mg
$425,884	Real Loss Indemnity costs—added to total of Real Losses
$167,604,000	Water Supply Operating Cost

Table continued next page.

Table A-3 City of Philadelphia annual water balance in IWA/AWWA format—*continued*

Fiscal Year 2003—July 1, 2002 to June 30, 2003	
	Fiscal Year 2003 Customer Account Data
13,794	Number of Large Meter Accounts, 1-in. and greater
460,179	Number of Small Meter Accounts, $^5/_8$ in. & $^3/_4$ in. (also includes some large)
	Performance Indicators
5.926	Unavoidable Annual Real Losses (UARL), mgd—calculation that includes allowances for leakage on various system components. This is a system-specific calculation and includes key Philadelphia parameters: Average Pressure—55 Psi, miles of water mains—3,160, Total service connections and fire hydrants—545,737, and average service distance from curbstop to customer water meter—12 ft
11.9	Infrastructure Leakage Index—Ratio of Real Losses over UARL (dimensionless)
86.8	Nonrevenue Water, mgd—Real Losses + Apparent Losses + Unbilled Authorized Consumption
26.4%	Water Resources Indicator—Real Losses over Corrected System Input Volume
32.1%	Financial Indicator—Nonrevenue Water by Volume = NR Water over Corrected System Input Volume
8.3%	Financial Indicator—Nonrevenue Water by Cost = NR Water Costs over the Water Supply Operating Costs
129.2	Real Losses—Gallons/Service Connection/Day

NOTE: The breakdown among leakage categories is approximate an based largely on estimates rather than measured nightflows

supply main servicing a discrete area of approximately one thousand properties. Twenty-four hour flow measurements were obtained using an insertion metering device on the sole supply main. One of the four test areas—DMA4—displayed a consistently high flow rate even during minimum night hours, suggesting high leakage. The initial BABE analysis estimated 54 equivalent service connection leaks (ESCL) existed in this DMA. Several leak surveys and sewer examinations were conducted but found insufficient leaks to account for the high night flow rate. In 2003, a review of customer consumption data found a number of high-consumption accounts in this largely residential area. The city arranged with its AMR provider to obtain—on a single night—two meter readings for most of the active accounts in the DMA; one reading taken at 2:00 a.m. and another at 4:00 a.m. A number of properties gave constant high consumption through the minimum night hours, suggesting leakage on building plumbing. These findings are significant in that they confirmed that much of the high flow rate occurring in DMA4 goes into customer properties rather than out of water distribution piping as leakage. In applying the AMR night readings to the BABE model, only 11.5 ESCLs are now believed to exist in the DMA, compared to the initial assessment indicating 54. The integrated use of DMA and AMR technology is providing outstanding capability to accurately identify where wasteful water flow trends are occurring in the city.

Additional DMAs are envisioned in Philadelphia and will be included in the AWWA Research Foundation project "Leakage Management Technologies", which will run from 2004 through 2006. Philadelphia is likely to continue to apply the successful leakage management methods that have led to significant, sustainable leakage reductions internationally in the past decade.

Addressing Apparent Losses

Philadelphia's FY2003 water audit indicates that the city's real losses (70.5 mgd) are five times its apparent losses (13.3 mgd) on a volume basis. Conversely, apparent losses exert an annual impact of $10 million because of lost revenue, compared to $3.7 million for real losses, largely as excess production costs. This stark difference occurs because apparent losses are valuated at the retail cost charged to customers, which is much higher than the marginal cost of production used to valuate real losses. Because apparent losses represent service rendered without revenue recovered, these losses are usually highly cost-effective to recover.

Prior to 1997, Philadelphia was greatly hampered in reliably assessing its apparent losses. Although its customer population is fully metered, poor access to gain meter readings resulted in an average of only 1 out of every 7 water bills issued being based on an actual customer meter reading. While compromising the accuracy of customer water consumption data, estimated water bills also resulted in frequent billing adjustments and a high call volume of customer billing complaints. From 1997 to 1999 Philadelphia successfully installed the largest AMR system in the US with over 400,000 properties read remotely via radio transmission to vans patrolling set meter reading routes. With a primary intention of improving customer satisfaction with the billing process, AMR is also assisting water loss reduction. During its first five years of operation, Philadelphia's AMR system has greatly improved the integrity of customer consumption data because relatively few estimates now exist and accurate monthly customer meter readings are the norm.

Forthcoming improvements in the city's billing software will allow closer tracking of consumption and billing trends. Directly assisting water loss reduction, the AMR system includes tamper detection capabilities to thwart unauthorized consumption. While employing AMR, the city reorganized its metering and meter reading groups because manual meter reading was no longer necessary. A revenue protection mission was added to the metering group, which now focuses on customer account investigations as well as meter replacement and repair. With most of the customer population having new water meters, attention is directed at a notable number of suspect accounts. Such accounts include "hard-to-install" holdouts from the initial AMR installation as well as the city's "nonbilled" accounts. The latter represent customer accounts that have had billing suspended for one of a variety of administrative reasons. As nonbilled accounts grew without close monitoring over recent years, they came to represent a high potential for apparent loss. Often customers in nonbilled status would continue in such status even after water consumption resumed on the account. The city's Revenue Protection group completed its fourth year of operation on June 30, 2003, during which time its recoveries totaled $7.8 million and over 9 mgd. In the course of conducting its investigations, Revenue Protection identified a number of gaps in permitting, accounting, and information-handling procedures, which have since been corrected. The program is also focusing on adding many overlooked municipal buildings to the city's billing roles. The program revealed that up to 12,000 "zero consumption" accounts exist during any month. In several thousand investigations to date, about 50 percent of these properties were found vacant with no water consumption, meaning the unchanged meter readings from month-to-month are correct. However, roughly 35 percent of these accounts have incorrectly missed consumption because of the malfunction of the meter reading equipment; and 15 percent have been found to be vandalized by tampering. Philadelphia has also achieved success in stemming unauthorized consumption from fire hydrants by installing locally manufactured Center Compression Locks (CCL) on most of its problem fire hydrants.

Reducing apparent losses is attractive because it offers high economic payback. In this way, it "creates" previously uncaptured sources of funding and allows utilities to delay rate increases by equitably spreading costs among all customers. Philadelphia has made considerable headway in reducing apparent losses but, with an estimate of over $10 million of such nonrevenue water still existing, much work remains.

Philadelphia's Water Loss Future

The city of Philadelphia has taken a leadership role with the American Water Works Association to raise awareness of water loss in the industry and the need for consistent reporting and loss control structures. Additionally, the city continued its tradition of water supply innovation by becoming the first US water utility to employ the best practice water audit methodology developed by IWA and AWWA. The city is piloting progressive leakage management technologies, including the use of DMAs, and is embarking on an important project funded by the AwwaRF in this regard. Because of these and related endeavors, the city remains committed to the efficient management of its valuable water resources, to keep water rates affordable for residents and attractive for economic development in Southeastern Pennsylvania.

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CASE STUDY H—WATER CONSERVATION VOUCHER INCENTIVE PROGRAMS, SAN DIEGO COUNTY WATER AUTHORITY, SAN DIEGO, CALIFORNIA

In the spring of 1991, the Water Authority in conjunction with its member agencies began the first phase of a multiphased program to offer incentives for the installation of ultralow-flush toilets (ULFT). The program initially offered traditional ULFT rebates. The Water Authority introduced the voucher concept in 1994 as an innovative ULFT incentive solution for customers who wanted to conserve water but could not wait for a rebate. This concept was intended to improve the participation of hard-to-reach market segments, such as customers on fixed incomes and multifamily residents. Vouchers eliminate the need for the customer to "front" the total purchase price of the device. The vouchers are used at the time of purchase so after-purchase rebates are not available. In 1996, the Water Authority and its member agencies implemented the Commercial, Industrial, and Institutional (CII) Voucher Program. In 2000, the Water Authority added residential high-efficiency clothes washers (HEW) to the Voucher Program. The Voucher Incentive Programs is funded by the

Water Authority, its member agencies, and the Metropolitan Water District of Southern California.

The residential HEW program provides a $125 financial incentive to encourage customers to choose a high-efficiency clothes washer (HEW) instead of a standard top-loading model. HEWs use 40 percent less water, 55 percent less energy, and less detergent; clean better; and are gentler on clothes than standard clothes washers. Drying time can be cut in half. This program generates both water and energy savings. HEWs must be from the Consortium for Energy Efficiency list but also have a water efficiency factor of 9.5 or less. To date, almost 21,000 HEWs have been purchased using the incentive. When the program was first implemented, 2,287 vouchers were used in FY 2001. This has increased to over 7,933 vouchers in FY2003, with the number still growing. By the end of FY 2004 (June 30, 2004), the Water Authority anticipated over 10,500 vouchers used to purchase HEWs. Because approximately 30 percent of the HEWs purchased through the program have a water efficiency factor below 6.0, these HEWs will save the Water Authority 3,500 acre-feet of water.

Through the residential ULFT program, participating residential customers are offered a voucher redeemable with local plumbing dealers for up to $75 off the purchase price of an approved ultralow-flush toilet (ULFT) or $95 for a dual-flush toilet (DFT). Vouchers may only be applied to the cost of the toilet tank, bowl, and sales tax. Beginning in the fall, only those ULFTs that qualify under the Supplemental Purchase Specification will be eligible for the voucher. Through Dec. 31, 2003, almost 438,000 toilets in the Water Authority's service area have been retrofitted using available financial incentives.

The CII program provides point-of-purchase vouchers to customers replacing water inefficient equipment in commercial, industrial, or institutional settings. The vouchers are up to $95 for ultralow-flush toilets, urinals, and waterless urinals; $300 for coin-operated high-efficiency clothes washers (this will reduce to $150 in FY 2005); $500 for cooling tower conductivity controllers; $100 for water brooms (for participating agencies); and $2,000 for X-ray processor water conservation units. Additional products are added periodically. Since this program's inception, over 6,300 acre feet of water have been saved through the installation of 27,500 water-conserving products in the commercial, industrial, institutional sectors.

For more information on these programs, please contact:

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Index

NOTE: *f.* indicates a figure; *t.* indicates a table.

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