



Best Practices to Consider When Evaluating Water Conservation and Efficiency as an Alternative for Water Supply Expansion

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Glossary

Apparent Losses	<p>Includes all types of inaccuracies associated with customer metering, data archiving and billing; plus all unauthorized consumption (illegal use).</p> <p>Note: Overregistration of customer meters leads to underregistration of Real Losses. Underregistration of customer meters leads to overestimation of Real Losses.</p>
Authorized Consumption	<p>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.</p> <p>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.</p>
CARL	<p>Current Annual Real Loss (CARL) is the volume of water lost from reported leaks, unreported leaks, background losses, and storage tank overflows.</p>
Conservation	<p>Water conservation is any beneficial reduction in water use or in water losses. Conservation should be distinguished from curtailment.</p>
Curtailment	<p>Mandatory reduction in water use as needed during drought or emergency situations to achieve immediate results</p>
Economic Level of Leakage analysis (ELL)	<p>An ELL analysis identifies the amount of leakage that can be avoided through control measures whose costs are balanced against the savings of reduced leakage.</p>
Efficiency	<p>Water efficiency or water use efficiency refers to the accomplishment of a function, task, process, or result with the minimal amount of water feasible</p>
ILI	<p>Infrastructure Leakage Index (ILI) is a performance indicator quantifying how well a distribution system controls real losses (leakage) at the current operating pressure. It is determined by dividing CARL by UARL. ILI is an indicator best suited for utilities with well-validated water audit data, and has not yet been proven valid for very small water utilities. Small systems in this case include those with average operating pressure less than 35 psi, or where $(Lm \cdot 32 + Nc) < 3,000$. Lm = length of mains (in miles, including hydrant lead length) and Nc = number of customer service connections. Those systems should use the Real Losses performance indicator Op24.</p>
Marginal cost of water supply	<p>The cost of supplying an additional increment of water</p>

Glossary

Non-revenue Water	Those components of System Input, which are not billed, or revenue producing. Equal to Unbilled Authorized Consumption plus Apparent Losses plus Real Losses.
Op24 (Operational Real Losses performance indicator)	<p>Op24 is a performance indicator useful for smaller systems for which ILLI is not appropriate. If average system pressure is not available, losses can be calculated as:</p> <p>Gallons/service connection/day</p> <p>or</p> <p>Gallons/miles of main/day *only if service connection density is less than 32/mile</p> <p>If average system pressure is available, Op24 should be calculated as:</p> <p>Gallons/service connection/day/psi</p> <p>or</p> <p>Gallons/miles of main/day/psi *only if service connection density is less than 32/mile</p>
Real Losses	Water that is piped into the system, but lost before making it to the end user. These are physical losses such as breaks and leaks from water mains and customer service connection pipes, joints, and fittings; from leaking reservoir walls; and from reservoir or tank overflows.
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.
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.
UARL	Unavoidable Annual Real Loss (UARL) represents the theoretical technical low limit of leakage that would exist in a system if all water loss control efforts were exerted.
Unbilled Authorized Consumption	Those components of Authorized Consumption, which are not billed, or revenue producing. Equal to Unbilled Metered Consumption plus Unbilled Unmetered Consumption.
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.
Water Supplied	System Input minus water exported to others.

Executive Summary

A key function of a water utility is to ensure that it has adequate supply to provide water services to its domestic, commercial, and industrial customers. Because population continues to grow nationally, and at faster rates in some parts of the country, utilities often need to consider whether it is appropriate to develop additional supplies. Such supplies may be provided by greater withdrawals from surface water or groundwater, construction of reservoirs, or construction of desalination or water reclamation facilities. Any of these types of projects carries a cost. As water utilities consider options, it makes sense to ensure that they are effectively managing the water resources already under their control. More efficient use of water may avoid impacts to aquatic resources, provide greater ecosystem protection, and/or free up the water saved to serve additional needs.

EPA has developed this best practices document to help water utilities and federal and state governments carry out assessments of the potential for future water conservation and efficiency savings to avoid or minimize the need for new water supply development. The document can also be used by a utility or a third party to conduct assessments of how the utility is managing its water resources from a technical, financial, and managerial perspective.

The document consists of six major practices, with suggested metrics to guide evaluations of progress. No single metric is intended to serve as a stand-alone test. Instead, the combined information on water conservation and efficiency implementation, with emphasis on planned measures, can inform reviews of a project's purpose and need, and analysis of alternatives.

- The first practice involves conducting a water audit. The AWWA Free Water Audit Software® available from the American Water Works Association (AWWA) is used to complete a water balance and produce performance indicators for how well the basics of the water system are understood, including how much of the water distributed is authorized, metered, and/or billed.
- Next, because leakage represents the largest real losses for most systems; the second practice focuses on assessing and addressing water loss minimization through leakage control. Metrics focus on measures of leakage tailored to system characteristics, identifying an economic level of loss, and measures (in place and planned) to assess and control water loss.
- Metering of water, the third practice, allows for accurate accounting of water distributed, and can help identify unseen sources of leakage and prioritize abatement measures. When metered usage is communicated to customers, it also helps inform and incentivize how end uses are managed.
- The fourth practice is an examination of water rate structure. Charges for water should reflect the full long-range costs (i.e., forward-looking, not historical) of operating and maintaining a water utility, as well as the scarcity and value of the resource. The rate structure should also encourage and reward conservation and efficient use.
- End user water conservation and efficiency analysis, the fifth practice, begins with characterizing the system in terms of customer types and demand (e.g., single family residential, multifamily residential, commercial, institutional, industrial). This then allows for identification of demand drivers and demand reduction opportunities through targeted programs and incentives for end users.
- The final practice is a written plan which includes definitive and measurable goals for optimizing system performance and ensuring efficient water use, with timelines for implementation.

Background

Water is vital. Public water supply, aquatic habitat, energy generation, agriculture, commercial and industrial uses, and recreational opportunities all depend on water. Balancing competing uses of surface water—instream and off-stream—and groundwater, while protecting water quality, is challenging our limited water supplies in ways that require new solutions for responsible use.

Providing clean and reliable public water supply is a topic foremost on the agendas of many communities across the United States and the world. However, water supply reservoirs and withdrawals from surface water or groundwater can also have significant negative environmental impacts and do not address the root problem of the need to use our limited water supply wisely.

Environmental Impacts

Reservoirs, created by damming streams and sometimes pumping water from other surface waters, are often the first choice of water authorities seeking to meet demand due to the apparent quick fix provided by the ease of creating a large amount of storage. However, adverse impacts of impoundments and withdrawals (direct or for pumped storage) are well documented in the literature and include effects on the impounded areas, as well as upstream and downstream reaches.¹⁻⁴ The United States Geological Survey (USGS) has determined that hydrologic alteration is the primary cause of ecological impairment in river and stream ecosystems.⁴ The conversion from lotic (moving water) to lentic (non-flowing water) makes impounded areas unsuitable habitat for riverine species. Many species, particularly migratory fish and associated species, cannot bypass the barrier to reach habitat and spawning grounds in upstream reaches.

The physical, chemical, and biological health of the downstream reaches may be greatly impacted due to numerous changes when releases are managed for purposes related to reservoir use. Downstream hydrology can be altered in ways that degrade physical stability and disrupt sediment transport dynamics. Decreased flows may result in habitat-smothering sedimentation; increased velocities may scour and erode stream banks. Altering the hydrologic regime can impact water quality, eliminate natural variability, change water and food transport downstream, increase temperature and nutrients, decrease dissolved oxygen levels, and induce cyclical changes in cues for life cycle events of aquatic species.

Narrower ranges of flows disconnect rivers and streams from floodplains, reducing hydration of riparian areas and limiting access to habitat for some aquatic species. A modified rate of change in stream flows can devastate riparian species such as cottonwoods, whose successful seedling growth depends on the rate of groundwater recession following floodplain inundation.⁵ Withdrawals and impoundments reduce the volume of water downstream, which can impact water quality, may require recalculation of National Pollutant

EPA Statement of Principles on Efficient Water Use

1992, Reaffirmed in 2014 EPA Office of Water memo from Deputy Assistant Administrator Nancy K. Stoner, Statement of Principles on Efficient Water Use and the WaterSense Program^{90,91}

- In order to meet the needs of existing and future populations and ensure that habitats and ecosystems are protected, the nation's water must be sustainable and renewable. Sound water resource management, which emphasizes careful, efficient use of water, is essential to achieve these objectives.
- Efficient water use can have major environmental, public health, and economic benefits by helping to improve water quality, maintain aquatic ecosystems, and protect drinking water resources. As we face increasing risks to ecosystems and their biological integrity, the inextricable link between water quality and water quantity becomes more important. Water efficiency is one way of addressing water quality and quantity goals.
- The efficient use of water can prevent pollution by reducing wastewater flows, recycling process water, reclaiming wastewater, and using less energy. The U.S. Environmental Protection Agency's (EPA) Office of Water strongly encourages all sectors, including municipal, industrial, and agricultural, to achieve efficient water use.
- EPA recognizes that regional, state, and local differences exist regarding water quality, quantity, and usage. Differences in climate, geography, state institutions, and laws favor a prudent approach in which water efficiency programs are tailored for specific locales.
- To promote efficient water use, EPA's primary role is to provide technical assistance and information concentrating on 1) improved management practices, 2) better science, 3) effective planning and coordination, 4) market incentives, and 5) public education.

Background

Discharge Elimination System (NPDES) dischargers' permit limits, and require Total Maximum Daily Loads (TMDLs) to be redone to factor in lower flows.

Not only do reservoirs cause disruption to the water cycle for the watershed and river basin, but they can also increase water loss in the basin due to evaporation. According to some estimates, evaporative loss may even be greater than some sectors' use (Figure 1). The cumulative impacts of evaporative loss from the tens of thousands of smaller reservoirs is also a concern, with one study in the Upper Oconee Basin in Georgia finding in excess of 10 million gallons/day in additional evaporative loss due to small impoundments alone.⁶ The State Climate Office of North Carolina maintains a webpage with current and historical open water evaporation estimates for many locations across the southeastern United States, which may be of interest in considering system losses from reservoirs.⁷ The U.S. Bureau of Reclamation is also engaged in research to improve estimates of reservoir evaporation and is participating in piloting an Open Water Evaporation Network to both improve estimates of evaporation and provide real-time information.^{8,9}

Many aquifers throughout the country are under stress due to increased pumping from existing wells or development of new wells. In regions such as eastern Massachusetts¹⁰, Florida, and central California, greater extraction of groundwater in areas with insufficient recharge has resulted in diminished water quality, dry wells, saltwater intrusion, land subsidence, and reduced streamflow in rivers where there is a connection between groundwater and surface water.¹¹ In 2014, as extreme drought continued to impact the state, the Governor of California signed a Sustainable Groundwater Management Act which includes new requirements to manage groundwater and called for the development of groundwater management agencies and plans in the most critically affected basins (see <http://www.water.ca.gov/cagroundwater/>).¹² In many locations in the state, groundwater levels dropped more than ten feet between 2006 and 2016 (Figure 2).¹³

Only taking what is needed helps minimize aquatic resource impacts of hydrologic alteration from withdrawals, inundation from impoundment to create storage, reduced flows when water is held back for storage, altered flow regimes, decreases in groundwater levels, and disconnection of rivers and streams longitudinally and from their floodplains.

Case Study:

The baseflow of the Ipswich River in northeastern Massachusetts is highly influenced by groundwater. All told, the watershed supports drinking water to more than 330,000 people from water systems that directly withdraw water from the river or withdraw from wells that influence river flow. When groundwater withdrawals are high, particularly periods of high withdrawal or drought, the river can suffer extreme low-flow or no-flow conditions. In 2003, the state issued a watershed action plan with several management actions including a goal to reduce water demand basin-wide by 15% through improvements in water conservation.¹⁴

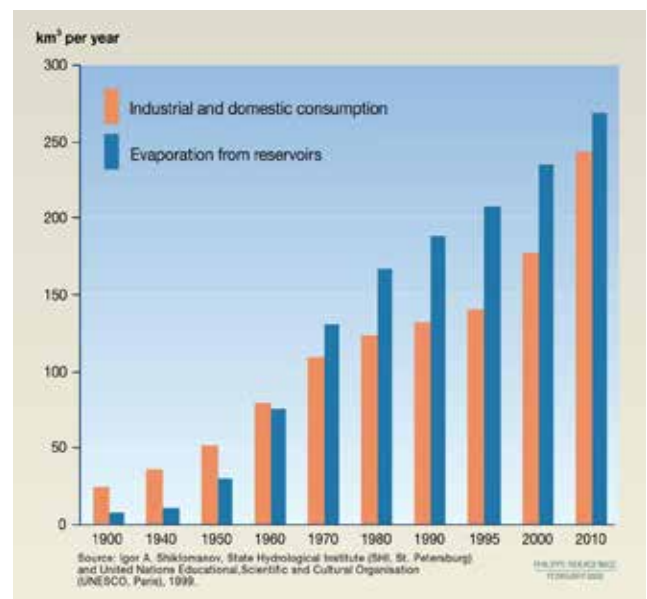


Figure 1: Global evaporation from reservoirs compared to industrial and domestic use. Values for years 2000 and 2010 represent projections. Graphic prepared by Philippe Rekacewicz using data from Igor A. Shiklomanov and UNESCO, 1999. *World Water Resources: Modern Assessment and Outlook for the 21st Century*.

Background

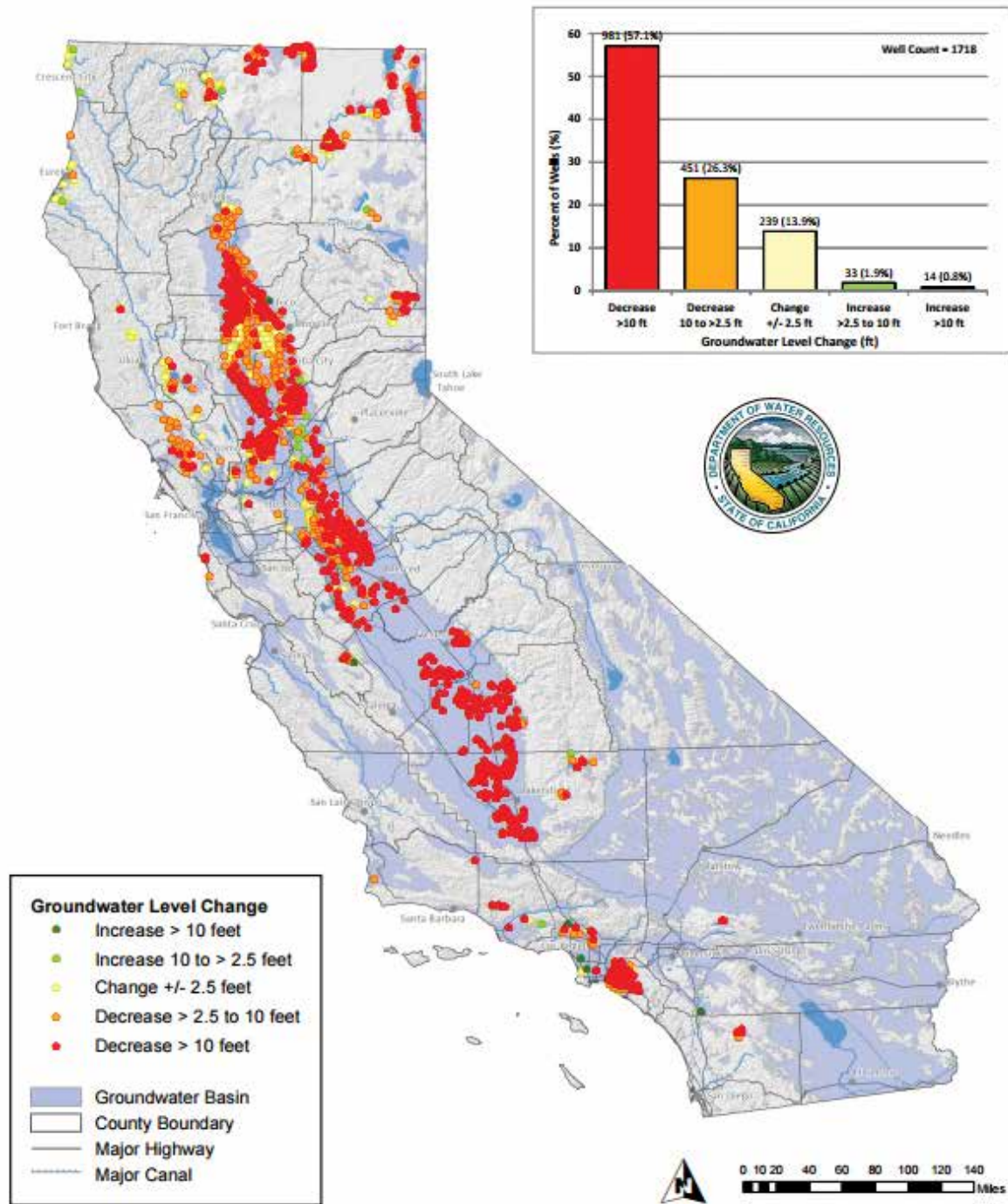


Figure 2. Groundwater level change from Spring 2006 to Spring 2016, based on water level measurements in wells. Based on data from the California Dept. Water Resources Water Data Library as of 4/26/2016. Updated 4/27/2016. Source: http://www.water.ca.gov/groundwater/maps_and_reports/MAPS_CHANGE/DOTMAP_S2016-S2006.pd.

Background

Economic Impacts of Water Supply Development

Development of new supplies, treatment and distribution infrastructure, and associated costs such as land acquisition and debt servicing can be very expensive in comparison to implementing water conservation/efficiency measures. According to a Georgia Environmental Protection Division March 2008 paper, dams, and reservoirs can cost \$4,000 per 1,000 gallons of capacity whereas water efficiency costs between \$0.46 to \$250 per 1,000 gallons saved or new capacity.¹⁵ The 2017 Texas State Water Plan estimated the 2070 weight-averaged unit costs of water supplies made available through construction of major new reservoirs at \$470 per acre-foot, compared to \$373 per acre-foot for municipal conservation strategies.¹⁶ It is important to note that, if developing a new reservoir, accounting for costs associated with environmental impacts of development, including providing compensatory mitigation for impacts to wetlands and streams, should be included when comparing costs and benefits of reservoir construction, operation, and maintenance to costs of efficiency implementation and other alternatives.

Conversely, optimizing system management and demand can be very advantageous for water utilities.¹⁷ Avoided or delayed infrastructure development projects and associated transmission, storage, and treatment requirements can save significant capital and debt service. Reduced demand can lower operating and maintenance costs such as pumping and chemical costs, as well as associated energy costs. When communicated effectively to the public, economic savings and resource stewardship can bolster confidence in system management and end-user buy-in to demand management programs. Effective public engagement in managing demand also involves end users as part of the solution to resource management.

Water-Energy Nexus

Improving water use efficiency can also reap benefits of lower energy demand because of reduced pumping for both supply distribution and wastewater, with associated environmental benefits. The Electric Power Research Institute estimates energy use by public drinking water systems to be roughly 39.2 billion kWh annually, and use by municipal wastewater treatment systems to be 30.2 billion kWh per year, constituting a combined 1.8% of all electricity used in the U.S..¹⁹ For municipal governments, energy usage for water and wastewater utilities can constitute a major portion of total energy expenses. Improving water use efficiency can reduce the need for capital investment on supply and treatment sides (chemical use and infrastructure), as well as related energy generation infrastructure. Inefficient water usage also impacts air resources by increasing the need for energy production. It takes energy to pump water from source to treatment facility; to treat water that is used inefficiently at the tap or for irrigation, or wasted as a result of leaks; as well as to pump wastewater generated from inefficient water use back to a wastewater treatment plant. Energy use can be reduced by such measures as installation of high efficiency shower heads and appliances to lower demand for heated water.

Case Study:

The baseflow of the Ipswich River in northeastern Massachusetts is highly influenced by groundwater. All told, the watershed supports drinking water to more than 330,000 people from water systems that directly withdraw water from the river or withdraw from wells that influence river flow. When groundwater withdrawals are high, particularly periods of high withdrawal or drought, the river can suffer extreme low-flow or no-flow conditions. In 2003, the state issued a watershed action plan with several management actions including a goal to reduce water demand basin-wide by 15% through improvements in water conservation.¹⁴

Case Study:

In 2007, Miami-Dade Water and Sewer Department (WASD) received a 20-year Water Use Permit from the South Florida Water Management District. The permit included conditions to address an anticipated supply-demand gap, and required WASD to develop alternative water supply sources and continue improvements in water use efficiency and water loss reduction. In 2011, WASD applied for a permit modification based on water use reductions as a result of lower than expected population growth, water loss reduction, successful implementation of the Department's Water Conservation Plan, and permanent two-day-a-week landscape irrigation restrictions by county ordinance. The county's finished water demand had decreased approximately 40 million gallons per day (mgd) below what was anticipated with the first 20-year water use permit application. Demand reduction had eliminated the anticipated supply shortage, which was the basis for several costly near-term alternative water supply projects.¹⁸

Background

Increasing energy use at water and wastewater utilities also has become a concern for EPA in efforts to reduce greenhouse gas emissions. One of the largest sources of greenhouse gases is emissions associated with generation of electricity from fossil fuel combustion.²⁰ The EPA report *National Water Program 2012 Strategy: Response to Climate Change* considers water conservation/efficiency to be an important factor in its climate change goals.²¹ Through 2015, EPA estimates that users of WaterSense-labeled products have saved more than 212 billion kilowatt hours, eliminating 78 million metric tons of greenhouse gas emissions.²²

Increased energy use also impacts water quality because power plants rely on our nation's water supply to meet their cooling needs. Forty-five percent of the 355 billion gallons of water used per day by Americans in 2010 was for producing electricity at thermoelectric power plants, by far the largest source of water withdrawal.²³ The U.S. Geological Survey no longer accounts for evaporative losses associated with thermoelectric generation in national estimates of water use, but some estimates range as high as 70% for some types of cooling plants.²⁴ These are important considerations in evaluating the positive impacts of water efficiency measures and the many indirect environmental impacts of water supply projects. These concerns can be partially addressed by implementing water efficiency measures which reduce water supply needs, in turn resulting in reduced energy needs.

Water Use Trends

Water withdrawals for public supply (for domestic, commercial, and industrial purposes) were approximately 42,000 million gallons per day (MGD) in the 2010 assessment of water use in the United States published by the US Geological Survey (USGS).²³ Use decreased in thermoelectric power generation and irrigation, as well as all other uses except mining and aquaculture since the previous (2005) USGS water use assessment.²⁵ Nationally²⁶, per capita water use by single-family residential customers is declining. However, with increasing populations, additional need may demand more from our resources in the future, and local population, land use, and industrial shifts may concentrate demand in ways not reflective of national trends. Efficient use can reduce withdrawal and storage needs, alleviating these pressures on natural systems and reducing financial costs to ratepayers for developing new infrastructure and storage. It is important to acknowledge that use in portions of service areas may shift as economic conditions change, such as addition of water-using appliances and fixtures. It is critical that management of total water demand is addressed in working towards sustainably meeting water resource needs.

Many communities have demonstrated success in reducing use even as populations grow. Conservation and efficiency programs adopted by the Metropolitan North Georgia Water Planning District and the state of Georgia have led to per capita demand declines of more than 30% between 2000 and 2015.²⁷ Total water withdrawals in the 15-county District have decreased by over 10 percent despite a 20 percent increase in total population (Figure 3).²⁸ The City of Santa Fe, New Mexico, reached a point when developers were seeking permits, but the system had no additional water capacity. These developers had to "find" water by retrofitting older homes and buildings, a process now termed *capacity buy back*.¹⁷ Seattle, in particular, has achieved notable improvements in efficiency (Figure 4, Figure 5). Between 1990 and 2010, population in Seattle's regional service area increased by 15 percent while water demand decreased about 30 percent (50 MGD).²⁹

Background

Water Demand Forecasts

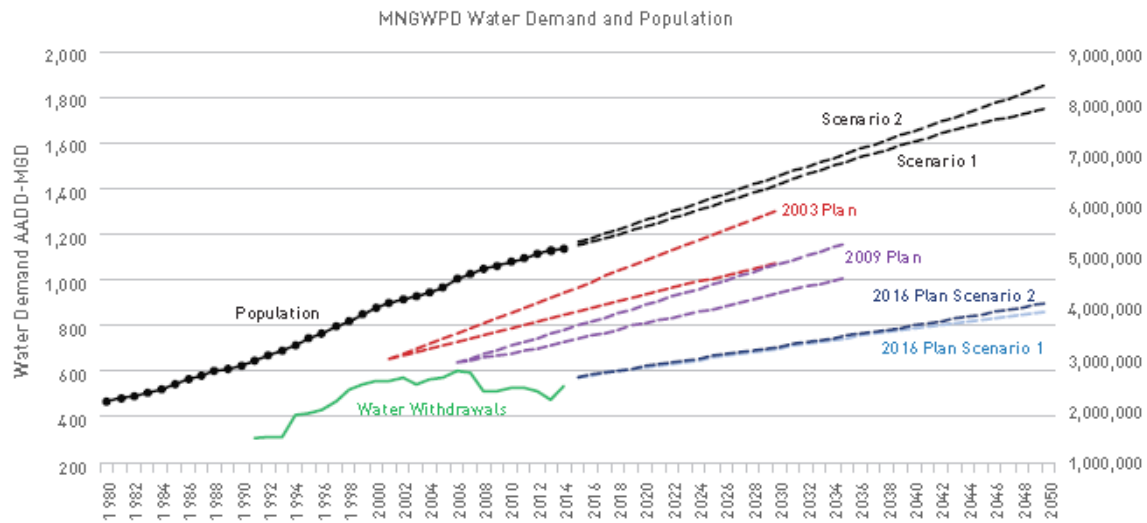


Figure 3. Metropolitan North Georgia Water Planning District Water Demand and Population. Source: MNGWPD 2015²⁷

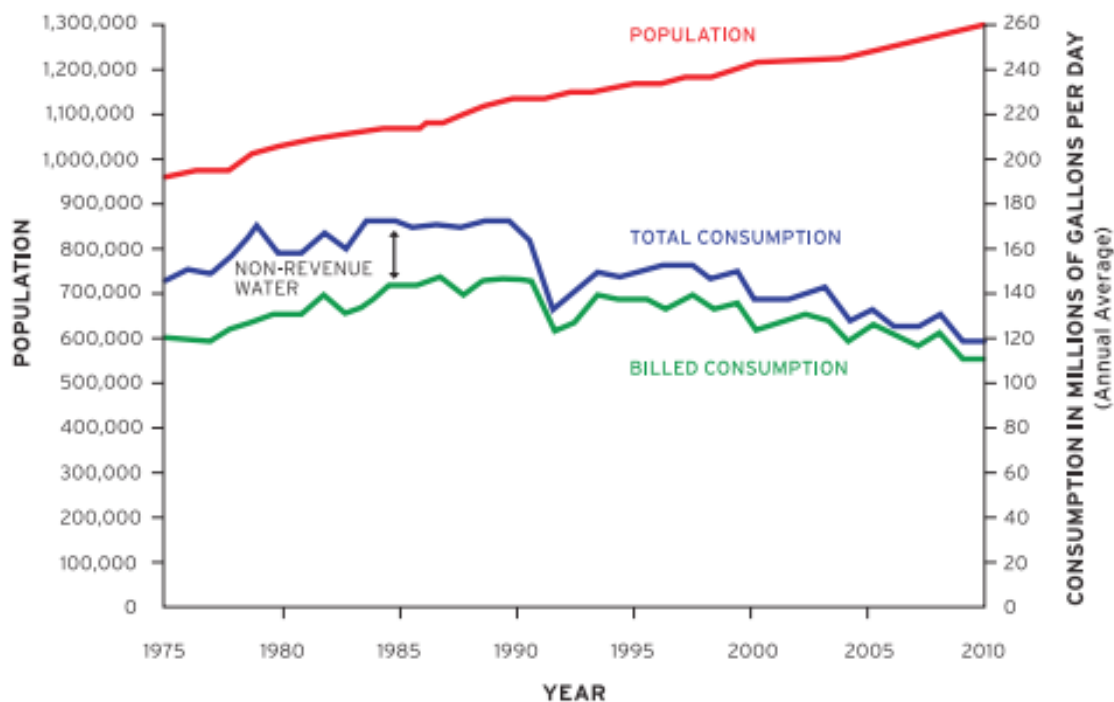


Figure 4. Growth in population and water consumption, Seattle Public Utilities. Source: *Water Supply Forum (2012) 2012 Regional Water Supply Update*.²⁹

Background

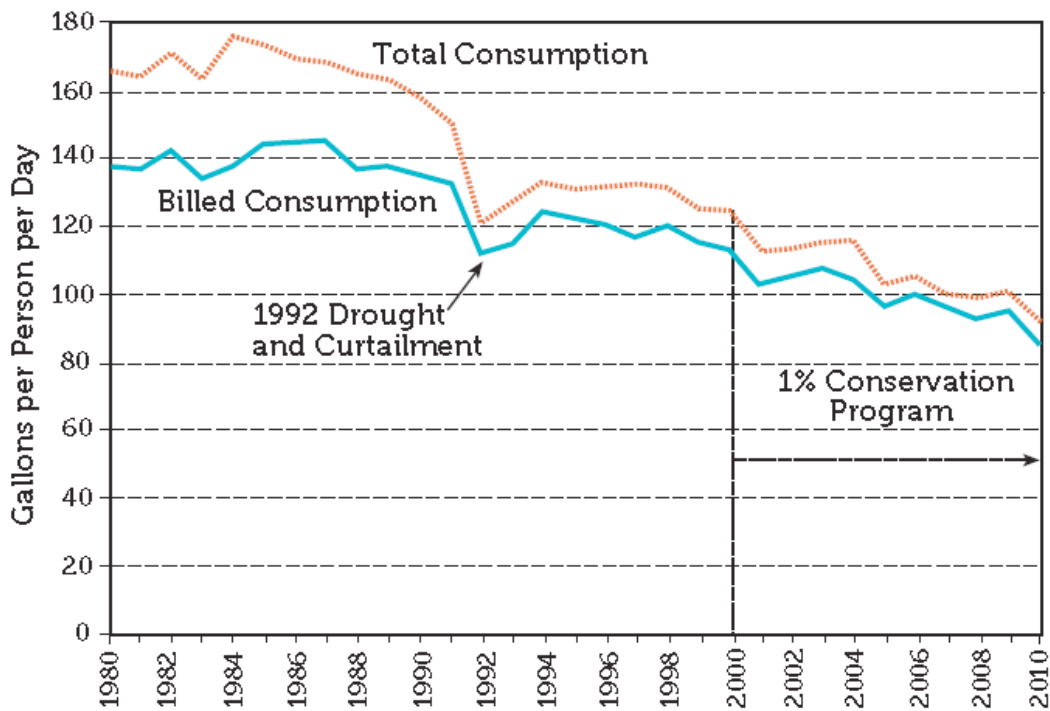


Figure 5. Per capita water consumption 1980-2010, Seattle Public Utilities. Source: Seattle Public Utilities. (2011) *Saving Water Partnership 2010 Annual Report & Ten Year Program Review*.

Water conservation can be described as “any beneficial reduction in water use or in water losses.”³⁰ However, conservation should be differentiated from curtailment, which means mandatory reduction in water use as needed during drought or emergency situations to achieve immediate results.¹⁷ Water efficiency or water use efficiency refers to the accomplishment of a function, task, process, or result with the minimal amount of water feasible. It is also an indicator of the relationships between the amount of water needed for a specific purpose and the amount of water used, occupied, or delivered.³¹ Water efficiency is a tool of water conservation that reduces water demand without changing the quality of the use. The term demand management helps distinguish this from supply-side management.

Purpose of the Water Efficiency Best Practices

This best practices document has been developed to help support assessments of the potential for future water conservation and efficiency savings that could avoid or minimize the need for new water supplies. It builds on a document that EPA Region 4 published in June 2010. That document, *Guidelines on Water Efficiency Measures for Water Supply Projects in the Southeast*³², provided guidance on many of the same aspects of water efficiency as this document. Since that time, auditing tools and guidance published by the American Water Works Association (AWWA) have become widely accepted standards, bringing more quantitative tools into use. With auditing tools and reference values available for what constitute well-managed systems with minimal losses and efficient households, EPA recognizes the value of more performance-based, quantitative evaluations in providing a reasonable basis for reviews of proposed water supply projects. To assist in development of this document, EPA consulted with members of a Technical Advisory Group who provided their independent critical input on current standards and methods of evaluating water conservation and efficiency. Using their

Background

recommendations, EPA developed the document, which was then peer reviewed by an independent panel.

Both EPA's Office of Water and the WaterSense program have an interest in helping communities and water utilities make the best use of their water resources and build resilience to water shortages. A water utility seeking a new water supply, particularly one that could involve environmental impacts, should be able to clearly define the water supply challenge driving consideration of new supply development, and demonstrate justifiable need. In other words, a utility should be able to demonstrate that its existing supplies are not sufficient to address projected demand. For some utilities, accommodating peak summer outdoor water use or small but high-demand segments of the user population may be drivers. For other utilities, water lost through leaking distributions systems might constitute significant quantities and drive interest in developing new supplies.

Auditing and review of water supply systems helps gauge whether demand and distribution are being managed effectively. Optimal system management and incentivizing efficient use helps ensure that unnecessary impacts to aquatic resources and the environment are avoided. The best practices that follow help to ensure systems are operating at optimal efficiency or are on track to do so, and that projected need—the basis for predicting any future supply-demand gaps—is reasonable. Opportunities for system improvements (e.g., management by pressure zone, improved leak detection, and repair or replacement of leaking infrastructure) may be an untapped “source” that can help meet demand and avoid more expensive development of new supply and impacts to aquatic resources.

Local governments and water utilities can use these best practices to carry out a self-assessment in order to evaluate the opportunity to minimize the need for additional capacity before consideration of a water supply project. As AWWA says in its *Water Conservation Program Operations & Maintenance Standard, G480-13*, utilities should treat conservation “as equal to other water supply options, and where appropriate, include water made available through conservation as part of the supply portfolio when conducting supply-and-demand forecasting analyses.”³³

The document sets targets and common points of reference for evaluation of feasible, cost-effective water conservation and efficiency measures that the utility can implement in the future to optimize existing water supplies, as it is the potential for future water savings that can avoid or minimize the need for new water supply. The analysis of efficiency potential should have as its demand reduction goal (performance-based savings target) the same yield (MGD) as the proposed water supply project.

If used by a state or federal agency, the document could help ensure that partners involved in reviewing a proposed reservoir or other water supply project use consistent methods in evaluating the purpose, need, and analysis of alternatives. EPA may also use these review procedures to evaluate water demand projections for non-reservoir projects such as new or significantly increased surface water withdrawals or groundwater supply withdrawal which are being reviewed through CWA Section 404 permitting, EPA grants, the National Environmental Policy Act (NEPA), or other EPA programs. Proposals for water supply expansion projects should clearly address the water supply challenge (i.e., when and where there are water limitations) facing the utility, as the project basis when proposing projects that may be reviewed by EPA.

For water supply projects, alternatives may include supply approaches such as expanding an existing reservoir or intake, purchase from another system, or reuse; or demand management approaches such as instituting more comprehensive efficiency measures. Non-structural approaches to addressing supply needs such as efficiency measure implementation should be considered as part of needs and alternatives analysis to evaluate opportunities to avoid or minimize impacts to aquatic resources. These should be considered modular elements of an integrated planning approach that optimizes re-

Background

source management so as to meet end users' needs as efficiently as possible, with the least environmental impact practicable. If a new reservoir or withdrawal is pursued, it should be sized, configured, and operated in accordance with efficiency-based need so as to minimize impacts.

Utilities and state agencies can also use the practices as a means to demonstrate overall capacity in technical (e.g., sound asset management), financial (e.g., rates/revenues), and managerial (e.g., sound planning) areas. Finally, these best practices can be used by water utilities, municipalities, counties, and other entities involved in water resource planning to communicate to their constituents, boards, and members about the benefits of water conservation and efficiency and to demonstrate sound management of financial assets and resources.

Assistance Opportunities

Water efficiency and reuse programs help systems avoid, downsize, and postpone expensive infrastructure projects such as developing new source water supplies, building new treatment capacity, and expanding pumping and delivery infrastructure. When unneeded investments are avoided, systems have more resources for other critical needs. The Drinking Water State Revolving Fund (DWSRF) and Clean Water State Revolving Fund (CWSRF) programs can be important sources of financial assistance to help states and systems initiate a variety of efficiency measures and programs. The CWSRF and DWSRF programs, which operate in every state and Puerto Rico, work like banks. Federal and state contributions are used to capitalize the programs. These assets, in turn, are used to make low or no-interest loans for important drinking water and water quality projects. Under the loan fund and set-asides, state DWSRF programs can provide financial assistance to initiate a variety of water efficiency measures and programs. With recent changes to CWSRF eligibilities made available through the 2015 Water Resources Development Act, a wide range of water efficiency, water reuse, and alternative water projects can be funded through that program. These types of projects are eligible because they address the ability of wastewater treatment plants to meet the environmental goals of a community with efficiency and at minimum cost. Eligible types of borrowers differ based on the type of project. Water audits and conservation plans that are reasonably expected to result in a capital project are also eligible.

Best Practices

This document describes six best practices that water utilities can undertake to assist them in considering water efficiency as an alternative to development of new supplies. The practices are:

1. Water System Management: Supply Side and Demand Side Accounting
2. Water Loss Minimization: Leak Management
3. Metering
4. Conservation Rate Structure
5. End Use Water Conservation and Efficiency Analysis
6. Water Conservation and Efficiency Plan

For each section, the document describes the purpose of the practice and what information it provides. It provides a description of the approach to address the practice, with examples of how they have been used by water utilities. Each practice suggests one or more *metric* that a utility can use to assess progress. Where appropriate, a *benchmark* is also proposed to provide a target against which to assess progress. Each section also identifies one or more *deliverable* that complements identified metrics. The deliverable could be used by utility management or a state/federal authority as a demonstration of how the utility is addressing the practice. Finally, each section includes a list of resources.

1. Water System Management: Supply Side and Demand Side Accounting

To conduct a robust assessment of the potential for optimizing water resources through improved water efficiency, a water utility must understand how water moves through its system of pipes and pumps from source to end user. For the purposes of these review procedures, it is important to understand how water utilities are implementing and will implement measures to ensure optimization of existing supplies, and to identify opportunities for saving water that can reduce the need for additional supplies before pursuing new reservoirs or other supply development activities that would have adverse environmental impacts.

Some of the key questions a water utility should ask itself include:

- Where is the water going? How much water is lost between withdrawal and delivery? How much revenue is lost? The water supply sector both in the U.S. and internationally has moved to a standard in which all water must be accounted for in the system; “unaccounted for water” as an industry category of water loss no longer exists.^{34,35} It is no longer acceptable for a system to have water moving through its pipes and not know its destination.
- What are the drivers of demand (a particular user category? a small subset of high-use accounts within a category? seasonal uses in some categories)?
- What management approaches are feasible for managing system usage and loss before reaching diminishing returns (e.g., has the system achieved an economic level of loss)?

To effectively manage a water system, it is important to begin by understanding the dynamics of water inputs, outputs, demands, and supply constraints. By limiting unnecessary or wasteful source water withdrawals, water authorities gain financial benefits through improved revenue recovery, less wear and tear on infrastructure, fewer service disruptions, and improved system integrity.³⁷

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System Input Volume (corrected for known errors)	Authorized Consumption	Billed Authorized Consumption	Billed Metered Consumption (including water exported)	Revenue Water
			Billed Unmetered Consumption	
		Unbilled Authorized Consumption	Unbilled Metered Consumption	Non-Revenue Water (NRW)
			Unauthorized Unmetered Consumption	
	Water Losses	Apparent Losses	Unauthorized Consumption	
			Customer Metering Inaccuracies	
			Systematic Data Handling Errors	
		Real Losses	Leakage on Transmission and Distribution Mains	
			Leakage and Overflows at Utility's Storage Tanks	
			Leakage on Service Connections up to point of Customer metering	

Figure 6. Water balance components. Source: American Water Works Association (AWWA). 2006. *Water Conservation Programs — A Planning Manual (Manual of Water Supply Practices M52), 1st edition.* Denver, CO.³⁸

Inputs, or the volume of water pumped into a water utility system (through withdrawal or purchase), should equal the volume of water taken out of (or lost from) the distribution system. This water balance can be broken down into the categories outlined in Figure 6, with volumes for each category determined through a top-down water audit, the recommended starting point for water utilities compiling an initial audit.³⁷ The top-down approach uses information from existing records, data, and information systems to gain broad perspective on how system volumes fit into a water balance. A bottom-up approach, by contrast, is a more detailed look into validating results (e.g., with actual field measurements, analysis of leakage reports, billing system review, and/or meter inspections), and can help the utility achieve more refined understanding of the system and opportunities to improve operations and management. Bottom-up auditing can also ground truth top-down audit results by refining real loss volume estimates.

Utilities may be particularly interested in the values that populate the two categories to the far right: revenue water and non-revenue water (NRW). Revenue water is the volume that is billed and produces revenue.³⁷ Non-revenue water (NRW) is water that is piped, pumped, and treated, but not producing revenue for the utility. Examples include unbilled but authorized consumption (e.g., parks department irrigation); customer metering inaccuracies, data handling errors, or theft (called apparent losses because the water is used but not on the books); and system leakage (real losses). Unbilled use and losses cost the utility through treatment, energy for pumping, wear and tear on the system, and wasting sources of water supply. If losses of NRW are high, why should a utility invest in a new, costly water supply reservoir and incur the environmental impacts involved? Analysis of its water balance (Figure 6), will enable a utility to account for all water supplied to its distribution system, and to begin evaluating alternatives for reducing NRW to an economic level so as to preserve water resources.

Apparent losses are “nonphysical losses that occur when water is successfully delivered to a water user but, for various reasons, is not measured or recorded accurately.”³⁷ Apparent losses are “paper” losses: water that is used and should be paid for, but is not due to issues such as metering inaccuracies, unauthorized use, and data handling errors. Reducing apparent losses can increase revenues for a utility, and may provide incentive for end users to reduce or eliminate wasteful practices.

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Real losses are water that is piped into the system, but is lost before making it to the end user. These are physical losses such as breaks and leaks from water mains and customer service connection pipes, joints, and fittings; from leaking reservoir walls; and from reservoir or tank overflows. To understand where both real and apparent losses are occurring, the utility must understand how water flows through the system, beginning with system inputs.

Case Study:

Asheville Water Resources Department initiated a multi-faceted water conservation program in 2012. Water auditing using AWWA methods identified non-revenue water comprised primarily of real losses, and the department committed resources to leak detection, meter testing, zone metering, pressure reduction, and evaluating unbilled uses. These measures have already resulted in significant water savings, including reductions of real losses from 6 mgd in late 2012 to less than 5 mgd by the beginning of 2016 (Figure 7).

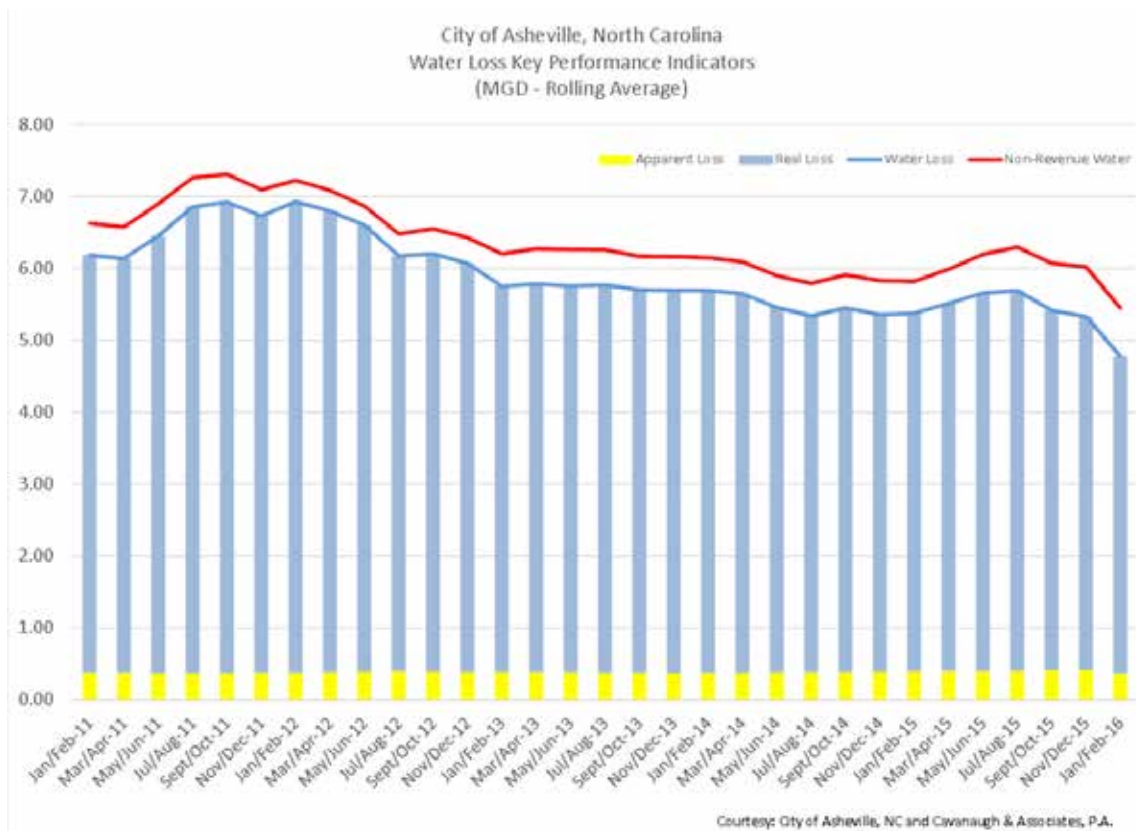


Figure 7. City of Asheville, NC water loss key performance indicators. Source: City of Asheville, NC and Cavanaugh & Associates, P.A. 2016.

Conducting the Audit

To create a baseline for supply-side accounting (including system water loss), a utility should conduct standardized top-down audits (12 months of data) annually. The AWWA and the International Water Association (IWA) have created a standardized water audit methodology, now available as a tool that will assist utilities in completing the water balance: the [AWWA Free Water Audit Software](#)³⁹. This methodology standardizes the process for determining the fate of water brought into the system and should replace historical methods that included calculations of “unaccounted-for water.” It has been successfully incorporated into regulations in several states including Georgia, California, Tennessee, and Texas. The software allows the user to enter either known (measured) or approximated values related to the water balance. It also involves inputs such as length of mains, service connections,

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operating pressure, and cost data. Results produced include several performance indicators (described below) that can be used for planning purposes by the utility. For guidance on using the free software and comprehensive auditing procedures, AWWA has published *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*.³⁷

Prior to seeking a new source of water supply, a water utility should have five years' worth of auditing data. Five years of data is needed to establish trends in performance indicators, and the utility should continue completing water audits annually with a goal of achieving a high level of data validity and improving audit results over time. The outputs of the audits (e.g., Data Validity Score, Non-Revenue Water, Infrastructure Leakage Index – described below) should then be used to develop and submit a water loss control or leak management plan to control water loss to an economically feasible level (explained in the section *Water Loss Minimization: Leak Management*). Due to the uniqueness and complexity of each utility's water system, it is important to analyze the various benchmarks and thresholds together. No single benchmark or metric tells the whole story, and with tools to achieve more informed system accounting on hand, we are much better able to responsibly manage public water resources. As the Alliance for Water Efficiency highlights in their 2014 guidance on rate-setting:

In the past, demand forecasts have tended to overestimate demand as they have relied on historical consumption patterns and simple assumptions. Methods have improved over time to capture the trend of declining water demand and incorporate variables that impact demand, such as weather and climate change, new legislation, penetration of more efficient technology, efficiency programs, and demographic changes.⁴⁰

Metric: Data Validity

If evaluating a potential water supply project, utilities should have five years of data from the AWWA Free Water Audit Software[®]. The Data Validity Score is the component of the water audit output that describes the accuracy of the water utility data. The score accounts for how much of the data used relies upon estimates and/or default values rather than values specific to the utility. The reliability of the audit is only as good as the data entered into the software. Data will never be perfect, but should improve and should meet or surpass the following threshold if the utility is seeking to develop new water supplies.

It is also recommended that water audits be reviewed by someone trained in assessing reliability of data validity scores. As stated in the Georgia Water System Audits and Water Loss Control Manual (version 2.0, March 2016):

The process of validation confirms the integrity of the component water consumption and loss values in the water audit. The validation of all performance indicators and values used in the determination of these indicators is of utmost importance. Data of low validity will lead to inaccurate performance indicator values and poor guidance for the water utility. No matter how sound the auditing process, poor data gives an inaccurate picture of the water system and its performance.

A Water Research Foundation (WRF) project designed to assess adoption of AWWA water audit methodology found that in 21.1% of audits, self-reported data included implausible results.⁴¹ The authors then used filters to screen out those implausible results (Figure 8) and found that the excluded audits had self-reported Data Validity Scores four points higher than those that passed the filtering criteria (77.1 vs 73.1). In other words, utilities with implausible audit results also tended to assess their data validity higher than utilities with realistic audit data. The authors noted that the Georgia and Tennessee datasets had the fewest audits excluded for implausible data, and that those regions also have more

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training for audit reviews. The Georgia audits had been through Level 1 (“desktop review”) validation by third-party reviewers. These results speak to the need for independent review of audit results so as to confirm the reliability of the results.

The same WRF project also published median performance indicator values (Figure 9) for audits from five regions using AWWA audit methodology (using most recent audit year data, and only audits that passed filtering tests as above). For systems wishing to gauge performance against a larger dataset, these median values may provide useful perspective.

	METRIC	CRITERIA FOR EXCLUSION
volumetric	Infrastructure Leakage Index	< 1.0 > 20.0
	Real Losses	< 0 (negative) – if ILI does not apply
	cost of Non-Revenue Water	> 100% of system operating costs
	incomplete audit	key fields not filled out
financial	Customer Retail Unit Cost	more than 2 orders of magnitude off of the regional median
	Variable Production Cost	more than 2 orders of magnitude off of the regional median

Figure 8. Criteria used to exclude audits for implausible results. Source: Sturm R, Gasner K, Andrews L. *Water Audits in the United States: A Review of Water Losses and Data Validity*. Denver, CO; 2015.

	PERFORMANCE INDICATOR	MEDIAN	AVERAGE	UNIT	n	FILTERS
financial	customer retail unit cost	\$4.67	\$8.33	\$ / 1,000 gallons	1,545	passes customer retail unit cost check
	variable production cost	\$950.00	\$2,085.28	\$ / million gallons	1,489	passes variable production cost check
	NWR as % of operating cost	7.8%	10.2%	% of operating cost	630	passes both cost checks passes volumetric validity checks does not come from Texas (operating cost not reported)
operational	Apparent Losses	5.73	14.88	gallons / serv conn / day	1,290	passes volumetric validity checks
	Real Losses (serv conn)	39.88	51.81	gallons / serv conn / day	812	passes volumetric validity check service connection density ≥ 32 conn / mile of main
	Retail Losses (mains)	785.54	1,132.42	gallons / mile of main / day	478	passes volumetric validity checks service connection density < 32 conn / mile of main
	Real Losses (pressure)	0.59	0.79	gallons / serv conn / day / PSI	812	passes volumetric validity checks service connection density ≥ 32 conn / mile of main
	ILI	2.48	3.12	(dimensionless)	644	passes basic volumetric validity checks UARL calculation applies – $(32 \times Lm) + Nc \geq 3,000$
	data validity score	73.1	71.7	points out of 100	679	passes basic volumetric validity checks does not come from Texas

Figure 9. Median performance indicator values for audits passing screening criteria. Source: Sturm R, Gasner K, Andrews L. *Water Audits in the United States: A Review of Water Losses and Data Validity*. Denver, CO; 2015

Benchmark: Data Validity Score

As explained in the water audit software (under the tab *Loss Control Planning*), Data Validity Scores can be divided into five levels.³⁹ A low Data Validity Score (50 or lower) means the data is less reliable and data input improvements should be the primary focus for the utility. As data collection and reliability improve, the score will improve. Figure 10 suggests areas for improvement based on a utility’s data validity score.

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Water Loss Control Planning Guide					
Functional Focus Area	Water Audit Data Validity Level / Score				
	Level I (0-25)	Level II (26-50)	Level III (51-70)	Level IV (71-90)	Level V (91-100)
Audit Data Collection	Launch auditing and loss control team; address production metering deficiencies	Analyze business process for customer metering and billing functions and water supply operations. Identify data gaps.	Establish/revise policies and procedures for data collection	Refine data collection practices and establish as routine business process	Annual water audit is a reliable gauge of year-to-year water efficiency standing
Short-term loss control	Research information on leak detection programs. Begin flowcharting analysis of customer billing system	Conduct loss assessment investigations on a sample portion of the system: customer meter testing, leak survey, unauthorized consumption, etc.	Establish ongoing mechanisms for customer meter accuracy testing, active leakage control and infrastructure monitoring	Refine, enhance or expand ongoing programs based upon economic justification	Stay abreast of improvements in metering, meter reading, billing, leakage management and infrastructure rehabilitation
Long-term loss control		Begin to assess long-term needs requiring large expenditure: customer meter replacement, water main replacement program, new customer billing system or Automatic Meter Reading (AMR) system.	Begin to assemble economic business case for long-term needs based upon improved data becoming available through the water audit process.	Conduct detailed planning, budgeting and launch of comprehensive improvements for metering, billing or infrastructure management	Continue incremental improvements in short-term and long-term loss control interventions
Target-setting			Establish long-term apparent and real loss reduction goals (+10 year horizon)	Establish mid-range (5 year horizon) apparent and real loss reduction goals	Evaluate and refine loss control goals on a yearly basis
Benchmarking			Preliminary Comparisons - can begin to rely upon the Infrastructure Leakage Index (ILI) for performance comparisons for real losses (see below table)	Performance Benchmarking - ILI is meaningful in comparing real loss standing	Identify Best Practices/ Best in class - the ILI is very reliable as a real loss performance indicator for best in class service

For validity scores of 50 or below, the shaded blocks should not be focus areas until better data validity is achieved.

Figure 10. Water Audit Data Validity Level/Score from the AWWA Free Water Audit Software[®]

A Data Validity Score of 51 is the minimum level of data validity that a utility can achieve in order to be considered able to begin long-term water loss control goal-setting. Because target-setting and benchmarking for a dynamic water loss control program are still preliminary at this level, utilities with an AWWA audit Data Validity Score of 70 or less should focus on data improvement before expending capital resources on significant infrastructure projects such as expansion of supply, line replacement, real loss detection and repair, or large scale meter change-out.

A Data Validity Score of at least 71 falls within the range for Level IV. A utility scoring within Level IV should be able to conduct long-term water loss control planning and benchmarking using the software performance indicators, and those indicators can be used to gauge system performance as part of a review of need and alternatives for proposed planning for the system.

The states of Tennessee and Texas, and the California Urban Water Conservation Council⁴² use Data Validity Score thresholds of at least 65 for regulatory and/or utility management purposes. For instance, the threshold Data Validity Score required by the Tennessee Comptroller of the Treasury Utility Management Review Board increased on January 1, 2015 from greater than 65 to greater than 70 for a utility to avoid being referred for further review. That threshold will increase to a score of greater than 75 on January 1, 2017, and again to greater than 80 on January 1, 2019.⁴³ In Texas, utilities with Data Validity Scores below 70 must implement a plan to identify where data collection can be improved.⁴⁴

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Deliverable: Data Validity Score (if <71)

If data validity is less than the threshold score (71), the utility should submit a strategy outlining any improvements planned or underway with a timeline to achieve or surpass the Data Validity Score threshold. Utilities should show a defensible, progressive effort to improve their water audit Data Validity Score over time.

Deliverable: Data Validity Score (if 71 or greater)

If data validity is at or greater than the threshold score (71), the utility should present other aspects of system evaluation, submitting other deliverables described in these guidelines.

Metric: Non-Revenue Water (NRW)

Reduction in NRW over time is a good indicator of effective water system management. The indicator is comprised of unbilled authorized consumption, apparent losses, and real losses. Because it represents water pumped, treated, and distributed but not billed, the financial value is also readily calculated and may represent a significant opportunity to the utility and ratepayers.

Benchmark: Non-Revenue Water

A utility should be able to show an improving trend in NRW over a five-year period, demonstrating a reduction in NRW as an annual volume in millions of gallons.

Deliverable: Non-Revenue Water

The utility should report non-revenue water as an annual volume in millions of gallons for at least the five previous years. This is an output of the AWWA water audit process. Plans to reduce NRW should be captured in a water conservation and efficiency plan (see Section 6), with annual targets in line with water loss control strategies.

Resources

American Water Works Association (AWWA). 2016. *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*, 4th edition. Denver, CO.

American Water Works Association. (2014). AWWA Free Water Audit Software®. Available from <http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx>

Georgia Department of Natural Resources. *Georgia Water System Audits and Water Loss Control Manual, Version 2.0*. Atlanta, Georgia; 2016.

US Environmental Protection Agency. 2013. *Water Audits and Water Loss Control for Public Water Systems*. (EPA 816-F-13-002). Washington, DC.

2. Water Loss Minimization: Leak Management

This section addresses leaks from a utility's treatment and distribution system and infrastructure. Leaks on the end user side of the system are treated separately below, in 5. *End Use Water Conservation and Efficiency Analysis*.

Leakage represents the largest real losses for most systems; thus, this section focuses on assessing and addressing loss minimization through leakage control. Tank overflows are also a form of real loss, but are much more visible and readily managed. Leakage may result from a range of conditions, including material weaknesses and physical stresses, operational problems such as excessive pressure or rapid changes in pressure, corrosion, seasonal stresses, leaks at connections and fittings, and accidental or deliberate damage. With most of the country's underground water infrastructure constructed 50 or more years ago, the effects of aging infrastructure are seen annually in approximately 240,000 main breaks, leakage of 1.7 trillion gallons of treated drinking water, at the related loss of approximately \$2.6 billion.⁴⁵ Leakage should be managed proactively and cost-effectively to keep it at economically low levels, and for effective stewardship of a shared and increasingly scarce resource. EPA's 2010 document *Control and Mitigation of Drinking Water Losses in Distribution Systems* includes details on techniques for leak detection and strategies for intervention when issues are identified.³⁵

Fundamental to assessing loss and calculating performance indicators are the metrics CARL and UARL, as described by AWWA:

Current Annual Real Loss (CARL) is the volume of water lost from reported leaks, unreported leaks, background losses, and storage tank overflows.

Unavoidable Annual Real Loss (UARL) represents the theoretical technical low limit of leakage that would exist in a system if all water loss control efforts were exerted. Note that UARL has not yet been sufficiently proven valid as a performance indicator for small systems. For small systems such as these, AWWA recommends using the Op24 performance indicator in assessing real loss.³⁷

Infrastructure Leakage Index (ILI) or **Op 24** (real loss per service connection per day or real loss per mile of main, depending on connection density) are the metrics to use to gauge real loss; abatement of real losses can be evaluated through analysis of five-year trends in these performance indicators. ILI, determined by dividing CARL by UARL, indicates a utility's operational management of real losses in that it is a ratio of the actual real losses experienced by the utility to the lowest technically feasible level of loss for that system. ILI will fall in the ranges shown in Figure 11 with values closer to 1.0 indicating that the utility has brought real losses close to the theoretical technical low limit of leakage.

Op24 can be used as a performance indicator for small systems (those with average operating pressure less than 35 psi, or $(Lm * 32 + Nc) < 3,000$ where Lm = length of mains (in miles, including hydrant lead length) and Nc = number of customer service connections).³⁷ for which the audit output does not calculate the ILI. Op24 does not have a normalized target range. ILI and Op24 can fluctuate annually, and should be reviewed in concert with the utility's Data Validity Score.

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Guidelines for Use of the Level Infrastructure Leakage Index as a Preliminary Leakage Target-setting Tool (in lieu of having a determination of the system-specific economic level of leakage)			
Target ILI Range	Water Resources Considerations	Operational Considerations	Financial Considerations
1.0–3.0	Available resources are greatly limited and are very difficult and/or environmentally unsound to develop.	Operating with system leakage above this level would require expansion of existing infrastructure and/or additional water resources to meet the demand.	Water resources are costly to develop or purchase. Ability to increase revenues via water rates is greatly limited due to regulation or low ratepayer affordability.
3.0–5.0	Water resources are believed to be sufficient to meet long-term needs, but demand management interventions (leakage management, water conservation) are included in the long-term planning.	Existing water supply infrastructure capability is sufficient to meet long-term demand as long as reasonable leakage management controls are in place.	Water resources can be developed or purchased at reasonable expense. Periodic water rate increases can be feasibly effected and are tolerated by the customer population.
5.0–8.0	Water resources are plentiful, reliable, and easily extracted.	Superior reliability, capacity, and integrity of the water supply infrastructure make it relatively immune to supply shortages.	Cost to purchase or obtain/treat water is low, as are rates charged to customers.
Greater than 8.0	While operational and financial considerations may allow a long-term ILI greater than 8.0, such a level of leakage is not an effective utilization of water as a resource. Setting a target level greater than 8.0—other than as an incremental goal to a smaller long-term target—is discouraged.		
Less than 1.0	In theory, an ILI value less than 1.0 is not possible for most systems*. If the calculated ILI is just under 1.0, excellent leakage control is indicated. If the water utility is consistently applying comprehensive leakage management controls, this ILI value validates the program's effectiveness. However, if strict leakage management controls are not in place, the low ILI value might be attributed to error in a portion of the water audit data, which is causing the real losses to be understated. If the calculated ILI value is less than 1.0 and only cursory leakage management controls are used, the low ILI value should be considered preliminary until it is validated by field measurements utilizing the bottom-up approach.		

*An ILI value less than 1.0 can be achieved in small, stand-alone systems of less than 3,000 service connections, and in flexible pipe (such as plastic) systems with high N1 values at pressures less than 40 psi.

Figure 11. AWWA Water Loss Control Committee—preliminary leakage management target-setting guidelines. Source: American Water Works Association (AWWA). *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*, 4th Edition. Denver, CO; 2016.

Like any of the water auditing benchmarks, ILI and Op24 are utility-specific performance indicators, with an important factor being the ability to **show an improving trend over a five-year period**, or to provide appropriate justification about why that trend cannot be shown. However, it may not be realistically feasible for a utility to try to achieve an ILI very close to 1.0, nor cost-effective, particularly if resources would be better directed to more cost-effective conservation and efficiency measures. To help determine a meaningful level of effort in addressing leakage, a utility should seek to identify an achievable level of loss control balanced against the cost of supplying water to end users.

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Economic Level of Leakage

An **Economic Level of Leakage (ELL)** analysis should be used in developing a leakage management program (or water loss control plan) by helping identify what loss control measures can realize a benefit relative to their costs. An ELL analysis identifies the amount of leakage that can be avoided through control measures whose costs are balanced against the savings of reduced leakage (see Figure 12).^{35,37} To determine an ELL, a utility should start with a review of the water audit results and its performance indicators (such as Op 24 and Infrastructure Leakage Index, explained above and in the AWWA M36 Manual (see “County Water Company” example in Chapter 7)).³⁷ Water utilities calculate their costs associated with water loss using only direct, short-term costs, such as chemicals for treatment and power for distribution. For a water system seeking

expansion of water supply, the calculation of the Economic Level of Leakage (ELL) should be compared to costs that would be associated with expansion of water supply infrastructure (reservoirs, treatment plants, pumping equipment, compensatory mitigation, etc.).³⁷ Determining an ELL is beneficial as an iterative process, performed periodically to reflect current conditions.

Utilities should conduct a component analysis of real loss to identify the various forms of leakage (reported, unreported, background, hidden), and conduct an evaluation to determine the cost effectiveness of options to improve control of those losses. The free Real Loss Component Analysis Model is an Excel®-based spreadsheet tool that supports this type of analysis. The Water Research Foundation project 4372a report, *Real Loss Component Analysis: A Tool for Economic Water Loss Control* provides detailed information on use of the Model, and provides two case studies.⁴⁶ The companion *Water Distribution System Failure Data Collection: Instructions and Data Field Names and Definitions* supports collection of data used for real loss component analysis.⁴⁷

To maintain leakage at economically low levels (the amount of leakage that can be feasibly reduced from an economic perspective), a utility should implement a **leakage management plan and/or water loss control program** addressing each of the four pillars described by AWWA: active leakage control, optimized leak repair activities, pressure management, and system rehabilitation and renewal (Figure 12). A sample leakage management plan can be found in the AWWA M36 Manual (pp. 236-239 and Appendix B).³⁷ Ultimately, the program should incorporate the best approach for the given utility, and support reporting on loss control metrics. Water savings through leak abatement should be incorporated into projections for future water supply needs for the utility.

Pressure management is an important part of controlling leakage, and influences how metrics such as ILL are calculated. Care should be taken when comparing metrics across years if average pressure (for a system or zone) changes across time, as this may skew the appearance and comparability of calculated metrics. Particularly for systems with varied topography, pressures needed for one area may be excessive in others. Controls that allow for management of pressure by distinct zones can help abate wear on infrastructure and reduce leakage.

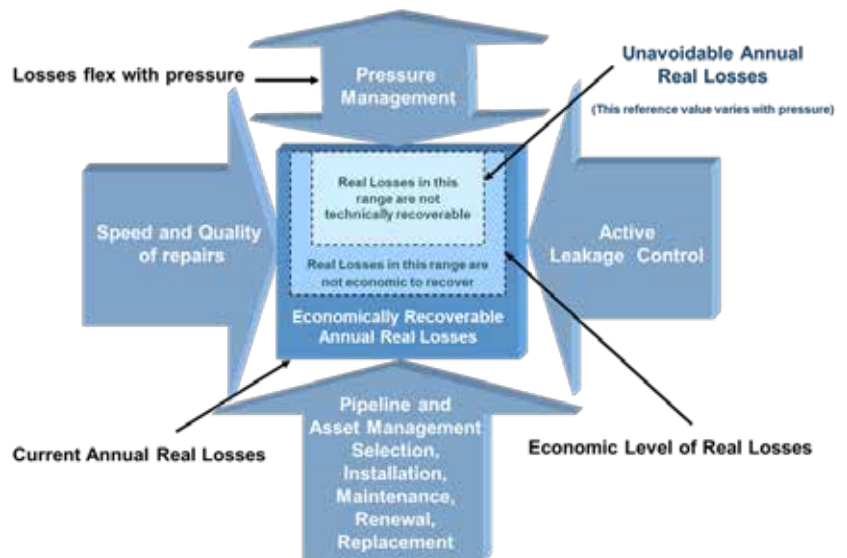


Figure 12. Four-pillar approach to the control of real (leakage) losses. Source: American Water Works Association (AWWA). *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*, 4th Edition. Denver, CO; 2016.

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Various methods can be used to optimize capital investment in proactive leakage management (as opposed to reactive leak detection and repair). Defining District Metered Areas (DMAs) is one approach that sets up the analysis of flows during minimum hour periods (night flow analysis) to distinguish legitimate customer consumption from leakage occurring in the DMA.³⁵ Once DMAs are established with discrete metered zones, they can also serve as early-warning systems for new leakage. AWWA's M36 provides detailed consideration of using DMAs for isolation and measurement of flows in leak detection.³⁷

Metric: ILI or Op24

If a water utility has not achieved a water audit Data Validity Score of 71 or greater, then the utility should work on improving its Data Validity Score in order to have greater confidence in the data on which to base water resource planning, non-revenue water management interventions, and financial decisions. If a water utility has achieved a Data Validity Score of 71 or greater, then:

Benchmark: ILI or Op24

Infrastructure Leakage Index (ILI) of 1.0 to 3.0 or declining trend in Op24 may indicate effective leakage controls, but a utility's score will depend upon system characteristics such as average pressure. For a smaller system, Op24 should show a declining trend over a five-year period. Indicators of system leakage should be considered in concert with economic level of leakage control analysis.

Deliverable: ILI or Op24

A utility whose water audit Data Validity Score is equal to or exceeds 71, and whose ILI exceeds 3.0, should focus on its loss reduction strategy, or provide an economic level of leakage analysis demonstrating that an ILI greater than 3.0 is justified for the utility. If the utility is small and the water audit output does not calculate the ILI, then **Op 24** should be used. The utility should show a declining trend in Op24 over a five-year period. The utility should document regular maintenance activities and planned interventions in the form of a leakage management plan or water loss control program.

Metric: Economic Level of Leakage

If a water utility has not achieved a water audit Data Validity Score of 71 or greater, then the utility should work on improving its Data Validity Score in order to have greater confidence in the data on which to base water resource planning, non-revenue water management interventions, and financial decisions. If a water utility has achieved a Data Validity Score of 71 or greater, then:

Case Studies:

The Macon Water Authority (MWA) used existing water system data (after completing an AWWA water loss audit) to launch pilot DMAs to address leak management in a fast, cost-effective way.⁴⁸ Results of the pilot estimated recoverable real loss for two zones at 621 million gallons per year, with an annual cost impact of approximately \$645,000. One of the most notable aspects of this pilot, however, was that MWA was able to initiate a new, proactive leakage management tool (i.e., DMAs) without any capital investment; all of the data was already available through their water audit process, and the system had pressure zoning capabilities incorporated. One particular note about the effectiveness of DMAs is that a DMA "may reveal that a given zone has high levels of leakage, but low levels of recoverable leakage, which is helpful in the planning of leak detection activities."⁴⁸

The Water & Wastewater Authority of Wilson County, Tennessee purchases 100% of its potable water supply from outside sources.³⁵ The Authority uses the AWWA Free Water Audit Software[®] annually, and has been focused in recent years on controlling leaks to an economically low level. Using DMAs, the Authority monitors minimum night flows on its four largest DMAs, and then has used the field data to seek out the locations of suspected leaks. In one such effort, a leak flowing into an underground sink hole was identified and repaired, bringing real loss in that DMA down from 1.6 gpm/mile to 0.3 gpm/mile. This represents avoided losses of 34 million gallons per year. Audit results have shown decreases in the ILI (from 1.24 in FY08/09 to 1.11 in FY09/10) and in the real losses (from 645.59 gallons/mile/day in FY 08/09 to 575.49 gallons/mile/day in FY09/10). Although it faces many of the challenges faced by small, rural systems (e.g., limited personnel and financial resources, piping in unpaved areas, long distances between sounding locations, low connection density), the success of this program demonstrates that approaches tailored to the individual utility can realize significant water loss control benefits.³⁷

In 2007, the South Florida Water Management District granted Miami-Dade Water and Sewer Department (WASD) a 20-year Water Use Permit with conditions requiring implementation of a water loss reduction plan. WASD has deployed loggers, improved acoustic detection implementation, and in 2014 alone proactively found and repaired 1,240 water leaks. WASD's program is expected to realize water savings of 14.25 mgd by 2017.¹⁸

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Deliverable: Economic Level of Leakage Analysis

The utility should provide Economic Level of Leakage (ELL) analyses conducted regularly (e.g., annually) for the most recent five years so as to document movement relative to achieving an economic level of leakage. In the calculation of ELL for a water system seeking expansion of water supply, the costs of real losses should be compared to costs for expansion of water supply infrastructure (reservoirs, treatment plants, pumping equipment, compensatory mitigation, etc.), to help gauge whether controlling losses is a more cost-effective means of securing water supply. Summary outputs of a component analysis of real loss should be provided, along with conclusions identifying cost-effective real loss control measures.

Metric: Water Loss Control Program/Plan

For a sample leak management plan, see AWWA's M36, pages 236-239 and Appendix B.³⁷

Deliverable: Water Loss Control Program/Plan

The utility should establish and actively administer a water loss control program that addresses improvements in data validity, active real loss detection and reduction, and revenue recovery through apparent loss control. The plans should address how much of the system is surveyed for leaks, how often, and with what methods. Through the implementation of its water loss control program, the utility should be able to document how much water can be saved through leakage management, adjusting its water demand projections accordingly.

Resources

American Water Works Association (AWWA). 2016. *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*, 4th edition. Denver, CO.

American Water Works Association Research Foundation & US Environmental Protection Agency. 2007. *Leakage Management Technologies*.

Georgia Department of Natural Resources. 2016. *Georgia Water System Audits and Water Loss Control Manual, Version 2.0*. Atlanta, Georgia.

Sturm R, Gasner K, Wilson T, Preston S, Dickinson MA. 2013. *Real Loss Component Analysis: A Tool for Economic Water Loss Control*. Denver, CO.

Water Research Foundation. 2013. WaterRF 4372: *Real Loss Component Analysis: A Tool for Economic Water Loss Control* - software. Available from <http://www.waterrf.org/Pages/Projects.aspx?PID=4372>.

Water Research Foundation. 2013. *Water Distribution System Failure Data Collection: Instructions and Data Field Names and Definitions*.

US Environmental Protection Agency. 2010. *Control and Mitigation of Drinking Water Losses in Distribution Systems*. EPA document # EPA 816-R-10-019. Washington, DC.

3. Metering

Meters measure the volume of water passing through pipes along the way from withdrawal to distribution and delivery. Increasingly, meters can also provide real-time accounting of the timing and patterns of use. Such detailed information can help identify unseen sources of leakage and prioritize abatement measures. Utilities providing customers treated wastewater (reclaimed water) for irrigation or other uses, either at no cost or as billed water, should meter this water, as well. A water utility should assess the potential (future) water use reductions/water savings from the following metering-related policies and programs, and adjust future water demand projections to account for the lower water use expected of billed metered customers.

Universal metering, including sub-metering

Metering all water use in the system, also known as universal metering, provides critical data for water system management and planning purposes. Universal metering of both public and private accounts is a water industry best practice.³³ In addition, these data provide important information about water end use that supports more targeted water conservation and efficiency programs and policies. The benefits of universal metering are many, and include a better understanding of system operations, the ability to identify system losses more accurately, the ability to target conservation and efficiency incentives to customers, and awareness on the part of the customer regarding their level of consumption, providing a first step toward eliminating wasteful uses of water.

Some utilities bill multifamily, industrial, and commercial buildings a fixed water rate, which does not encourage conservation because it lacks any linkage to degree of use. Multifamily residential buildings may also bill individual units a flat rate even if the main account is billed based on volumetric use, eliminating an incentive for efficiency on the part of the end users. The water utility should work to ensure water meters are installed on all houses, and on individual commercial, industrial, and institutional facilities so water users can measure, monitor, and directly pay for their use. This should be required for all new construction, and via retrofit wherever possible, with triggers such as establishment of new accounts or property sales. Without metering, customers lack incentive and information for managing their water use.

Authorities should also encourage sub-metering on each unit of multi-family residential buildings. EPA recognizes that stakeholders have in the past had concerns about whether apartment complexes or similar residential communities receiving water from a public water system (PWS) through a master meter and reselling it to residents qualify as PWSs. A December 16, 2003, EPA memorandum entitled “Applicability of the Safe Drinking Water Act to Submetered Properties” describes the agency’s position on the value of submetering:

The purpose of this memorandum is to announce EPA’s revised policy concerning the applicability of the Safe Drinking Water Act (SDWA) to submetered properties. Submetering, as applied in this policy, means a billing process by which a property owner (or association of property owners, in the case of co-ops or condominiums) bills tenants based on metered total water use; the property owner is then responsible for payment of a water bill from a public water system. Under the revised policy, a property owner will not be subject to SDWA regulations solely as a result of taking the administrative act of submetering and billing. Property owners must receive all of their water from a regulated public water system to qualify under the terms of this policy revision for submetered properties.

... Throughout the country, submetering of apartment buildings has been found to be an effective but little-used tool to support water conservation. Water conservation is an integral part

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of watershed protection, particularly in arid and drought-stricken areas. In addition to helping reduce the risk of water shortages, water conservation also provides other important benefits. Water conservation helps insure in-stream flows, thereby providing protection for ecosystems, which can become out of balance when demands stress water resources. Water conservation also helps reduce stress on water supply and wastewater infrastructure.⁴⁹

Sub-metering ultimately provides the end user with data about their water consumption and, if coupled with pricing that is based on actual metered use, can provide an incentive (i.e., price signal) to the customer to eliminate wasteful practices. Sub-metering has been shown in one study to reduce water use by 15 percent over flat-rate billing.⁵⁰ A utility should adjust future water demand projections to account for the lower water use expected by institution of sub-metering.

Bulk metering calibration and replacement program

A utility should consider having a large meter calibration and replacement program to ensure that meters are the right type and right size for their respective purposes. Meters that are mismatched to current uses (e.g., are matched to service line but not purpose, or are held over from a time when they served a site with significantly different use) may not register flows correctly. Industrial, commercial, and other large sized residential meters used in many such settings do not register low flows well and therefore can result in unmetered/under-reported water use and undetected leaks. This can result in lost revenue when water used is not measured or, therefore, billed, and also fails to send correct use and pricing signals to customers.

Bill all customers based, in part, on their actual metered volumetric water use

Along with universal metering, the water utility should ensure that all customers are billed, at least in part, based on their actual water use. No customers should be billed a flat charge of any kind as the total form of billing. Rather, charges should correspond to use. This is not to say that the entire water bill should correspond to consumption; portions of the bill can be used to recoup fixed costs in its system through a fixed base charge. Another form of charge that can be scaled to both help systems recover the cost of new infrastructure associated with growth, and to influence incorporation of water-saving features in new development is water connection charges matched to anticipated demand (e.g., lot size, landscape type, efficiency of fixtures).⁵¹ For more detail on rate-setting, see the section below on conservation rate structures and related references.

Source water metering

Utilities should implement metering not only of end users, but also of all water sources including groundwater, surface water, water purchases, and/or reclaimed water.³³ It is critical to meter water sources to know how much water is running through the utility's pipes, pumps, and plants. Source water data is required for the AWWA water audit and provides a starting point for determining how much water is moving through the system.

Source water meters should be flow-verified by accuracy tests and calibrated routinely (dependent on type of meter). Utilities should report on both the flow-verification and calibration routines and be able to share a table of basic information about the measuring device: type, identification number, frequency of reading, type of recording register, unit of measure (and conversion factor, if necessary), multiplier, date of installation, size of pipe or conduit, frequency of flow verification and calibration, and dates of last flow verification and calibration.³⁷ The fourth edition of AWWA's M36 includes detailed information on validating meter data in Appendix A, "Validating Production Flowmeter Data and Annual Water Supplied Volume."³⁷

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Metric: Universal metering, including sub-metering

Benchmark: Universal metering

All water users and sources (100%) are metered. The water utility should ensure water meters are installed on all accounts, both public and private, and bill (at least in part) based on metered use.

Deliverable: Percentage of service connections metered

The utility should report the percentage of all service connections that are metered.

Deliverable: Universal Metering

As in the AWWA Free Water Audit Software[®] output, the utility should report total authorized consumption (gallons per day) and a breakdown as follows: 1. Billed metered, 2. Billed unmetered, 3. Unbilled metered, and 4. Unbilled unmetered.

Deliverable: Savings Potential of Metering Practices

The utility should submit an assessment of the savings potential from the following metering-related practices and adjust water demand projections to account for shifts in water use expected from any changes in comprehensiveness of metering and meter management:

- Universal metering
- Sub-metering
- Bulk metering calibration and replacement program
- Billing of all customers based, in part, on their actual metered volumetric water use
- Source water metering

Resources

American Water Works Association (AWWA). 2016. *Water Audits and Loss Control Programs (Manual of Water Supply Practices M36)*, 4th Edition. Denver, CO.

Satterfield Z, Bhardwaj V. 2004. *Tech Brief—Water Meters*. Morgantown, West Virginia.

4. Conservation Rate Structure

Rates should be structured such that they reflect the full long-range costs (i.e., forward-looking, not historical) of operating and maintaining a water utility, as well as the scarcity and value of the resource, while also encouraging and rewarding conservation and efficient use. According to the Alliance for Water Efficiency:

The major shortcoming of ratemaking based solely on historical costs (rather than future costs) is the risk of underpricing the water, which can lead to overconsumption and further increase stresses on system capacity. From a practical perspective, using historical data to forecast the future encourages utilities to overinvest in capacity while providing little incentive to deploy existing resources more efficiently through rate design and other load management techniques.⁴⁰

Balancing pricing of water to incentivize efficiency while at the same time covering a water utility's bottom line takes careful consideration.⁵² There are no one-size-fits-all solutions, and any solutions identified should be reviewed regularly to adjust to new information and trends. Too often, water utilities provide water at a cost that neither recaptures the true cost of that water and related services, nor reflects the scarcity and value of the resource.

Given the significant potential for water savings through conservation rate structures, it is important that water utilities estimate the potential demand reductions from pricing water for efficiency before pursuing a reservoir or building an intake, treatment plant, or transmission system. To ensure that the rate structure continues to reflect current and projected conditions, support financial stability, and incentivize conservation and efficiency, it should undergo periodic evaluation (e.g., annual). Water utilities (or associated wastewater utilities) providing customers treated wastewater (reclaimed water) for irrigation or other uses should factor in availability of supply, and along with full metering, consider rates that are tiered or otherwise maintain incentives for efficient use.

When a utility is considering the need for capacity expansion, and the unit cost of conservation implementation would be lower, the costs of conservation program implementation can be incorporated into rate-setting, particularly for marginal cost pricing and higher use blocks (if used).⁵³

Full Cost Pricing

As stated by the Alliance for Water Efficiency (AWE) in their 2014 document *Building Better Water Rates for an Uncertain World*, "Over the last two decades the cost of providing water has increased at a rate greater than the rate of general inflation."⁴⁰ Water rates which reflect the full cost of service can help utilities capture the actual costs of operating water systems, bring in revenue, and provide seasonal and long-range stability for utility operations. Costs can include personnel and non-personnel operations and maintenance, debt service on capital investments, depreciation (equipment replacement), and price escalation (future construction). A flat service fee can be used to cover utility fixed costs such as long-term pipe maintenance and replacement. These costs of operating and maintaining the delivery system are common to all users, and having these fully funded helps prevent losses through deteriorating system conditions, benefitting all users. This component does not send a price signal to encourage conservation, however, and some utilities may opt for a completely consumption-based pricing structure provided it does completely support effective operations and maintenance. Variable costs such as energy for pumping and chemicals for treatment will change with volume of water supplied, but should also be accounted for and recovered fully.

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Rate Planning and Revenue Stability Planning

The balance of base charges and volumetric charges will depend on many factors such as utility size, user profiles, and demand patterns. With informed analysis, however, rate structure and pricing can be set to encourage efficiency and provide for revenue stability. As recognized by the Environmental Finance Center at the University of North Carolina (EFC-UNC):

...in the long-term (with planning), sustained reductions in average and peak water use can drive savings in capital investments. This can be achieved by recognizing decreasing demand and delaying investments in capacity and/or treatment expansions. Additionally, by promoting water efficiency, utilities may meet state regulations, act as responsible stewards of water resources, and engage with their customers in a positive manner.⁵⁴

Rates should be reviewed regularly (e.g., with annual budget review)⁵⁵ and adjusted as needed to meet both operating and long-term costs. For help with communicating to users about the need for/ benefits of rate increases or shifting rate structures, refer to the Alliance for Water Efficiency's *Building Better Water Rates for an Uncertain World*.⁴⁰

Conservation Use Rates

Water pricing should encourage and reward water conservation, while also ensuring that utility costs are adequately covered. This is often accomplished with an increasing block rate system which—in addition to the flat fee for fixed costs—includes a variable rate for volume of water consumed, with higher rates as water consumption increases. Increasing block rates (also called inclining or tiered block rates) can be structured with a reasonably priced first tier for water quantities that provide for essential household needs, and increasing price signals at higher use rates that represent more discretionary use. This allows for equitable provision for basic needs and avoids burdening low-income customers. Other rate structures, such as flat rate (not flat charge) billing, can also incentivize conservation when priced appropriately.

According to the AWWA Standard G480-13, *Water Conservation Program Operation and Management*, "Utilities shall use a nonpromotional water rate that provides the financial incentive for customers to reduce water use. Nonpromotional water rate structures include inclining tier rates, marginal cost pricing, seasonal rates, and water budget-based rates as defined in AWWA M52."³³ These rates can be combined by a utility in accordance with drivers of use. For example, an inclining block rate structure may form the core of the structure, with seasonal rate adjustments to respond to and manage peak demand drivers. A cost-of-service analysis separates costs into functional categories, allocates them by function (e.g., base, maximum day), and distributes the functionalized costs to customer classes.⁴⁰ A utility may also wish to consider using a mix of rate structures by customer class, e.g., increasing block rates for residential customers according to those use patterns and others tailored to industrial, commercial, and institutional users (see the following section for more on customer classification).⁵⁶

Managing demand through pricing can also be an advantage to the utility in that revenues may remain level or even increase if set to account for elasticity of demand.⁵⁷

- **Inclining block rates** (also known as increasing or inclining tier rates) - Conservation pricing can be accomplished with a tiered fee system which includes a base charge for fixed costs and a variable rate for volume of water consumed. Significantly higher rates are charged as water consumption increases as a way of calibrating revenue recovery to the fixed costs and variable costs, respectively (Figure 13). A utility can set rates in the upper tiers to approximate the marginal cost of water supply (the additional cost of supplying the next increment of water).^{40,56} Structuring

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rates using cost-of-service principles means that a utility recovers costs according to cost causation. For example, seasonal high-volume users would pay a rate based on costs incurred to provide storage and related costs to supply peak demand.⁴⁰ Increasing block rate structures are generally considered conservation-oriented, but the most effective mix of pricing signals for any given system will depend upon its particular characteristics and drivers of use.

Note: **Decreasing block rates** are the opposite of inclining tier rates. Rather than rates increasing as water use increases, rates are actually discounted with bulk or large-volume water usage. Decreasing block rates should be eliminated if they still exist in any water system seeking to improve efficiency.

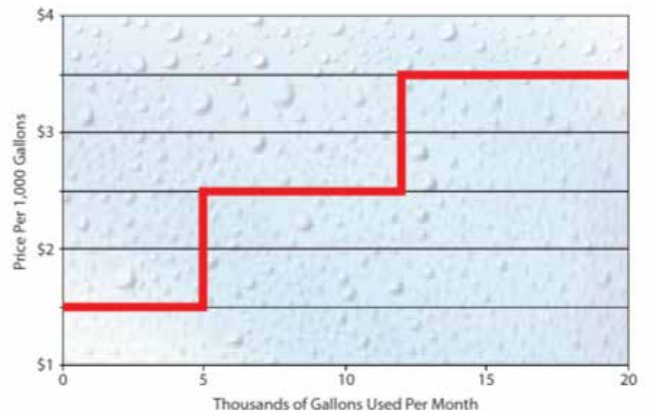


Figure 13. Source: SWFWMD. *Water Rates: Conserving Water and Protecting Revenues. Water Rates: Conserving Water and Protecting Revenues.*

It should be noted that although increasing block rates have been favored in many recommendations as most likely to support conservation-oriented behaviors by end users, some simpler rate structures (such as uniform rates) can send customers stronger conservation price signals, as well. In fact, the 2015 study *Water and Wastewater Rates and Rate Structures in Georgia* conducted by the UNC Environmental Finance Center found that a significant minority of surveyed utilities using increasing block rate structures had less effective conservation pricing signals than some utilities employing aggressive uniform rates.⁵⁸ Uniform rates—a consistent amount charged per unit of water—should be distinguished from flat fees that charge customers the same amount regardless of volume used.

It has been found that a relatively small increase in price does not significantly affect usage, but that higher prices do affect usage, whether as a single larger increase or aggregate of multiple smaller increases.⁵⁶ For this reason rates need to be designed so that the price is sufficient to encourage conservation. The utility should consider potential customer reactions to large one-time increases, though, and may wish to consider a series of smaller increases, and/or an outreach strategy to communicate the need for and reasoning behind significant pricing changes. High end users in particular tend to be influenced by rate structures with three or more tiers, and can be effectively targeted with such a structure.³⁸ Customers with primarily nondiscretionary indoor use (i.e., their water use consists mainly of drinking, cooking, sanitation, and cleaning already at efficient levels) may respond to higher costs by pursuing leak repair, whereas wasteful indoor uses may be curbed more effectively through utility education programs stressing the need for water savings and give-away/rebate programs.³⁸

- **Seasonal rates**—A seasonal rate structure charges higher rates when utility costs are higher and/or supply reliability is lower, typically in summer. For many water agencies, costs increase during warmer months because of the need for extra capacity to serve demand for outdoor uses. Some water agencies may also increase their reliance on more expensive sources of water to accommodate this demand. A seasonal rate design reflects that the resource in demand costs more to provide in some periods than others, and signals this to users.⁴⁰ Seasonal pricing can help promote outdoor water conservation as well as provide financial incentive to fix outdoor leaks. The Alliance for Water Efficiency's *Building Better Water Rates for an Uncertain World* provides guidance

Case Study:

Starting in 1999, the City of Greensboro, North Carolina began shifting from a decreasing block rate structure to a flat rate for **non-residential** customers, and total consumption by the top ten customers shrank 31%, or 429 million gallons per year, by 2008⁵⁹. The Water Resources Department is aware through discussions with several of these customers that they made significant changes to deliberately reduce their water consumption. Greensboro also changed its residential rate structure in 2000 to an increasing tiered block rate structure, and from 2000 to 2008, per-account residential usage decreased over 20%. Although difficult to discern in detail from the influence of other conservation measures, the Greensboro Water Resources Department attributes the change in large part to the new rate structure.⁵⁹

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for incorporating peak demands (e.g., seasonal, day, hour) into cost allocation. The AWWA further points out how a block structure can mesh with peak demands such as seasonal outdoor use:

Because a system must be constructed to meet peak-day and peak-month water demands, system capacity is underutilized during non-irrigation seasons. Moreover, if the system were sized to meet the average demand or winter demand only, the resource and infrastructure demands could be much smaller. Consequently, an increasing block rate structure may be designed to recover the cost of constructing and maintaining extra capacity for the peak demands. Because this capacity is underutilized, the per unit cost of water is higher than for base capacity, which is used year round. In short, a block structure can remain consistent with, if not enhance, the relationship of rates to costs of service.⁵⁶

- **Water budget-based rates**—Tailored allocations are developed for customers (individually or by class, e.g.), and rates increase as the allocation is exceeded. Water budget-based water rates—also known as individualized, goal-based, and customer-specific rates—are block rates where the blocks are defined using one or more customer characteristics, and the water budget defines an efficient level of water use.⁴⁰ These characteristics could include the number of people per household, lot size, and/or the evapotranspiration requirements of a customer’s landscape. Athens-Clarke County, Georgia, for example, has water budget based rates as part of an inclining-tier rate structure, helping to shave peak demand. The utility charges the lowest rate for use within a “winter average” budget based on household size for residential customers, with rates increasing in tiers as use exceeds the winter average by given percentages. Non-residential customers are billed based on an “annual average” use rate, with non-residential outdoor use charged at the highest tier rate. In the case of water budget-based rate structures, as well, communication with customers is key. The Western Municipal Water District in southern California developed such rates and defined each of the five rate tiers in accordance with use level: efficient indoor use, efficient outdoor use, inefficient use (based on exceeding water budget by up to 25%), excessive use, and unsustainable use (based on exceeding budget by over 50%). Customers have responded by becoming more efficient, with “over-budget” use decreasing by 34% from 2012 to 2013.⁴⁰
- **Drought surcharges**—Water utilities may wish to consider a role for temporary rate adjustments (e.g., “drought surcharges”) that are tied to drought conditions and water storage levels. Although these are more appropriately considered short-term curtailment than regular conservation and efficiency measures, they are included here as measures utilities may wish to incorporate into rate structures. The Alliance for Water Efficiency points out that drought pricing sends “a higher price signal to indicate the scarcity value of water during a drought emergency,” avoids the inevitable revenue decrease that will accompany an effective drought-related conservation campaign with customers, and “can avoid the political backlash that occurs when water rates are increased after customers have heeded the call to perform a civic duty by curtailing use.”⁴⁰ Surcharges on excessive water use can also help raise awareness and incentivize changes by customers to eliminate wasteful practices.

Case Study:

In response to Stage 3 Drought conditions, in 2007 the Birmingham (AL) Water Works (Alabama) instituted surcharges for customers who used more than 8,977 gallons per month as a means to encourage conservation, along with other measures such as limitations on irrigation and other uses. Demand subsequently declined from an average of 114 million gallons per day to about 95 million gallons per day.⁶⁰ In 2016, as drought again impacted their service area, the Water Works has implemented a 400% surcharge on residential customers exceeding 9,000 gallons per month and non-residential customers who exceed 110% of their average use.

In determining how to charge customers for irrigation water, utilities should be aware that there are conflicting data related to whether this incentivizes water conservation and efficiency. Some indicate that metering irrigation separately and designating it as a separate customer class enables the utility to target programs and shut off irrigation water when circumstances warrant it. Others indicate that an irrigation meter has the potential to incentivize additional outdoor water use if

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irrigation water is charged at the same rate as indoor water but does not carry a sewer charge. This may also pose difficulty for the utility if pricing does not reflect costs of providing this water, which is typically a peaking demand that may involve additional storage or relying on more expensive sources. As the Alliance for Water Efficiency states in their rate-setting guidance, “water rates that reflect resource costs induce customers to align consumptive choices with those costs.”⁴⁰

Specific charges billed to customers can be used to fund related efficiency measure implementation. The city of Pleasanton, California, used a \$0.05/cf 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.³⁸

Case Study:

Charlotte-Mecklenburg Utility Department (CMUD) saw a decrease in average consumption per residential account for seven consecutive years, dropping 25% from 7/1/02 to 6/30/09. Since then, average monthly consumption per residential account has remained nearly flat, holding steady around 7 CCF (5,236 gallons). During that same timeframe, the service population and number of accounts has continued to grow. CMUD credits the community’s successful water use reduction to several factors including customer response over time to a CMUD water rate structure that generally incentivizes water efficiency (such as adoption of conservation habits such as high efficiency shower heads and toilets).⁶¹

Utility bill

Water customers will respond not only to price signals regarding their water usage, but also to increased knowledge of their own water usage.¹⁷ Monthly utility bills, if they present information effectively, are a key outreach tool for educating customers. Water bills should show customers’ usage in gallon increments, which are far easier for customers to understand than cubic feet or other unfamiliar units. If a unit other than gallons is used, a readily understood conversion factor should be presented on the bill. It should show billing on a monthly basis and include the customer’s historical data (perhaps in graph form) for comparing use from month to month and year to year. Also helpful, in particular for high use customers, is a comparison between the customer’s own use, an “average” customer, and a “conserving” water customer. It should also provide information on rates and any surcharges so that customers can fully understand the price signals built into the utility’s rate structure. Shorter billing cycles (e.g., monthly rather than every two months) provide more frequent feedback on use and reminders to customers regarding the cost of water.⁵³

One final note: Utilities should promote understanding of how pricing provides stability, relates to the value and cost of the resource, how infrastructure maintenance factors in, and the need to fully cover costs of providing water. Information on how use relates to pricing and the value and cost of the resource empowers customers to understand and direct how they fit in to the system, manage their use, and manage their costs. Many resources are available to support these activities, such as AWE’s *Building Better Water Rates for an Uncertain World: Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability*.

Metric

Demand reductions from pricing water for efficiency

Deliverables: Conservation Pricing Documents

- A recent rate structure analysis that examines conservation rate structure approaches that both address revenue stability as well as incentivize conservation and efficiency. The rate structures evaluation should address the water utility’s water demand challenges (e.g., peak outdoor use, outdated indoor plumbing fixtures, customer leaks).

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- Projection of demand reductions expected to result from pricing water for efficiency
- Documentation of critical water demand challenges (peak summer use, indoor water leaks/outdated plumbing) supported by analysis of usage patterns over the course of a year
- A copy of legally adopted rate ordinance that includes a conservation rate structure designed to incentivize efficiency and conservation
- Documentation of all rate changes within five years of submittal
- A utility bill reflecting the adopted conservation rate structure

Resources

Alliance for Water Efficiency. 2014. *Building Better Water Rates for an Uncertain World: Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability*. Chicago, IL.

American Water Works Association (AWWA). 2012. *Principles of Water Rates, Fees, and Charges (Manual of Water Supply Practices M1)*, sixth edition. Denver, CO.

Pacific Institute and Alliance for Water Efficiency. 2013. *Need To Know: Water Rates Series*.

Pacific Institute. 2013. *An Overview of the 'New Normal' and Water Rate Basics*.

Texas Water Development Board. 2013. *Best Management Practices for Municipal Water Users*.

5. End Use Water Conservation and Efficiency Analysis

In order to determine what water conservation and efficiency programs and policies will be most effective in managing demand, a water utility needs to understand the makeup of its customer base and conduct a thorough assessment of end use water efficiency measures. If using this practice to determine the potential for water efficiency to avoid or minimize the need for a new reservoir or other water supply development project, the end use efficiency measures analysis should have as its demand reduction goal (savings) the same yield (MGD) as the proposed water supply project. Such performance-based targets are important when trying to determine how to secure savings to offset water supply needs and use water efficiency and conservation as a “least environmentally damaging practicable alternative.” Even if proposed water supply goals do not appear achievable through these measures, if construction of new infrastructure can be postponed, years of debt service can be saved by the utility. In addition, the analysis should clearly address the water supply challenge (i.e., when and where there are water limitations) facing the utility.

Water Use Profile & Customer Use

As the AWWA advises in their manual *Water Resources Planning: Manual of Water Supply Practices M50*, “An early assessment of demand reduction is appropriate, because this source may obviate the need to develop new supplies or defer the need for a new source for a number of years.” Early assessment of demand reduction potential can also lead to reduced size and impacts of a potential supply project.

The first step in developing an end use water conservation and efficiency analysis is to gain understanding of a utility’s customer base by developing a current water use profile for the utility’s service area and defining customer classification. The term “customer class” refers to a group of customers (e.g., single-family residential, multi-family residential, commercial, industrial, institutional, wholesale) defined by similar characteristics or patterns of water usage.³¹ A current water use profile establishes a baseline for water use against which the utility can measure progress. Customer base makeup varies among utilities, and the characteristics of water use in a given customer class (e.g., institutional) can differ from those in other water systems depending on climate, socioeconomics, etc. Given that different customer classes respond differently to price signals and have different usage patterns, the utility should model different rates tailored to different customer classes.

This profile can be used for priority-setting purposes in identifying potential targets for improved conservation and efficiency measure implementation. In addition, the utility should **document seasonal variability** in water use broken out by customer class. For residential use, the utility should determine per capita use, both average and seasonal. The more refined the seasonal values, the more usefulness they will have. Monthly or weekly data, for example, can show with greater specificity when shifts in use begin, which can shed light on drivers of demand and opportunities to manage them. For non-residential customer classes, the utility should also determine use per account, across a seasonal or more refined time scale.

Because systems often have specific drivers of maximum demand and storage needs, understanding these can help optimize system management and meet needs in the most effective manner. Some systems with high residential outdoor usage may experience peak demand in summer months when residential irrigation is highest. Others may have industrial customers with peak usage driven by factors unrelated to season. In some cases, it may be possible to manage peak demands (e.g., with incentives to industrial customers or for behavior change in residential customers) so as to even out demand and reduce withdrawal and/or storage needs. Accurate information on use trends is critical to understanding how well a system is managed and where improvement can be sought. For systems

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wishing to consider metrics for use by sector or season, alternative metrics such as those described in AWWA's guidance report *Water Conservation Measurement Metrics* can provide insight.^{62,63}

The service area should be clearly defined, and population projections from an authoritative source should be provided. The user population should be characterized by category (at least single-family residential, multi-family residential, industrial, commercial, and institutional). For projections, the applicant should account for whether customer class makeup and use is expected to change during the timeframe of the projected need (e.g., age distribution, household size, housing stock age, housing turnover and retrofit vs new plumbing, customer-side losses, other sector shifts, etc.). If a significant shift from multi-family to single-family residential accounts is expected, for example, differences between use patterns in these two categories should be considered (e.g., outdoor use may increase).

Note: Demand rates should be calculated by category, not on a per capita basis for the system as a whole. Other use categories (e.g., industrial) can affect total system demand, and the values are not comparable over time or to indicators of performance. Only residential use should be presented in terms of per capita values.

When forecasting future demand, utilities should consider the influence of measures such as regulatory or voluntary plumbing product standards or code requirements for new construction as part of the baseline. Such code-driven conservation measures may account for a significant percentage of total water needs by 2030 nationally, but the gains realized by any given utility will depend on local factors like the age of housing stock and local real estate market turnover.

Utilities may also wish to use customer water use indicators in demand accounting that can inform rate-setting and conservation planning in more detail. Vickers et al.⁶⁴ have identified the following nine indicators, primarily for single-family residential customers, as helpful in refining the ability to identify meaningful demand patterns: customer average use, rank of customer average use, percentile of customer average use, zero- and low-use accounts, customer baseline demand, customer maximum demand, customer peaking ratio, customer use profile, and "hidden" irrigation accounts. Resources spent working with the highest ranked customers or top 10% of users, for example, may yield the greatest reductions in demand, or identify opportunities to shift drivers of peak demand for better system management.

Utilities should consider using specific customer subgroups within categories to help effectively identify opportunities for targeted communications and incentives to direct efforts.⁶⁴ For example, if a large percentage of use is from institutional accounts, separating out the types of institutions may provide useful insight (e.g., older schools might benefit from plumbing retrofit incentives). Conversely, if there are a few accounts comprising a large volume of demand within a category, it may be more effective to partner with the individual customers (e.g., offer free audits) to identify opportunities for savings.

End Use Water Conservation and Efficiency Measures

Once a current water use profile and targets are developed, the utility should evaluate efficiency measures targeted at each customer class as needed to address its water supply challenge, and focus the most aggressive water conservation and efficiency measures on the customer classes and uses that have the most potential for water savings. The utility should keep in mind that drivers of use may apply fairly evenly across a customer class, or a small number of users may represent a disproportionate portion of use.

Case Study:

The Town of Cary, North Carolina, has gone beyond profiling demand by customer class to exploring drivers behind changes in demand. For example, they found that despite an overall decreasing trend in residential water use, newer homes tend to use approximately 20 percent more water on average than older homes. This elevated consumption is despite having newer, more efficient water fixtures. Outdoor use associated with inground irrigation systems installed with newer homes was identified as a key driver of the higher use rate.⁶⁵

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Depending on the community, measures may target indoor water use, outdoor use, or both. For older communities, outdated plumbing might provide an opportunity for significant water savings through retrofit of toilets and other plumbing fixtures. Many studies of communities with older plumbing found that high-volume toilets in particular drove a large portion of indoor residential use. Leaks from “running” toilets are one of the largest sources of losses for end users. In a community with a significant rental customer base, fixing leaks inside homes that would otherwise go unaddressed might be a particular issue. In more affluent communities, a focus on outdoor water use and automatic irrigation systems might be particularly effective. It is also important to examine how changes in weather affect water use. For instance, drought may increase water use until restrictions are implemented. In locations where a large portion of homes have exposed pipes and freezing events that call for letting faucets drip to avoid pipe ruptures, authorities may wish to consider means of requiring pipe protection in new construction. At a steady rate of one drip per second, for example, each faucet sends five gallons per day down the drain.⁶⁶

As described above, the water utility should, through the development of the water use profile, identify targets and opportunities for water savings. The specific measures evaluated will depend on the specific user profile, usage patterns, and water supply challenge(s) of the water utility.

An analysis of efficiency measures is often conducted using a model designed for that purpose. There are many tools available. Most models are Microsoft Excel® spreadsheet-based tools that vary in complexity and specificity. All models require customization to local uses and needs as well as utility-specific data.

- The Alliance for Water Efficiency (AWE) has developed a “Water Conservation Tracking Tool” that “can evaluate the water savings, costs, and benefits of conservation and efficiency programs for a specific water utility... Using information entered into the Tool from the utility’s system, it provides a standardized methodology for water savings and benefit-cost accounting, and includes a library of pre-defined conservation activities from which users can build conservation programs.” This model is actively being developed and has several versions tailored to higher efficiency plumbing codes in states such as Georgia. It is available free of charge to members of AWE.
- The Demand Side Management Least-Cost Planning Decision Support System (DSS), developed by Bill Maddaus, and IWR-MAIN Water Demand Management Suite® (developed by CDM Smith), are sophisticated proprietary tools. They assist the water utility in analyzing water conservation at the end use level, provide cost-benefit analysis, and facilitate the economic analysis of active conservation programs.

Utilities can also make use of information, programs, and products labeled through EPA’s WaterSense program. WaterSense is a voluntary program that protects the nation’s water resources by promoting a label for water-efficient products. The program brings together utilities, governments, manufacturers, retailers, consumers, and other stakeholders to decrease indoor and outdoor non-agricultural water use through the adoption of more efficient products and practices. Whereas many may remember performance challenges (e.g., the need to double flush “efficient” toilets) from the early days of efficient water fixture development, industry has responded positively by developing far superior products. Products carrying the WaterSense label are independently certified to not only use at least 20 percent less water than the federal minimum, but also to meet rigorous performance and quality criteria. Utilities can make use of WaterSense programs to promote water efficient practices and products, and may also wish to consider providing incentives for (e.g., rebates) or requiring

Case Study:

As part of the conditions of its 2007 Water Use Permit, Miami-Dade Water and Sewer Department is required to report on efficiency measure implementation on an annual basis. As of the 2014 Annual Report, the department had already achieved savings of 12.3 mgd, ahead of even the 2016 planned savings level.⁶⁷

Did You Know?

In 2015 alone, WaterSense-labeled products helped users save 437 billion gallons of water. Through 2015, the program estimates that users have saved more than 1.5 trillion gallons of water and 212 billion kilowatt hours, eliminating 78 million metric tons of greenhouse gas emissions and saving \$32.6 billion in water and energy bills.²²

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use of WaterSense-labeled products in some circumstances (e.g., by changing state plumbing code requirements for new construction).

Some WaterSense statistics for estimated water savings when replacing older residential fixtures with WaterSense labeled fixtures are⁶⁸:

Water Saving Fixture	WaterSense Estimated Water Savings
Toilets	13,000 gallons/year for an average family
Bathroom Faucets	700 gallons/year for average family
Showerheads	2,900 gallons/year for average family

Utilities may wish to encourage the reuse of treated wastewater. Reusing treated wastewater (reclaimed water) has been shown to reduce water withdrawals significantly in many communities. Reclaimed water is used for evaporative chillers for commercial cooling systems, boiler makeup water for steam heating systems, and other commercial uses. It can also be used for irrigation of golf courses, ball fields, parks, and residential/commercial lawns and landscaping. To avoid the risk of this water being seen as cheap or “free” from an environmental perspective, it should be metered and billed to encourage responsible use. Otherwise, end users might actually increase uses that they would otherwise avoid, reducing returns to the basin. When the City of Port Orange, Florida provided unmetered reclaimed water at very low rates, that water was used liberally, to the point of threatening system pressures as users switched to reclaimed water the 1998-2001 drought. After meters were installed and an increasing block rate applied to reclaimed water, demand became more manageable.¹⁷

Water authorities may also wish to allow the reuse of graywater for commercial applications such as hotels, dormitories, apartment buildings, and residential applications. Some states either have or are developing guidelines for graywater reuse, such as the Georgia Graywater Reuse Guidelines in development by Georgia Environmental Protection Division to permit graywater use for toilet and urinal flushing, as well as for subsurface irrigation.⁶⁹

Industrial, Commercial, and Institutional

Of the 42,000 MGD of freshwater withdrawn for public supply in 2010, about 57 percent was for domestic use. The remainder was distributed for industrial, commercial, and other purposes; the exact breakdown was not estimated by USGS²³, but in general ICI (industrial, commercial, and institutional) users may represent 20 to 40 percent of billed urban water demand for many public water supply systems.³¹ ICI customer uses can be variable and complex, and thus difficult to apply broad standards to, even for users of a similar type. Price signals may influence some users, particularly for peaking uses, but water efficiency may not be a focus for many others. Incentivizing site- or customer-specific audits may be the most effective means of identifying opportunities for achieving efficiency implementation with ICI customers. In many situations, there may be considerable overlap with residential efficiency considerations (e.g., faucets, showerheads, toilets, and outdoor irrigation). In others, however, particular consideration of the needs of the facility may focus on significant opportunities for water and financial savings (e.g., healthcare, food prep). A range of WaterSense and ENERGY STAR labeled products may be appropriate for use in ICI facilities. Cooling systems can represent significant water use, and especially if older single-pass systems are in use, may present opportunities for considerable savings.^{31,70} WaterSense has a comprehensive best management practices guide that identifies additional opportunities for savings.

Case Study:

Milton Hospital in Milton, Massachusetts, realized significant savings by installing a foot pedal-operated spray rinser on a kitchen sink and saw net benefits in less than a month. With water savings of 370,000 gpy that also avoided sewer costs, the \$240 purchase and installation of the spray rinser began saving the hospital \$3,300 per year.⁷¹

Case Study:

NASA's Marshall Space Flight Center in Huntsville, Alabama, initiated improvements to a key cooling system in 2009, projecting water savings of 420,808 gallons over eight months. Once implemented, however, engineering and water treatment changes realized savings of 821,300 gallons of water, in addition to 434,900 kWh of energy and thousands of dollars in financial savings.⁷²

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A billing system that distinguishes customers by criteria specific enough to assess use patterns can greatly assist in reviewing drivers of demand.⁷⁴ For example, rather than identify customers only by meter size, which may include residential, commercial, and business customers in the same category, utilities can also classify ICI customers by NAICS (North American Industry Classification System) codes.³¹ A 2016 report from the Water Research Foundation recommends an approach that includes the following 12-15 principal categories which can be placed into further sub-categories, to classify ICI customers based on their review of several utility systems:

- | | |
|--------------------------------|------------------------------------|
| 1. Lodging | 13. Other Institutional |
| 2. Office Building | 14. Largest Individual Users |
| 3. School or College | 15. Dominant End Use |
| 4. Health Care Facility | 12. Other Commercial |
| 5. Eating or Drinking Place | • Landscape only |
| 6. Retail Store | • Laundromat |
| 7. Warehouse | • Commercial or Industrial Laundry |
| 8. Auto/Auto Service | • Car Wash |
| 9. Religious Building | • Park or Recreational |
| 10. Retirement or Nursing Home | • Golf Course Area |
| 11. Manufacturing | • Power Plant/Utility |
| 12. Other Commercial | • Server Facility/Data Center |

Case Study:

To address withdrawals from the Sparta Aquifer that were outpacing recharge rates significantly, officials of the City of West Monroe, Louisiana turned to their largest industrial customer. The city piloted and developed a plant for treating wastewater to drinking water standards primarily to supply the paper mill. As of 2012, the mill had cut well withdrawals in half, displacing it with 5 mgd reclaimed water, thereby helping to stave off saltwater intrusion into the aquifer.⁷³

Source: Information for Water Demand Analysis: Barriers and Best Practices, Presentation at WaterSmart Innovations, 2016, Lisa R. Krentz and Jack C. Kiefer, Sr., <https://www.watersmartinnovations.com/documents/sessions/2016/T-1626.pdf>.

A 2016 AWWA report described the results of a survey of water utilities on their incentive programs for ICI customers. Examples of particular approaches to consider for incentive programs include:

Industrial

- Incentive programs targeted at high water users for industrial processes

Commercial

- High efficiency pre-rinse spray valves (PRSV) for all restaurants and food preparation facilities
- Retrofit incentives rebates for commercial clothes washers, high-efficiency toilets, etc.
- 'Retrofit on reconnect' requiring the upgrading of plumbing fixtures when a new customer establishes a water account
- Conservation pricing targeting peak water use. Given that irrigation water is discretionary and non-essential, this water should be priced at the highest tiered bracket.

Institutional

- High efficiency pre-rinse spray valves (PRSV) for all restaurant/cafeteria facilities
- Retrofit incentives for commercial clothes washers, high-efficiency toilets, etc.

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- ‘Retrofit on reconnect’ requiring the upgrading of plumbing fixtures when a new customer establishes a water account
- Require sub-metering of individual units of large facilities and monthly billing based on actual metered consumption
- Implementation of cooling tower efficiency program

Residential

Drivers of high water use will vary among communities, and may depend upon a variety of factors such as age of housing stock and plumbing, community norms concerning landscaping, income level, age of appliances, and household sizes. Many studies have identified older, inefficient toilets, leaking toilet flappers, and inefficient appliances as being responsible for large volumes of indoor residential use.

In their 2012 paper analyzing single-family residential water demand DeOreo and Mayer found consistent, significant declines in household and per capita water use between their seminal 1999 Residential End Uses of Water Study (REUWS)⁷⁵ and more recent studies that looked at retrofit of older homes, newer standard homes, and high-efficiency newer homes (built to meet WaterSense specifications and with ENERGY STAR-certified clothes washers). Declines in indoor residential use, primarily due to new technologies such as more efficient toilets and appliances such as clothes washers, ranged from 13.3% to 42.7% for homes with different plumbing and appliance profiles, a considerable decrease.⁷⁶ The 2016 updated Residential End Uses of Water, Version 2 study (“REU2016”) found a decline of 22% in average annual indoor household water use since the original REUWS.⁷⁷ Homes with high efficiency fixtures and appliances achieve indoor water demand under 40 gpcd, and DeOreo et al concluded that average daily indoor water use is expected to reduce to 110 gallons per household per day (or 36.7 gpcd) in the coming years.⁷⁷ Identifying and addressing households with larger leaks on the end user side can also be an effective targeting strategy because they may represent a disproportionate volume of water lost by end users.⁷⁶

DeOreo and Mayer also have found that outdoor water use can contribute significantly to demand, but that a small number of users that over-irrigate can represent a disproportionate amount of outdoor use.⁷⁷ In one study, 8% of homes fell into the highest use category for irrigation, but represented 38% of the total excess irrigation.⁷⁶ Examining use patterns can help a utility identify such inefficient use, which may also drive peak demand during certain times of the year, and make targeted improvements in technology or behaviors with incentives or restrictions.

Some conservation approaches include giveaways or rebates of water-saving devices, including high efficiency showerheads and toilets, faucet aerators, and replacement toilet flappers (warped flappers allow water to leak). Many states, including Florida and Georgia, have held sales tax “holidays” on WaterSense and ENERGY STAR products to encourage their use.⁷⁸ A 2004 study by the Tampa Water Department and the U.S. Environmental Protection Agency (EPA), *Tampa Water Department Residential Water Conservation Study*, involved retrofitting 26 homes with such devices and measuring use with trace flow meters.⁷⁹ They found that these retrofits lowered daily water usage by an average of 92 gallons (46%) per household. According to the study, toilet leaks contribute the most to household

Case Study:

Effective conservation programs can save communities significant amounts, especially when considering not only acquisition, storage, pumping, treatment, and delivery of water for use, but also capture, treatment, and movement of wastewater. The Town of Cary, NC, has a long-standing conservation program that has achieved significant savings since its inception in 1995. Consumption data for 1996-2011 show overall per capita use (residential and non-residential) declining by 20%, with single family residential per capita use showing the greatest decline at 24%.⁶⁵ These per-capita reductions in consumption saved nearly 0.9 billion gallons of water over that period, or nearly 160,000 gallons per day. In 2011 dollars, this resulted in savings of approximately \$55,000 per year in treatment and finished water pumping costs, or approximately 1% of the FY2011 Water Treatment Plant (WTP) operations and maintenance budget.⁶⁵ It also allowed Cary to delay expansion of the Cary/Apex WTP by 2-3 years, with a three-year delay in this capital investment valued at approximately \$3.5 million.

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leakage. Yet another approach to supporting efficiency measure implementation is with billing-related financing. The Bay Area Regional Energy Network in California, for example, has worked with a number of water agencies to carry out Pay As You Save (PAYS®) programs that allow customers to pay for water efficiency improvements through a monthly charge on their utility bill.

Utilities may also wish to consider passing ordinances to establish retrofit requirements. DeKalb County, Georgia's "retrofit upon resale" ordinance went into effect for residential properties in 2008, and for commercial properties (which includes apartments) in 2009, requiring that any property sold must be certified as having high efficiency plumbing fixtures. In 2014, the State of Colorado passed a law that requires some plumbing fixtures sold in the state to have the WaterSense label (Conn. Gen. Stat. § 21a-86a).⁸¹

Particular approaches to consider include:

Residential – Single Family

- Provide water efficiency audits and 'direct-install' programs targeted at high water users
- High-efficiency toilet direct install program, giveaways, and rebates
- Rebates for high efficiency washing machines
- 'Retrofit on reconnect' requiring the upgrading of plumbing fixtures when a new customer establishes a water account
- *See also following section on outdoor/landscape use
- Change plumbing codes to require WaterSense labeled products, where practicable

Residential – Multi-Family

- Provide water efficiency audits and 'direct-install' programs targeted at high water users
- High-efficiency toilet direct install program, giveaways, and rebates
- Require sub-metering of individual units and monthly billing based on actual metered consumption
- *See also following section on outdoor/landscape use
- Change plumbing codes to require WaterSense labeled products, where practicable

Outdoor/Landscape (ICI and Residential)

On average, outdoor uses (primarily turf and landscape irrigation, but also car washing, cleaning, and swimming pools, e.g.) are estimated to constitute about 30% of residential use in the United States.³¹ The outdoor use rate varies considerably by locality, however, depending upon factors such as weather, prevalence of inground irrigation systems, and prevalence of swimming pools in residential settings. In South Florida, for example, outdoor water use accounts for approximately half of household water use, with approximately half of that lost to evaporation and over-watering.⁸² Watering too often and too long is the primary source of water waste associated with landscape irrigation, with overspray and runoff onto surfaces such as sidewalks and roadways being common problems. Outdoor watering bans have been used effectively as short-term drought management measures. "We knock off about three million gallons per day by going to one-day-a-week watering," says Allan

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Williams, water resources director for the City of Greensboro (North Carolina). “If we ban all outdoor watering, we knock off about eight million gallons per day.”⁸⁰ However, bans are short-term responses to water shortages and should be distinguished from long-term conservation measures.

Water utilities should consider separate metering of irrigation water, accompanied by a pricing structure which encourages efficiency. Other measures should be the requirement of rain and moisture sensors for irrigation systems. Florida, for example, has required that automatic irrigation systems have rain sensors since 1991 (Florida Statute 373.62).⁸³ Because the use of native and drought-tolerant plants and more efficient irrigation can produce significant water savings, water utilities should develop incentives to encourage their use in the landscape. Water utilities can work with planning and zoning departments to encourage residential developments that have more diverse landscapes and demonstrate how creative use of native plantings and mulching can provide attractive, low maintenance yards that require no irrigation. The Florida Water Star and Florida-Friendly Landscaping programs have been successful in encouraging more efficient landscapes that provide multiple benefits. Utilities can also develop programs to improve the efficiency of irrigation systems. An example is Tampa, Florida, whose Sensible Sprinkling irrigation evaluation program resulted in a 25 percent drop in water use, contributing to a 26 percent decrease in per capita water use from 1989 to 2001 even as the city’s water service population increased 20 percent.⁸⁴

Case Study:

The City of Albuquerque, New Mexico, generates a water conservation budget using a water rate surcharge, with over \$1 million in revenue returned to customers annually in the form of incentives, including residential and commercial landscape rebates.⁸⁵ Approved landscaping projects can receive \$1.00/ft² for converting turf to xeriscaping, \$1.50/ft² for replacing turf on steep slopes with plants from an approved rainwater harvesting plant list, and related incentives such as \$25 for purchase of rain sensors. These rebates for outdoor measures have been increased lately as conservation planning recognized that much progress had been achieved in indoor efficiency implementation, and greater emphasis was needed on outdoor water use.⁸⁶

Particular approaches to consider include:

- Outdoor water incentives: rebates for moisture/rain sensors, WaterSense labeled irrigation controllers, irrigation audits, large water user rainwater/graywater/condensate capture retrofit program
- Policy: Outdoor watering schedule that allows watering only when evaporation rates are lowest; moisture sensor requirement
- Require irrigation professionals certified by WaterSense labeled programs for design, installation, or auditing of outdoor irrigation systems

Deliverable: Water Use Profile Indicators

The water utility should provide the following information for the five calendar years prior to submittal (see example in AWWA’s M52 Manual, Table 3-2, p. 42).³⁸

- Clearly defined service area and customer base
- Customer classes defined to include at a minimum: residential-single family, residential multi-family, commercial, industrial, and institutional customer classes.
- For residential use, separate indoor and outdoor use if possible. If not, provide estimate based on winter demand.
- Customer numbers and water consumption (million gallons/day) by customer class (see recommended customer class breakout above)

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- Seasonal variability of water use by customer class, preferably on a refined time scale such as monthly, weekly, or daily if possible. Provide graph of each customer class's seasonal usage.
- Average (e.g., by season) and peak (highest total water use measured on an hourly, daily, or monthly basis as most relevant to drivers of supply constraints) use by customer class

Metric: Residential Gallons Per Capita Per Day (gpcd)

A useful indicator of efficiency of residential use, when derived appropriately, is water use in terms of gallons per capita per day (gpcd). Simply put, residential use is single-family plus multi-family consumption divided by the total population served. This metric helps determine the potential for water conservation and efficiency in the residential customer classes as it is measuring similar water uses and generally similar plumbing fixtures and appliances. Single-family and multi-family residential use patterns do differ, however, often because of outdoor water use, metering, or plumbing and appliance differences. The utility should separate single-family and multi-family consumption if at all possible to be able to identify different use patterns that may have implications for demand management. The utility should also separate indoor use from outdoor use if at all possible, as outdoor use is much more variable than indoor use and its inclusion makes comparisons difficult.

It should be noted that overall system use—the total amount of water diverted and/or pumped for potable use divided by the total population served—is only meaningful in very limited circumstances. This measure is not helpful in terms of determining the potential for water conservation and efficiency, as it includes ICI water users that can skew the per capita measure. This measure is not helpful for goal-setting nor is it appropriate for comparing utilities to each other because of the variations in customer make-up.

Benchmark: Gallons Per Capita Per Day (GPCD)

There is no one recommendation for the amount of water that should be used indoors because types of fixtures and appliances vary. However, three estimates that can be used as benchmarks of indoor use for a conserving household are: < 45.2 gpcd³¹, < 44.7 gpcd⁷⁵, or 36.5 gpcd⁸⁷ as a target for efficient use.

Deliverable: Gallons Per Capita Per Day (GPCD) Calculations

The water utility should provide documentation of calculations to develop residential use numbers.

Deliverable: Assessment of Water Savings Potential

The utility should submit an assessment of the savings potential from end use best management practices (at least those described above), and adjust future water demand projections to account for the lower water use expected of customers. Vickers (2001) provides several useful worksheets in appendices that can be helpful in guiding assessment of potential savings of ICI, residential, and outdoor water use.³¹

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Resources

Alliance for Water Efficiency. July 2011. Water Conservation Tracking Tool, version 2.0. Available to members from: <http://www.allianceforwaterefficiency.org/Tracking-Tool.aspx>

American Water Works Association. 2016. *National Survey of Commercial, Industrial and Institutional Water Efficiency Programs*.

Ontario Water Works Association. 2008. *Ontario Outdoor Water Use Reduction Manual*.

University of North Carolina Environmental Finance Center. 2009. *Residential Irrigation: An exploration through the lens of five NC communities*.

US Environmental Protection Agency. 2012. *WaterSense at Work: Best Management Practices for Commercial and Institutional Buildings*. Washington, DC.

US Environmental Protection Agency. 2013. *Water Efficiency for Public Water Systems. Office of Water*; Washington, DC.

US Environmental Protection Agency. July 2013. *Water-Smart Landscapes: Water Efficient Landscapes Start with WaterSense*. EPA Document # EPA 832-K-12-2002. Washington, DC.

US Environmental Protection Agency. EPA WaterSense website for commercial and institutional users of water. <http://www.epa.gov/watersense/commercial/>

US Environmental Protection Agency. EPA WaterSense website for residential outdoor uses of water. <http://www.epa.gov/watersense/outdoor/>

Vickers, A. 2001. *Handbook of Water Use and Conservation* (p. 446). Amherst, MA: WaterPlow Press.

6. Water Conservation and Efficiency Plan

A well designed conservation and efficiency plan sets the stage for successful implementation of measures to avoid water loss and to manage demand for effective water resource management. Crafting such a plan and integrating it into infrastructure planning helps ensure that a utility is optimizing existing operations before considering development of additional resources for predicted needs. A utility may wish to hire or designate an interested staff member as a water conservation coordinator. In addition to implementing a water conservation program, such a coordinator could seek funding opportunities and help communicate to end users and stakeholders about the program. Again, AWWA says of water conservation in integrated resources planning that utilities should “treat conservation as equal to other water supply options, and where appropriate, include water made available through conservation as part of the supply portfolio when conducting supply-and-demand forecasting analyses.”³³

Water utilities should have a written plan which includes definitive and measurable goals for optimizing system performance and ensuring efficient water use, with timelines for implementation. The plan can be incorporated in an existing document such as a water use plan or environmental management system, or can be separate. It can also include a process through which benefits and costs are evaluated. Planning documents should recognize effects of efficiency and conservation measures already implemented, and forecast the effects of planned measures⁸⁸. Strategies for calculating savings can be found in resources such as AWWA’s M52 manual³⁸ for larger utilities, and Green (2010)¹⁷ for utilities with fewer than 100,000 customers.

The plan should describe at a minimum how the utility is addressing these guidelines. Additional guidance on effective planning and measures to consider is available from other sources such as Amy Vickers’ *Handbook of Water Use and Conservation* (2001)³¹, AWWA’s *Water Conservation Programs –A Planning Manual* (aka M52 Manual, 2006), and EPA’s 1998 *Water Conservation Plan Guidelines*⁸⁸. The process for developing the plan is laid out in nearly identical steps in all three documents:

M52 Water Conservation Programs—A Planning Manual (AWWA 2006)	Handbook of Water Use and Conservation (Vickers 2001)	Water Conservation Plan Guidelines (EPA 1992) (Intermediate and Advanced)
<ol style="list-style-type: none"> 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 	<ol style="list-style-type: none"> 1. Identify conservation goals 2. Develop a water use profile and forecast 3. Evaluate planned facilities 4. Identify and evaluate conservation measures 5. Identify and assess conservation incentives 6. Analyze benefits and costs 7. Select conservation measures and incentives 8. Prepare and implement the conservation plan 9. Integrate conservation and supply plans, modify forecasts 10. Monitor, evaluate, and revise program as needed 	<ol style="list-style-type: none"> 1. Specify conservation planning goals 2. Develop a water system profile 3. Prepare a demand forecast 4. Describe planned facilities 5. Identify water conservation measures 6. Analyze benefits and costs 7. Select conservation measures 8. Integrate resources and modify forecasts 9. Present implementation and evaluation strategy

Best Practices

Particularly when considering developing new supply or storage such as a reservoir or source, a water utility can use the water conservation planning process to identify the water conservation and efficiency programs, policies and incentives that will yield a target amount of water savings. The water utility should use the projected reservoir or source yield (MGD) as the goal for the water conservation and efficiency plan and seek to optimize water savings. When determining benefits and costs as part of the screening process, the water utility should take into consideration the costs avoided by not building the water supply reservoir and the associated water infrastructure, such as drinking water and waste water treatment plants, etc., as well as any compensatory mitigation that would be required for impacts to wetlands and streams.

Utilities should also recognize the interrelationships between water, wastewater, stormwater, and energy when planning and evaluating infrastructure needs and solutions, using close collaboration among all related departments and organizations. The cost benefits of water conservation are even greater when the wastewater cost benefits are also considered. A gallon of water conserved is a gallon of wastewater not collected, treated, and disposed of, with energy savings from both water and wastewater processes. An Integrated Resource Management approach to infrastructure needs and solutions often provides greater benefits at lower costs.

EPA recommends that water utilities involve stakeholders in the development of efficiency and conservation programs and develop public outreach and education programs as part of their water efficiency and conservation plans, programs, and policies. Even though savings from an education program may be difficult to calculate, they have been demonstrated to promote adoption of indoor residential efficiency measures in particular, providing measurable decreases in use. Utilities should incorporate educational information about the source of their water, the value of water, the cost of their water services and the rate structure, customers' own water use patterns, and smart, simple water efficiency solutions. Educational initiatives should be directed at both children and adults. Opportunities for significant water savings can be overlooked without stakeholders at the table. Involving water users encourages buy-in and higher rates of efficiency measure implementation.¹⁷ Water utilities can partner with EPA's WaterSense program (epa.gov/watersense) to gain access to materials to help them engage with consumers to drive water efficiency in their service area.

Case Studies:

Comprehensive analysis and planning can result in big returns. Facing limits on supply that could be drawn from the Edwards Aquifer, as well as increasing population, the San Antonio Water System (SAWS) was confronting the possibility of having to buy additional water rights from an adjacent aquifer. Between the early 1980's through the 2000's, SAWS set out strategies and goals for implementing conservation measures across multiple sectors. By 2007, SAWS had reduced per-capita water use by 49 percent, meeting their water use reduction goal seven years early. Investments of \$4.8 million/year realized \$7.4 million in avoided water purchase and infrastructure costs.⁸⁹

Westminster, CO has long invested in efficiency programs, but water rates have risen nevertheless. When asked by customers about the reason for increasing rates, the City examined investments, rates, programs, and costs from 1980 to 2010. They found that although rates had necessarily gone up due to increasing costs of operating and maintaining systems over three decades, they had in fact avoided significantly higher costs that would have been incurred without conservation. Without the 21% reduction in per capita demand realized through conservation programs, rate structures, and plumbing code improvements, Westminster would have needed to develop additional supply and treatment, as well as wastewater management. Securing the resource, operations, infrastructure, and maintenance would have cost hundreds of millions of dollars passed on to customers in the form of 80% higher tap fees and 91% higher rates.⁹⁰

On December 17, 2015, the New York State Public Service Commission directed Suez (formerly United Water) to abandon the construction of a proposed \$130 million, 7.5 mgd desalination plant, saying that it was no longer needed.⁹¹ The Rockland County Task Force on Water Resources Management, working with The Rockland Water Coalition, Rockland County officials, Suez, and EPA's WaterSense program, identified conservation approaches and supply alternatives to ensure a safe, cost-effective, long-term water supply for Rockland County. The Environmental Committee of Rockland County Legislature unanimously approved a resolution to amend the County Procurement Policy to require County facilities to use WaterSense labeled fixtures when available and compatible with existing infrastructure. Rockland County is also establishing a [comprehensive water policy](#) that includes water conservation, leak detection, and incremental new sources of supply.⁹² Existing conservation measures, which include customer education, discounts on water-saving devices, and a summer/winter water rate structure, will continue. Several additional measures are also being proposed, such as helping municipal authorities develop conservation-oriented local ordinances, conducting water audits, and implementing a rebate program for customers who install water-saving appliances and irrigation tools.

Best Practices

Deliverable: Water Conservation and Efficiency Plan

The water utility should incorporate all of the analysis, measures, programs, policies, and savings above into a comprehensive water conservation and efficiency plan. Any opportunities identified through auditing or review of the elements of these guidelines (e.g., universal metering or rate structure adjustments) should be addressed. Any plans to reduce NRW (e.g., through more robust leak detection strategies) should be captured, with annual targets in line with water loss control strategies. The plan should identify funding streams for any measures with associated costs, ideally on a time-frame consistent with budgeting or planning cycles (e.g., five years). The water utility should evaluate and document a wide range of robust water efficiency measures and programs with the potential to secure significant water savings. Earlier actions may address the greatest opportunities or needs for implementing efficiency strategies (e.g., addressing outdoor use with irrigation incentives or requirements, or rebates for WaterSense products in high-use environments). The utility should select a combination of measures that will deliver the goal amount of water with the highest benefit-cost ratio.

Did You Know?

Thermoelectric power use accounted for 45 percent of total 2010 U.S. water withdrawals, or 161,000 MGD (million gallons per day), with 99 percent coming from surface waters.²³ Thermoelectric power is the primary water use category in all southeastern states except Mississippi, where irrigation is the largest use category. Resource authorities may wish to consider energy conservation measures and incentives in comprehensive planning to reduce overall stresses on and competition for water resources.

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Appendix A: Deliverables Chart

	Category of Water Conservation/ Efficiency	Metric	Benchmark or Threshold	Deliverable or Supporting Documentation	Resources & Examples
1a	WATER SYSTEM MANAGEMENT: Supply Side & Demand Side Accounting			Copy of annual AWWA Water Audit in the AWWA Free Water Audit Software ® for the five preceding calendar or fiscal years.	<p>AWWA M36 Manual AWWA Water Loss Committee</p> <p>States: Georgia, Tennessee, California Urban Water Conservation Council, Texas Water Development Board</p>
1b		Data Validity (from AWWA Water Audit)	If Data Validity Score is < 71 (out of 100)	Submit a strategy outlining planned improvements with a timeline to achieve or surpass the Data Validity Score threshold of 71	
1c		Data Validity (from AWWA Water Audit)	If Data Validity Score is ≥ 71	Submit a water loss management plan showing how the utility will continue to optimize operations to maintain and/or improve system efficiencies. Plan should report the amount of water loss reduction achieved within the past five years of AWWA audits and include a determination of the annual volume of water loss reduction that can be achieved over the upcoming five years.	
1d		Non-Revenue Water (from AWWA Water Audit)	Goal: Improving trend	From the AWWA water audit, report the last five years of non-revenue water as an annual volume in million gallons.	
	WATER SYSTEM MANAGEMENT: Supply Side & Demand Side Accounting		*Data Validity should be 71 or greater.	If data validity is less than 71 utility is to focus on improving data validity score. If ≥71, then see next steps in 2a-2d.	<p>AWWA M36 Manual , with sample plan on pp. 150-154 AWWA Water Loss Committee</p> <p>Leakage Management Technologies Report (EPA and AWWA Research Foundation)</p> <p>EPA Report: Control and Mitigation of Drinking Water Losses in Distribution Systems</p> <p>GA Water System Audits and Water Loss Control Manual</p>
2a		Infrastructure Leakage Index (ILI)	Infrastructure Leakage Index (ILI) < 3.0. If no ILI is generated in the audit, use Op 24 (see below).	AWWA Water Audit output: ILI should be less than 3.0 and approaching 1.0, indicating the utility's real losses are close to the UARL, making further reductions in real water losses unattainable or uneconomical.	
2b		Op 24	Utilities should demonstrate improvement in leakage reduction over a five year period by showing a decreasing trend in Op24.	AWWA Water Audit output: Utilities should report on Op24 as appropriate for system size. Op24 is the better indicator for small utilities (fewer than 32 connections per mile).	
2c		Economic Level of Leakage Analysis	Completion of assessment for use in leak abatement planning	ELL analysis conducted within last two years to determine the most cost-effective leak abatement opportunities and the potential for cost-effective water savings. Provide calculations that include avoided costs for expansion of water supply infrastructure.	
2d		Water Loss Control Program/ Plan	Utility has proactive water loss control program in place	Written leakage management plan for reduction of real losses, or Economic Level of Leakage (ELL) analysis demonstrating that an ILI of > 3.0 is justified for the utility's water system. Summary outputs of a component analysis of real loss, and conclusions identifying cost-effective real loss control measures. Incorporate water savings through leak abatement into projections for future water needs.	

Appendix A: Deliverables Chart

	Category of Water Conservation/Efficiency	Metric	Benchmark or Threshold	Deliverable or Supporting Documentation	Resources & Examples
3a	METERING	Universal Metering of all customers, public and private	100% of utility service connections metered (public and private) and billed based on metered use	<p>The utility will report on the percentage of all service connections that are metered.</p> <p>From AWWA Water Audit, utility will report total authorized consumption (gallons per day) and a breakdown as follows:</p> <ul style="list-style-type: none"> • billed metered • billed unmetered • unbilled metered • unbilled unmetered <p>The utility will provide an assessment of the potential for water savings through implementation of:</p> <ul style="list-style-type: none"> • Universal metering • Sub-metering • Bulk metering calibration and replacement program • Billing based on actual water use • Source water metering 	<p>AWWA M52 Water Conservation Programs – A Planning Manual</p> <p>National Environmental Services Center, Tech Brief: Water Meters, 2009.</p>
3b		Source Water Metering	Meter all sources including groundwater, surface water, or reclaimed water	Report on flow-verification and calibration routines. Information may include: measuring device information, including: type, identification number, frequency of reading, type of recording register, unit of measure (and conversion factor, if necessary), multiplier, date of installation, size of pipe or conduit, frequency of flow verification and calibration, and dates of last flow verification and calibration.	
4	CONSERVATION-RATE STRUCTURE	Effective conservation rate structure	Rate structure in effect which addresses revenue stability while incentivizing conservation and efficiency; no flat charges or declining-block rate structures in place.	<ul style="list-style-type: none"> • Rate Structure Analysis: The utility should provide a recent (less than two years old) rate structure analysis that examines a range of rate structures that both address the need for utility revenue stability as well as incentivizing conservation and efficiency. • Projection of demand reductions expected to result from pricing water for efficiency • Documentation of water demand challenges (peak summer use, indoor water leaks/outdated plumbing) supported by analysis of usage patterns over the course of a year. • A copy of legally adopted rate ordinance that includes a rate structure designed to incentivize efficiency and conservation. Utility will also provide documentation of all rate changes within five years of submittal. • A utility bill reflecting the adopted conservation rate structure. 	<p><i>Financing Sustainable Water</i> initiative. Alliance for Water Efficiency.</p> <p><i>Principles of Water Rates, Fees, and Charges (M1 Manual)</i>, AWWA, Sixth Edition</p> <p>EPA Web-based Water Pricing Resources</p> <p>SWIC-Recommended Guidance for North Carolina Utilities Attempting to Support Water Conservation in the Long-Term through Rate Structure Design and Billing Practices</p> <p>Need To Know: Water Rates Series, 2013. Pacific Institute and Alliance for Water Efficiency.</p> <p>UNC EFC Rates Dashboards and Info</p> <p>“Water Rates and Conservation,” David Mitchell and Tom Chesnutt. 2009.</p>

Appendix A: Deliverables Chart

	Category of Water Conservation/Efficiency	Metric	Benchmark or Threshold	Deliverable or Supporting Documentation	Resources & Examples
5a	END USE WATER CONSERVATION- AND EFFICIENCY ANALYSIS	Customer Classes		<p>Clearly describe service area and customer base</p> <p>Provide documentation of the number of customers by customer class and water consumption (million gallons/day) by customer class. Define customer classes to include at a minimum: residential-single family, residential multi-family, commercial, industrial, and institutional customer classes.</p> <p>For residential use, separate indoor and outdoor use if possible. If not, provide estimate based on winter demand.</p> <p>Document seasonal variability of water use by customer class, preferably on a refined time scale such as monthly, weekly, or daily if possible.</p> <p>Graph each customer class's seasonal usage.</p> <p>Document average (e.g., by season) and peak (highest total water use measured on an hourly, daily, or monthly basis as most relevant to drivers of supply constraints) use by customer class.</p>	<p>AWWA M52 Water Conservation Programs – A Planning Manual</p> <p>Amy Vickers, <i>Handbook of Water Use and Conservation, 2001</i></p> <p>Water Conservation Planning Tools and Models, Brian Skeens, CH2MHill</p> <p>Texas Water Development Board's Water Conservation Best Management Practices: BMPs for Municipal Water Users, February 2013</p>
5b		Gallons Per Capita per Day (GPCD)	Residential customer class GPCD (residential use/residential service population) for conserving households of < 45.2 GPCD or < 44.7 GPCD.	<p>Provide residential GPCD values, with documentation of calculations used to develop residential GPCD numbers. If indoor residential GPCD is higher than the targets, then this is an indicator of gains in efficiency that can still be made in the indoor residential sector.</p> <p>Note: Non-residential customer classes do not lend themselves to GPCD calculations.</p>	examples: Southern Nevada Water Authority
5c		Assessment of Water Savings Potential from Implementation of End Use Efficiency Measures	The utility should submit an assessment of the savings potential from implementation of end use efficiency measures, and adjust future water demand projections to account for the lower water use expected of customers. Vickers (2001) provides several useful worksheets in appendices that can be helpful in guiding assessment of potential savings of ICI, residential, and outdoor water use.	<p>For each of the classes identified (at least those described below in sections 5d-5i): Document the potential (future) water use reductions/savings from targeted conservation and efficiency measures.</p> <p>Provide an assessment of how future water demand projections would be changed by efficiency measure implementation.</p> <p>Provide an analysis to evaluate benefit-cost of water conservation and efficiency measures (to be compared to the benefit-cost of the proposed reservoir, intake, or other supply project).</p>	<p>Alliance for Water Efficiency Water Conservation Tracking Tool</p> <p>Proprietary models such as the Decision Support System model</p>

Appendix A: Deliverables Chart

	Category of Water Conservation/Efficiency	Metric	Benchmark or Threshold	Deliverable or Supporting Documentation	Resources & Examples
5d	Measures, policies, programs that should be examined as part of the End Use Water Conservation/Efficiency Analysis	Residential-single family	Indoor retrofit target: Homes built before 1993. Landscape target: See Landscape Section below	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • Provide water efficiency audits and 'direct-install' programs targeted at high water users; • High-efficiency toilet direct install program; high-efficiency toilet giveaways; high-efficiency toilet rebates; • Rebates for high-efficiency washing machines; • Require 'retrofit on reconnect', requiring the upgrading of plumbing fixtures when a customer establishes a new account with the water provider. 	DeKalb County, Georgia Ordinance; Inefficient Plumbing Fixtures Replacement Plan. 2008. Chapter 25, Article II, of the Code of DeKalb County, Georgia, Section 25-45 through Section 25-60
5e		Residential multi-family	Indoor retrofit target: Buildings constructed before 1993 and/or with high square footage and/or high water use. Landscape target - See Landscape section below	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • Provide water efficiency audits and 'direct-install' programs targeted at high water users; • High-efficiency toilet direct install program, giveaways, rebates; • Require sub-metering of individual residential units and monthly billing based on actual metered consumption. 	
5f		Commercial	Indoor retrofit target: Buildings constructed before 1993 and/or with high square footage and/or high water use. Landscape target – See Landscape section below	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • High efficiency pre-rinse spray valves (PRSV) for all restaurants; • Retrofit incentives/ rebates for commercial clothes washers, high-efficiency toilets, etc.; • 'Retrofit on reconnect' requiring the upgrade of plumbing fixtures when a customer establishes a new water account; • Require sub-metering of individual units and monthly billing based on actual metered consumption. 	WaterSense at Work: Best Management Practices for Commercial and Institutional Buildings EPA WaterSense Commercial Resources San Antonio Water System (TX) Commercial Programs
5g		Industrial	Indoor retrofit target: Buildings constructed before 1993 and/or with high square footage and/or high water use.	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • Incentive programs targeted at high water users for industrial processes. 	San Antonio Water System (TX) Industrial Retrofit Program

Appendix A: Deliverables Chart

	Category of Water Conservation/Efficiency	Metric	Benchmark or Threshold	Deliverable or Supporting Documentation	Resources & Examples
5h		Institutional	Indoor retrofit target: buildings built before 1993 and/or with high square footage and/or high water use. Landscape target - See Landscape section below	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • High efficiency pre-rinse spray valves (PRSV) for all restaurant/cafeteria facilities; • Retrofit incentives rebates for commercial clothes washers, high-efficiency toilets, etc.; • ‘Retrofit on reconnect’ requiring the upgrade of plumbing fixtures when a new customer establishes a water account; • Require sub-metering of individual units and monthly billing based on actual metered consumption. 	WaterSense at Work: Best management Practices for Commercial and Institutional Buildings
5i		Landscape	Landscape target: Focus on reducing the irrigation demands, managing peak demand	Utility to assess the potential water use reductions from incentives/policies/programs including but not limited to: <ul style="list-style-type: none"> • Pricing – Conservation rate structure targeting peak water use. Given that irrigation water is discretionary and non-essential, this water should be priced at the highest tier or bracket. • Outdoor Water Incentives – moisture/rain sensor rebates; irrigation audits; large water user rainwater/gray water, condensate capture retrofit program; • Policy –Outdoor watering schedule that allows watering only when evaporation rates are lowest; moisture sensor requirement; Require certified WaterSense irrigation professionals for installation of outdoor irrigation systems. 	EPA Report: Water-Smart Landscapes: Water Efficient Landscapes Start with WaterSense Ontario Outdoor Water Use Reduction Manual EPA WaterSense Outdoor Water Resources Georgia Water Stewardship Act, 2010 UNC EFC Utility Brief: Residential Irrigation, 2009
6	WATER CONSERVATION AND EFFICIENCY PLAN	Performance-based goal for water conservation and efficiency	Set a goal (in MGD) for water conservation and efficiency demand reduction that is the same as reservoir’s proposed yield in order to target minimization and/or elimination of the need for the proposed reservoir, intake, or other supply project. For more information on developing goals for water efficiency and conservation planning see the AWWA M52, Chapter 2, p. 15.	Utility to identify and document opportunities for savings such as eliminating water waste and reducing peak water use, etc. The water utility should incorporate all of the analysis, measures, programs, policies, and savings above into a comprehensive water efficiency and conservation plan. The water utility should evaluate and document a wide range of robust water efficiency measures and programs with the potential to secure significant water savings. The utility should select a combination of measures that will deliver the goal amount of water with the highest benefit-cost ratio.	AWWA M52 Water Conservation Programs: A Planning Manual USEPA Water Conservation Plan Guidelines, Appendix A, 1998 EPA Web page for water conservation and efficiency resources

For additional information, please contact:

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