MASSACHUSETTS
WATER CONSERVATION STANDARDS

The Commonwealth of Massachusetts
EXECUTIVE OFFICE of ENERGY AND ENVIRONMENTAL AFFAIRS
and
WATER RESOURCES COMMISSION
February 2018 [DRAFT]

Letter from the Secretary

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ABBREVIATIONS

ASR	Annual Statistical Report
AWWA	American Water Works Association
CMR	Code of Massachusetts Regulations
EEA	Energy and Environmental Affairs, Executive Office of (Massachusetts)
EPA	Environmental Protection Agency (U.S.)
gpcd	Gallons per capita per day
gpd	Gallons per day
gpf	Gallons per flush
gpm	Gallons per minute
HET	High-efficiency toilet
ICI	Industrial, commercial, institutional
I/I	Infiltration and Inflow
IWRMP	Integrated Water Resources Management Plan
LID	Low-impact development
MaP	Maximum performance testing
MAPC	Metropolitan Area Planning Council
MassDEP	Massachusetts Department of Environmental Protection
MEPA	Massachusetts Environmental Policy Act
MGL	Massachusetts General Laws
MWRA	Massachusetts Water Resources Authority
NEWWA	New England Water Works Association
NPDES	National Pollutant Discharge Elimination System
OTA	Office of Technical Assistance (Massachusetts)
psi	pounds per square inch
REUWS	Residential End Uses of Water Study
RGPCD	Residential gallons per capita per day
UAW	Unaccounted-for water
UMass	University of Massachusetts
WRC	Water Resources Commission (Massachusetts)

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Introduction to the Water Conservation Standards

Intent and Purpose

The *Water Conservation Standards* (the Standards) set statewide goals for water conservation and water use efficiency and provide guidance on effective conservation measures. The Standards also provide a vehicle to educate Massachusetts' citizens about the importance of water conservation, its crucial link to our natural resources, and how all consumers can use water more efficiently. Water conservation is defined as any beneficial reduction in water loss, waste, or use, and water efficiency is defined as the accomplishment of a function, task, process, or result with the minimal amount of water feasible[1]. As short-term droughts are predicted to occur more frequently in coming years due to climate change, water conservation and efficiency continue to become ever more critical tools for the Commonwealth's long-term sustainability.

This document includes both *standards* and *recommendations*. *Standards* represent best practices. They should be adopted by water suppliers and water users, as applicable, wherever possible. They should also be incorporated by state agencies into water resources management programs and the issuance of permits or approvals that govern water use. *Recommendations* represent emerging thinking in water-use efficiency. Although they may not currently be suited to a regulatory context or may not be as widely achievable in the short term as standards due to economic or technical limitations, the Massachusetts Water Resources Commission strongly encourages their adoption wherever possible. Together, the standards and recommendations should guide all programs affecting the planning and management of the Commonwealth's water resources, including but not limited to: local and state water conservation plans, the Water Management Act, the Interbasin Transfer Act, and the Massachusetts Environmental Policy Act (MEPA). They should also be incorporated into construction, rehabilitation, operation, and facility development activities statewide, as applicable.

The Standards are intended as a foundation, helping to establish baseline efficiencies across sectors. In times of drought and water supply shortage, the Commission strongly urges communities and agencies alike to go beyond the practices outlined herein whenever possible.

History

The Standards issued here are another revision of the original Water Conservation Standards, adopted by the Water Resources Commission (the Commission) on October 13, 1992. The 1992 Standards were intended to assist Massachusetts' public water suppliers in achieving efficiency in their systems and to foster education of residents, industrial facilities, and places of business on the importance of water efficiency and effective conservation measures. The Massachusetts Department of Environmental Protection (MassDEP) used the 1992 Standards to condition water withdrawal permits under the Water Management Act program, and the Commission used the Standards in reviewing applications under the Interbasin Transfer Act.

In July 2006, the Commission completed a major revision and update of the Standards. New sections addressed comprehensive planning, water audits, and agricultural water use, and key features of the Lawn and Landscape Addendum to the 1992 Standards were incorporated. Numeric standards for residential water consumption (65 gallons per capita per day) and unaccounted-for water (10 percent) were also added. In 2012, the Standards underwent minor non-substantive revisions such as changes to website addresses and agency names to ensure the citations, resources, and governmental entities listed were current. This edition represents substantive changes to the 2012 Standards. It is the intent of the Commission to review the standards every five years and update them as needed.

[1] Vickers, Amy. 2001. *Handbook of water use and conservation.* Amherst, MA: WaterPlow Press.

Background and Goals

Massachusetts's economy, environment, and quality of life are inextricably linked to its water resources. The Commonwealth receives an average of 49 inches of rainfall each year[2], although rainfall can vary significantly from year to year – during a severe drought year, precipitation can drop to below 30 inches. Because Massachusetts's geology features relatively shallow aquifers (natural underground storage capacity) in most regions, even short-term droughts can deplete water supply sources, streams, and ponds. With over six million people living on slightly more than six million acres of land, annual typical seasonal use patterns can also lead to shortages, as high summertime demand coincides with the period of highest water uptake by forests and other vegetated landscapes. In fact, despite abundant rainfall, some of the Commonwealth's water suppliers have difficulty meeting demands, between stresses on existing sources and constraints on new sources including cost, environmental impacts, and an increasing scarcity of suitable sites.

The Commonwealth's native plants and animals have evolved to depend on the water in our natural environment. Low stream flows and water body levels can decrease water quality, cause loss of habitat, and disrupt connections between habitats. Our ecosystems are quite resilient in the face of naturally occurring periods of drought, but human water withdrawals can magnify the duration, frequency, and severity of low water conditions beyond natural levels. Climate change is also expected to increase the frequency and severity of drought in Massachusetts. Rainfall patterns also appear to be shifting toward more total annual precipitation but concentrated into fewer, more intense storms, which leads to more rapid runoff and less retention of rainfall in the groundwater and stream systems[3]. Placing streams and wetlands under chronic and unnatural low-flow conditions can cause substantial harm to aquatic organisms and ecosystems, and ultimately to our economy and quality of life through loss of scenic and recreation value, loss of ecosystem services such as pollution mitigation, and loss of economically valuable species.

In short, stresses on Massachusetts water resources are felt by both our communities and our natural ecosystems. Massachusetts' water use and growth and development need to respond to these constraints. While Massachusetts has achieved great strides in water conservation and water efficiency, achieving one of the lowest residential per capita water demands in the country, significant opportunities remain for even greater improvements. By continuing to help Massachusetts make strides in water conservation and efficiency, the Standards are intended to:

1. Preserve water resources as the Commonwealth's public trust;
2. Sustain water supplies for current and future needs, including in times of drought;
3. Reduce negative impacts on aquatic ecosystems;
4. Reduce utility costs by**:**
    a) reducing water waste and associated energy and treatment costs;
    b) prolonging the natural life of system components and equipment; and
    c) postponing or eliminating the need to develop additional water supply sources;
5. Spur economic development by helping ensure reliable and sustainable access to water.

[2] National Weather Service, 30-year average (1981-2010)
[3] National Weather Service, "Climate Change in Massachusetts and its Impact on River Flood Behavior" (presentation to the MA Water Resources Commission, October 2017)

Thinking Long-Term

Water conservation and efficiency are critical to ensuring the long-term sustainability of water supplies and the abundant ecosystems that rely on water in the natural environment. Their promise lies in the idea that increasing knowledge, sophistication, technology and care can save substantial volumes of water and increase the productivity of each unit of water that is used. In turn, such an environmentally responsible approach to the use and management of water resources is a crucial factor in sustaining the economic health and continued vitality of the State, as well as its preparedness and resilience in the face of drought.

Overview of the Standards and Recommendations

There is a role for everyone in water conservation and efficiency efforts. Each segment of the water-using community can support the collective effort to reduce water waste and use water more efficiently for essential purposes. The standards and recommendations in this document are intended for adoption, as applicable, by: government entities and regulating bodies; municipal, private, and regional water suppliers; and water consumers, including individual households, businesses, industries, and public agencies.

The Standards are organized into ten chapters, addressing key areas of water supply planning, management, and use:

1. Comprehensive Planning and Drought Management Planning
2. Water Loss Control
3. Metering
4. Pricing
5. Residential Water Use
6. Public Sector
7. Industrial, Commercial, and Institutional
8. Agricultural Water Use
9. Outdoor Water Use
10. Public Education and Outreach

Each chapter begins with a bulleted list of target audiences based on the chapter's content, to help guide readers to the areas most useful to them. Additionally several chapters include lists of additional resources, tools, and references, and a set of appendices offer additional detail, background, and guidance.

1.0 Comprehensive Water Resource Planning and Drought Management Planning

This chapter applies primarily to:

- *Water suppliers*
- *Municipal bodies, boards, and departments*
- *State policy and regulatory entities*

Several human-influenced components impact a watershed's hydrological cycle – water withdrawals, wastewater discharges, and land-use decisions that impact stormwater flows. Together, these components can have a significant influence on the quantity and quality of water. An integrated approach is needed to keep water local and to begin to address and mitigate any hydrological imbalances that result. Water conservation is a major component of this approach and, as with energy conservation, is often the least costly and least damaging additional source of water. Planning for future upgrades, development, or expansion of water infrastructure within a community must take into consideration the interdependence of these three components.

The Local Water Resources Management Plan can provide a framework for implementing these Standards and establishing long-term priorities and plans for system maintenance, source protection, and, as necessary, new source development. The goal of the plan is to integrate water supply, wastewater, and stormwater planning at the community, water, sewer, or stormwater district, or water or sewer authority level.

Communities with severe water resource management problems may benefit from an Integrated Water Resources Management Plan (IWRMP). Components of an IWRMP may be triggered by the Massachusetts Environmental Policy Act (MEPA) or the Interbasin Transfer Act. The Clean Water State Revolving Fund also encourages integrated water resources planning. The IWRMP may encompass an assessment of a community's existing water supply, wastewater, and stormwater practices and the impacts of these on the water balance in the watershed. It also identifies future needs and evaluates alternative approaches to meet those needs.

Drought or emergency management plans are another important component of water supply and demand management programs. Pro-active planning for low rainfall conditions has assumed greater significance in light of the 2016-2017 drought, when much of the state was at Drought Level 4 (out of 5) for a prolonged period of time (see Fig. 1.1). Reductions in water use, increased water efficiency, examining and resurrecting emergency connections and overall planning for long-term water deficits and their impacts on various users will go a long

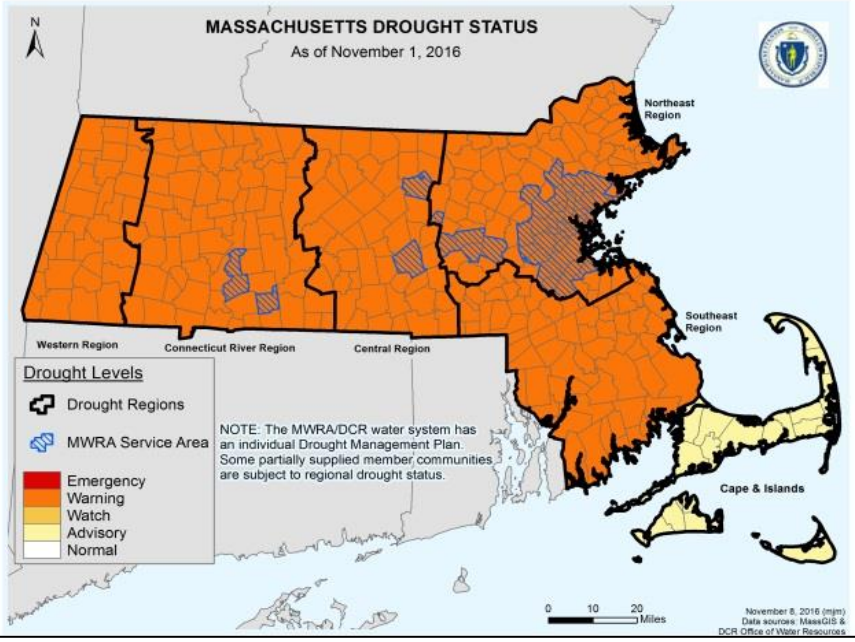


Figure 1.1 Massachusetts Official Drought Status as of November 1, 2016

way in creating a sustainable water supply for communities. Each public water supplier should have a written plan to respond to both naturally induced and human-made emergencies. A demand management plan that incorporates seasonal water use strategies is important for assisting water suppliers to reduce high seasonal demands and avoid excessive strain on the water supply and distribution system or on the environment (as described in Chapter 9.0, Outdoor Water Use).

1.1 Standards

1. **Develop a drought management plan** that follows American Water Works Association's Manual of Water Supply Practices M60: Drought Preparedness and Response (AWWA, 2011), and any state-developed drought planning guidance. Develop strategies appropriate to the system to reduce daily and seasonal peak demands and develop contingency plans to address the impacts of drought, seasonal shortages and other non-emergency water supply shortfalls.
2. **Develop emergency response plans** as per MassDEP requirements[4].
3. **Develop a written program to comply with these Conservation Standards** and, where possible, with the recommendations outlined in this document, in the operation and management of the water supply systems.
4. **Make the above documents readily available** to personnel from all municipal departments to facilitate compliance and, if necessary, enforcement.

1.2 Recommendations

1. **Integrated Planning –** Infrastructure planning evaluations within communities should include water supply, wastewater, and stormwater with greater emphasis on the issue that is most problematic. To assist with this integrated planning, see MassDEP's guidance for Water Resources Management Planning[5]. The plans should be updated periodically. Specific principles that should be considered include the following:
    - Stormwater. Stormwater is often a significant component of the water budget. How it is managed can help determine whether it is transported quickly out of a subbasin as direct runoff to streams and rivers or whether it recharges the groundwater and helps maintain a more natural hydrologic cycle in a subbasin. Integrated planning efforts should recognize stormwater as a resource and promote its recharge through infiltration measures including environmentally sensitive site design, low impact development[6], stormwater best management practices, and good operation and maintenance.
    - Wastewater. Infrastructure often transports wastewater out of its basin of origin, disturbing the water balance and depleting local streamflow and groundwater. To help replenish aquifers, enhance riverine base flows, and maintain healthy flow levels even in high-demand summer months, options

[4] http://www.mass.gov/eea/agencies/massdep/water/drinking/water-systems-ops.html#12
[5] http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/iwrmp.pdf
[6] Low Impact Development (LID) is an approach to land development and stormwater management that encourages groundwater infiltration, runoff detention and filtration. The primary tools of LID are site design to minimize land and vegetation disturbance and the use of landscaping features and naturally vegetated areas to encourage detention, infiltration and filtration of stormwater on site. Other tools include water conservation and use of pervious paving surfaces. See the low-impact development section of the Water Resources Commission website.

such as decentralized treatment plants, local recharge, and water reuse should be strongly considered. With appropriate considerations for treatment and water quality, communities should consider use of reclaimed water for ballparks, golf courses, driving range fields, and other recreational irrigation, as well as for large-scale development projects.[7]

- Infiltration and Inflow (I/I). Infiltration is defined as groundwater that enters the wastewater collection system through physical defects such as cracked pipes/manholes or deteriorated joints. Typically, many sewer pipes are below the surrounding groundwater table; therefore leakage of clean groundwater into the sewer (infiltration) is a broad problem. Where sewer pipes run through Zone II areas or other land areas contributing flow to water supply withdrawal points, infiltration to those pipes can significantly reduce the yield of that water supply. Inflow is extraneous flow entering the wastewater collection system through point sources. Inflow may be directly related to stormwater runoff from sources such as roof leaders, yard and area drains, sump pumps, manhole covers, and cross-connections from storm drains or catch basins. Inflow may also be contributed from non-storm-related point sources, such as leaking tide gates, cooling-water discharges, or drains from springs and swampy areas[8].

  I/I removal plays an important role in balancing the water budget by minimizing the amount of groundwater and stormwater lost into wastewater systems. As communities develop their I/I plans as required by 314 CMR 12.04, communities should strive to implement the seven overall goals approved by the I/I Task Force, as applicable:
  - Eliminate all sewer system backups;
  - Minimize, with a long-term goal of eliminating, health and environmental impacts of sewer system overflows related to I/I;
  - Remove all (and prevent new) inflow sources from separate sanitary systems;
  - Minimize system-wide infiltration;
  - Educate and involve the public;
  - Develop an operation and maintenance program; and
  - Improve funding mechanisms for identifying and removing I/I.

- Water Supply. Water supply development, whether for residential use, industrial use, development, irrigation or fire protection, needs to be within the water budget of the local basin. In many cases, water is moved via infrastructure from one basin to another, thus dewatering one basin in order to support another. This can lead to low streamflows, habitat impairment and other ecological problems in the donor basin. Ideally, the water should be used and discharged locally so as to create the least amount of disturbance to the water balance and the local ecology, and recharged whenever possible. In cases where transport of water across basin lines is required, alternatives must be considered, as required by the Interbasin Transfer Act. The preferred alternative would be one that is most protective of the environment while providing the most time- and cost-sensitive option.

2. **Communicate with other local officials –** To aid in community planning and decision making, water suppliers should keep local officials (Conservation Commissions, Zoning and Planning Boards, Selectmen, and other agencies concerned with development) regularly informed of water consumption and supply availability. These local officials should, in turn, ensure that their actions affecting land or water use do not impair the integrity of the public water supply by enabling source water to be diminished in quality or quantity, or by permitting development that exceeds the capacity of the system or impairs the quantity or quality of future potential sources.

[7] Regulations on reclaimed water (promulgated by MassDEP in March 2009) are available at 314 CMR 20.00: Reclaimed Water Permit Program and Standards.
[8] Infiltration/Inflow Task Force March 2001

3. **Water Banks/Water-Neutral Community Development** – Communities and water suppliers, especially those prone to capacity problems or experiencing significant growth, should consider establishing a water bank. The purpose of a water bank is to provide a water supplier, developer, or municipality with required resources to maintain or reduce existing demand on water resources, while accommodating the water needs of existing and future development. For example, a water bank could require that anyone seeking to connect to the municipal water supply must reduce from the existing water supply system or end users at least two gallons for every new gallon that is required. Alternatively, a developer seeking connection to a wastewater collection system may reduce infiltration and inflow or recharge stormwater. See Appendix A for further information on water banks, and sidebar on "water-neutral community development" tools available through the Net Blue Project.

The Net Blue Project

A collaborative initiative of the Alliance for Water Efficiency, the Environmental Law Institute, and River Network

Explore opportunities for water-neutral community development, in which offsets such as rainwater harvesting and conservation retrofits help ensure that new growth results in no net additional demands on the water supply system. Offsets can be targeted toward individual projects or applied at a wider level through local bylaws or ordinances. The Net Blue Project provides customizable tools and resources supporting this concept.

1.3 Resources

- MA Water Resources Commission Interbasin Transfer Act Performance Standards Guidance, Update 2001, Appendix B: Local Water Resources Management Plan Outline. Available at: https://edit.mass.gov/files/documents/2017/08/31/Performance%20Standards%20Guidance%20Document.pdf
- Net Blue – a collaborative initiative of the Alliance for Water Efficiency, the Environmental Law Institute, and River Network (2015). Information, workbooks, spreadsheets, and examples of opportunities to pursue "water neutral" community growth.
  Available at: http://www.allianceforwaterefficiency.org/net-blue.aspx
- American Water Works Association (2011). *Manual of Water Supply Practice M60: Drought Preparedness and Response*, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=26750
- American Water Works Association (2006). *Manual of Water Supply Practice M52: Water Conservation Programs - A Planning Manual*, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=6740
- American Water Works Association (2017). *Manual of Water Supply Practice M50: Water Resources Planning, third edition*, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=62573688
- ANSI/AWWA G480-13 (2013, First Edition): Water Conservation Program Operation and Management Standard, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=35009354
- Vickers, Amy. 2001. *Handbook of water use and conservation.* Amherst, MA: WaterPlow Press.

1.4 Related Appendices

- Appendix A: Water Bank Guidance
- Appendix B: Model Bylaws

2.0 Water Loss Control

This chapter applies primarily to:

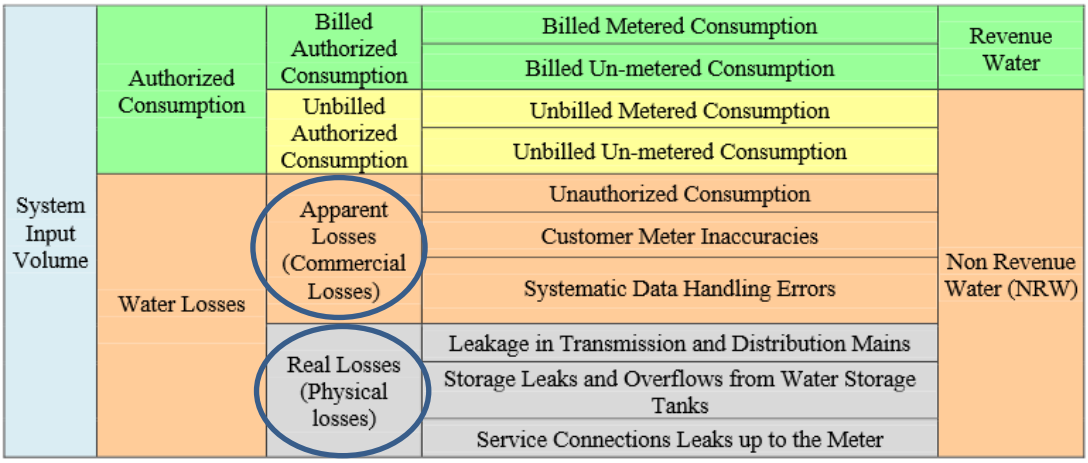
- *Water suppliers*
- *Municipal bodies, boards, and departments*

Water loss control is the implementation of best management practices to ensure that water entering a distribution system is efficiently delivered to each point of use. Water loss control measures typically fall into two categories - accounting for the water distributed in the system and managing the infrastructure to prevent system losses. Evaluating the measures for their effectiveness is also a part of water loss control.

Performing a water audit is an important first step of water loss control. Water audits provide water suppliers with a means of accounting for water, identifying and reducing water and revenue losses, and making better use of water resources. Audits help suppliers to categorize losses as either real losses from a system (such as distribution leakage, service connection leakage, and tank leakage and overflows) or apparent losses (such as data handling errors, unauthorized consumption, and metering inaccuracies). Figure 2.1 shows how real and apparent losses (circled) are defined within the American Water Works Association (AWWA)/International Water Association (IWA) water balance categories. The overall goal of the water audit is to help the public water supplier select strategies to reduce real and apparent losses.

Figure 2.1 The AWWA/IWA Water Balance

From U.S. Environmental Protection Agency. 2010 "Control and Mitigation of Drinking Water Losses in Distribution Systems," EPA 816-F-10-019



Determining and implementing intervention strategies is the next step in water loss control. Data from a water audit can be used for a component analysis to further categorize real losses in order to choose the most appropriate leak reduction measures. Managing infrastructure to minimize real losses is an important part of water loss control. Infrastructure maintenance and replacement, minimization of the number of joints and fittings, and minimization of leak repair times are strategies to control real losses. Regular leak detection survey and tracking programs provide critical information on real losses and are an essential component of system management. Detecting and fixing leaks can provide one of the largest returns on investment, especially in older systems. Another real loss control strategy is pressure management. Systems operating at higher pressures will have higher volumes of water lost through leaking joints and cracks in the pipe as well as increased leak frequency and pipe breaks. By optimizing pressure, suppliers can reduce leakage and can reduce stress on the distribution system infrastructure.

Evaluating the activities undertaken for their effectiveness is integral to successful water loss control. Evaluating data, tracking progress, comparing results to industry benchmarks and performance indicators, and identifying areas for improvement are the last steps in water loss control and are important for refining water loss control activities. A formal water loss control program consisting of all the above practices together with goals, assessment measures, and responsibilities will help suppliers:

- reduce unnecessary water withdrawals, environmental impacts from those withdrawals, and pumping and treatment costs;
- bolster revenue collection by addressing metering inaccuracies and unauthorized water use; and
- target maintenance efforts and infrastructure investments to minimize system disruptions and improve system integrity.

The Massachusetts Department of Environmental Protection (MassDEP) requires that public water suppliers that use more than 36.5 million gallons per year (annual average greater than 100,000 gallons per day) complete a basic water audit by calculating unaccounted-for water (UAW) as part of their Annual Statistical Report (ASR) submittal. UAW can include both real and apparent losses. Examples of UAW include, but are not limited to unavoidable leakage, recoverable leakage, meter inaccuracies, errors in estimation of stopped meters, unauthorized hydrant openings, illegal connections, data processing errors, and undocumented firefighting uses. UAW is defined as the residual resulting from the total volume of water supplied to a distribution system as measured by master meters, minus the sum of all volumes of water measured by consumption meters in the distribution system, and minus confidently estimated and documented volumes used for certain necessary purposes as specified by the MassDEP. In addition to a calculation for UAW volume, MassDEP's ASR has a calculation for UAW percentage in order to measure water system efficiency.

These volumes specified by MassDEP that can be confidently estimated and documented in writing and excluded from the calculation of UAW include fire protection, hydrant and water main flushing; water main flow testing; water main construction; storage tank overflow and drainage; bleeding or blow-offs; sewer and stormwater system flushing; street cleaning; and major main breaks, within parameters provided by MassDEP. Generally, leakage is classified as UAW; however, individual major water main breaks can be discounted on a case-by-case basis.

It is important to note that for many public water systems, a significant portion of UAW is not water that is physically wasted, misused or leaked (real losses), but water that is used for legitimate purposes but is not easily estimated or measured.

2.1 Standards

1. **Develop and Implement a Water Loss Control Program** – Communities should develop and implement a water loss control program. Guidance on water loss control programs can be found in EPA's "Control and Mitigation of Drinking Water Losses in Distribution System" as well as AWWA's M36. Elements to include in a water loss control program are:

    a. An annual water audit to better focus efforts on reducing real and apparent losses.
    b. Program goals and assessment measures.
    c. Record keeping, including tracking losses, leaks, and repairs, and tracking other volumes such as Confidently Estimated Municipal Use as defined by MassDEP.
    d. Leakage management including leak detection surveys, zone flow analysis, leak repair (as described in more detail in Standard #4), and pressure management.

e. System assessment and maintenance – To help eliminate and prevent leaks and water loss, water suppliers should perform assessments of their systems on a regular basis to determine where capital improvements are appropriate and incorporate the recommendations into a long-term capital improvement program. Specifically, aged and undersized or structurally deteriorated pipe should be replaced, and structurally sound pipe should be cleaned and lined to ensure long-term structural integrity.

f. Standards for installation, repairs, rehabilitation, and replacement of pipe. Poorly executed pipe installation and workmanship can contribute to unnecessary leakage, especially work done on service connections. All pipe work, repairs, and connections should be designed properly, executed properly, and inspected.

2. **Minimize real and apparent losses by meeting or demonstrating steady progress towards an unaccounted-for-water (UAW) percentage of 10% or less as calculated on the Annual Statistical Report form and approved by Massachusetts Department of Environmental Protection (MassDEP) as soon as practicable**. Water suppliers already meeting the 10% UAW standard should continue activities to account for all water and further reduce real and apparent losses, taking advantage of latest technology. The Commonwealth recognizes the existence of circumstances, such as aging infrastructure, that could affect a water supplier's ability to fully meet this standard. In such cases, the water supplier should document, as part of its regulatory requirements, all efforts that have been undertaken in order to comply with this standard, including development and implementation of a Water Loss Control Program.

3. **Conduct complete system-wide leak detection at least every three years.** Conduct more frequent leak detection surveys if needed as part of a Water Loss Control Program.

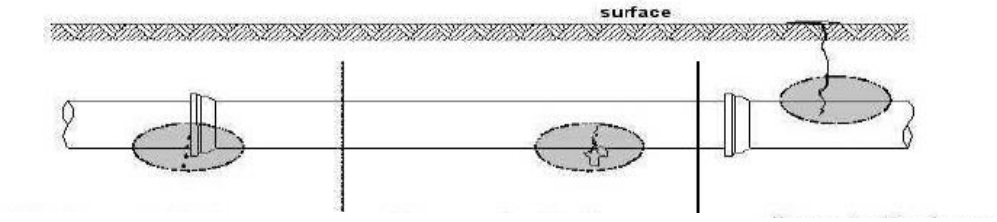
4. **Repair all found leaks as expeditiously as possible**. Establish a priority system to implement leak repairs. Leaks causing property damage or affecting public safety should be fixed immediately. Small leaks, if left unrepaired for long periods of time, can result in a greater volume of water loss than a large leak repaired more quickly. Water suppliers looking for guidance on the effect of time on leakage losses and the minimization of leakage run time should refer to AWWA Manual M36 "Water Audits and Loss Control Programs."

2.2 Recommendations

1. **Water Audits –** As a component of the Water Loss Control Program, conduct a desktop or paper top-down audit every year. This process uses existing information and records to do an annual water balance. The Environmental Protection Agency's (EPA) "Control and Mitigation of Drinking Water Losses in Distribution System" provides guidance on top-down audits and the basic steps. Examples of top-down audit methodologies are AWWA's Manual 36 and AWWA's Free Audit Software©, which is based on M36 and available on the AWWA website. Depending on the findings of the top-down audit, conduct problem-specific bottom-up audit(s) and activities to better refine numbers, identify sources of loss, and concentrate efforts on problem areas. Bottom-up audits and activities may consist of field measurements such as district metered area analyses, detailed investigations of practices such as metering, and a component analysis of real losses. A component analysis categorizes real losses into background leakage, un-reported leakage, and reported leakage. Water Research Foundation's "Real Loss Component Analysis: A Tool for Economic Water Loss Control" and the accompanying software model provides guidance for a component analysis and evaluation in order to identify least cost real loss

reduction strategies (see Figure 2.2 for the components of leakage and control strategies). Top-down and bottom-up audit analyses are strongly recommended for communities/systems showing significant and unexplainable increases in UAW from one year to the next, and for communities/systems that are unable to meet regulatory standards for UAW. Even if a community/system is meeting 10% UAW, an audit can prove useful. A water supplier can further confirm the basis of data entries in the water audit by having the audit "validated" by a qualified technical expert. The reference titled "Water Audits in the United States: A Review of Water Losses and Data Validity" cited in the Resources section of this chapter has more information about the levels of audit validation.

Figure 2.2 Components of Leakage and Control Strategies



Background Leakage	**Unreported Leakage**	**Reported Leakage**
Un-reported and un-detectable using traditional acoustic equipment.	Often does not surface but is detectable using traditional acoustic equipment.	Often surfaces and is reported by the public or utility workers.
Tools	**Tools**	**Tools**
• **Pressure Stabilization**	• **Pressure Stabilization**	• **Pressure Stabilization**
• **Pressure Reduction**	• **Pressure Reduction**	• **Pressure Reduction**
• **Main and Service Replacement**	• **Main and Service Replacement**	• **Main and Service Replacement**
• **Reduction in the Number of Joints and Fittings**	• **Reduction in the Number of Joints and Fittings**	• **Optimized repair time**
	• **Proactive Leak Detection and Repair**	

Source: Tardelli Filho, J. 2004. SABESP. Sao Paulo, Brazil: Internal reports, taken from American Water Works Association, 2016 "Water Audits and Loss Control Programs M36"

2. **Pressure management** - Although the topography of Massachusetts may make pressure management difficult in some systems, its use for water loss control should still be considered. There are several ways pressure management can be implemented including: a separate zone may be created with a pressure-reducing-valve or a pressure-reducing device that responds to demand or pressure, or is set to a time; or system-wide pressure may be reduced during low demand periods (e.g. at night or seasonally). Some systems may benefit especially if they have a single pressure zone and are having difficulty managing their water tanks and have water age issues. Systems need to consider water quality if creating a zone results in dead ends as well considering the impacts of reduced pressured on firefighting flow. Evaluating a system for pressure management is important if a system is calculating its unavoidable-real-losses (i.e. unavoidable leakage) using the equation developed by the International Water Association Water Loss Task Force; if a system or part of a system is at higher than needed pressure, unavoidable-real-losses may be higher than need be.

3. **Service Connection Leakage Control** - A significant portion of system leakage can be from service connections. Suppliers should have regulations in place to require property owners to fix leaks on their properties in a timely manner. Suppliers may also consider the use of meter pits at the beginning of service lines instead of meters within a house or building because if a customer is charged for leakage,

there is an incentive for the leak to be fixed. Other strategies for suppliers include a policy for service replacement by the supplier, especially as part of a water main replacement, and the inclusion of service connections in leak detection surveys.

4. **Leak Detection Services** – Water suppliers should consider pooling resources to procure leak detection services, similar to the Massachusetts Water Resources Authority program that procures a leak detection consultant for a three-year period and makes the consultant services available to customer communities on a task order basis. The three-year procurement results in lower pricing because it addresses a greater length of water main (about 5,000 miles) than would be procured by any one community (typically 100 to 200 miles).

5. **Automated Leak Detection** – Water suppliers should consider investing in an automated remote leak detection system. Leak listening devices may be installed permanently or temporarily throughout a system or just in problem areas. Noise information is logged and then automatically downloaded and processed. Alerts may be generated if there is a suspected leak. In addition, there are automated leak detection devices that can be installed on customer meters. These devices are able to listen for leaks on customer services and the near portion of the main.

6. **Pressure Reduction** – The Massachusetts Plumbing Code (248 CMR 10.14(g) Excessive Water Pressure) requires that a pressure-reducing valve be installed on the water service connection to a building when the supplied water pressure is 80 pounds per square inch (psi) or greater. Pressures of 80 psi or greater can damage building plumbing systems and fixtures and cause higher leakage and flow rates. Generally, service areas that can exceed 80 psi are found at low points or near water pumping stations. A licensed plumber can assess the need for, install, and adjust pressure-reducing valves thereby protecting a property owner's plumbing and conserving water. Water suppliers should evaluate their systems to determine where sustained system pressures may exceed 80 psi in order to respond to user inquiries and to work with plumbing inspectors and property owners to make them aware of the potential need of a pressure-reducing valve.

7. **Establish penalties and/or fines for stealing water** – Those with authority to set and enforce penalties for theft of public water such as municipal Water Commissioners, Town Selectmen, and public water suppliers should develop a new bylaw/ordinance or amend existing bylaws/ordinances to establish a penalty, by providing authority to levy a significant fine and/or penalty, that may be enforced criminally or otherwise. Private water suppliers are encouraged to work with those with authority to develop bylaws and ordinances for water theft. Massachusetts General Law (MGL Ch. 165, Sec. 11), establishes penalties for water theft consisting of triple the amount of damages or $1,000, whichever is greater, or imprisonment, or both[9].

2.3 Resources

- U.S. Environmental Protection Agency. 2013 "Water Audits and Water Loss Control for Public Water Systems," EPA 816-F-13-002
  https://www.epa.gov/dwcapacity/water-efficiency-and-conservation-resources-small-drinking-water-systems

[9] MGL Chapter 165, Section 11: Intentional injury to or interference with meter; penalty

- U.S. Environmental Protection Agency. 2010 "Control and Mitigation of Drinking Water Losses in Distribution Systems," EPA 816-F-10-019
  https://www.epa.gov/dwcapacity/water-efficiency-and-conservation-resources-small-drinking-water-systems
- American Water Works Association (2016). *Manual of Water Supply Practice M36: Water Audits and Loss Control Programs,* (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=51439782
- American Water Works Association, 2014 Free Audit Software© v. 5.0 available on AWWA's website, or most recent edition http://www.awwa.org/resources-tools/water-knowledge/water-loss-control.aspx
- Water Research Foundation, 2014 "Real Loss Component Analysis: A Tool for Economic Water Loss Control" Web Report #4372a http://www.waterrf.org/Pages/Projects.aspx?PID=4372
- Water Research Foundation, 2014 "Leakage Component Analysis Model" and the "Leak Repair Data Collection Guide".
  http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=27
  http://www.waterrf.org/resources/pages/PublicWebTools-detail.aspx?ItemID=28
- Water Research Foundation, 2015 "Water Audits in the United States: A Review of Water Losses and Data Validity" Web Report #4372b http://www.waterrf.org/Pages/Projects.aspx?PID=4372
- Georgia Association of Water Professionals, 2016 "Georgia Water System Audits and Water Loss Control Manual" produced for Georgia Department of Natural Resources
  http://c.ymcdn.com/sites/www.gawp.org/resource/resmgr/Water_Loss_Audit_files/GA_Water_Loss_Manual_V2.0.pdf

3.0 Metering

This chapter applies primarily to:

- *Water suppliers*
- *Municipal facilities and public works personnel*
- *State facilities personnel*
- *Industrial facilities, commercial facilities, and other consumers who own large meters (such as residential institutions and multi-family complexes)*

Complete system metering informs both suppliers and customers of how much water they are using, provides the supplier with valuable knowledge of customer use patterns, assists in demand management programs, and enables the supplier to bill the customer more accurately based on actual use. Complete system metering also provides essential data for managing water resources state-wide. With accurate knowledge about current water use, the supplier can more effectively identify potential water savings and assist specific users to implement water-saving measures, thereby providing the opportunity to reduce overall system demand. This would also free up water that may be needed by new customers, and enable the retention of more water in the natural environment. In addition, full and accurate metering means that water suppliers can be paid for all the water they provide, without lost revenue from unmetered or inaccurately metered water.

3.1 Standards

1. **Meter water sources to measure and record withdrawals of both groundwater and surface water and measure and record purchased water**. In addition, if there is potential for losses between withdrawal and entry to the distribution system, measure and record finished water.

2. **Ensure 100% metering of all water uses, including all indoor and outdoor water use at all municipal and state facilities (such as schools and athletic fields).**

3. **Implement a water meter repair/replacement policy and program, including a budget for the calibration, repair, and replacement of all sources of supply and distribution network water metering systems**. Consult American Water Works Association (AWWA) Manual M6 "Water Meters-Selection, Installation, Testing, and Maintenance" for guidance.

4. **Seal all water account metering systems against tampering and periodically inspect to ensure water works system integrity**.

5. **Calibrate source, raw, treatment, and finished water master meters at least annually, regardless of meter specification.**

6. **Calibrate and or replace all meters according to their type and specification.** Water suppliers should calibrate or establish the necessary regulations and controls to ensure that owners of large customer meters calibrate the meters according to the recommended interval and provide the results as part of a reporting requirement. The AWWA Standards (AWWA Manual M6) can be consulted for guidance on calibration requirements and accuracy standards. Time periods for calibration are generally based on meter size. Meter wear is a function of the amount of water metered rather than the passage of time.

7. **Properly size meters to handle required water flow rate and ensure a high level of metering accuracy.** For guidance, see AWWA Manual M6, Water Meters – Selection, Installation, Testing, and Maintenance and AWWA Manual M22 Sizing Water Service Lines and Meters.

8. **Billing frequency. If billing frequency is less than quarterly (i.e. annual or biannual), implement quarterly or more frequent billing as soon as practicable.** Bill customers on actual, not estimated, meter readings.

3.2 Recommendations

1. **Billing –**
   - Indicate the rate structure on the water bill.
   - Bill monthly (or at a minimum bi-monthly). This helps customers keep better track of their water use, take note of seasonal variations or potential leaks, and make adjustments in their water use accordingly. Frequent billing also reduces the risk of unexpectedly high water bills and unhappy customers resulting from undetected new leaks.
   - Base bills on estimated flows when metering is disabled or bypassed.
   - Read and bill temporary meters on a corresponding usage period.
   - Where applicable, share the cost of reading and billing between the water and sewer operations.
   - Move toward adopting billing software that allows customers to compare their individual water use for the previous 12 months, and compare their water use with average water use for their customer class.
   - Report average water use in gallons per day and provide a table or brochure on residential water use that includes: residential gallons per capita per day (rgpcd); a comparison of the average cost of bottled water to the cost of tap water; a comparison to water-use standards; and promotion of efficient water-use behavior (see Appendix C).
   - Along with water bills, provide printed material with advice on topics such as how to conserve water and the availability of rebates (see Appendix C).
   - Include an automated "thanks for conserving water" message on water bills when use has dropped over a comparable period the previous year, and a "please do what you can to conserve water" message for users whose water use has increased over the same time period.
   - In communities with Automatic Meter Reading systems, set up a web site to provide secure access to water use-data by customers and water auditors.
2. **Smart Metering–** Communities/water suppliers should consider investing in an automatic meter reading system (AMR) or advanced metering infrastructure (AMI) that allows remote reading of meters. Remote reading and data collection facilitate more frequent billing which can help improve cash flow, eliminate estimated meter readings, support water audits, potentially enable users to track their water use, and provide water suppliers with more detailed information on water-use patterns in the community. This can be useful in enforcing water-use regulations and investigating water theft and meter tampering. In addition, remote reading can enable suppliers to alert customers of leaks on their side of the meter and can enable suppliers to do a better job of accounting between customer meters and master meters. Overall, smart metering offers opportunities to improve revenue, customer service, and asset management.
3. **Minimize Use of Estimated Data –** Meter reading should be done in a manner that allows for actual data instead of estimated data for ASR reporting.

3.3 Resources

- American Water Works Association (2013). *Manual of Water Supply Practice M6: Water Meters-Selection, Installation, Testing, and Maintenance, fifth edition*, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=39928480
- American Water Works Association (20143). *Manual of Water Supply Practice M22: Sizing Water Service Lines and Meters, third edition*, (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=44766350

3.4 Related Appendices

- Appendix C: Example Water Bill Insert

4.0 Pricing

This chapter applies primarily to:

- *Water suppliers*[10]
- *Municipal bodies, boards, and departments*
- *State policy and regulatory entities*

The price of water can be an important driver of water conservation behavior. Moreover, studies show the more discretionary uses of water (such as lawn watering and car washing) are those most responsive to price signals. This underscores that water pricing should be a critical part of the Commonwealth's effort to promote water use efficiency among consumers.

At the same time, pricing structures must ensure the long-term financial integrity of water utilities, enabling them to provide safe, reliable, sustainable water services into the future. When the state's water infrastructure was developed through much needed initial public investment, replacement costs were largely under-accounted for in water utility budgets, resulting in water rates that have generally not reflected the true cost of water service provision. As utilities now face the costs to maintain, replace, and, in some cases, expand the original infrastructure, most find themselves facing financial needs that exceed the revenues they are able to collect through existing rates.

Additionally, suppliers tend to collect most or all revenues on a volumetric basis (charge-per-unit-sold), but costs are often fixed, especially in the short term. Many basic infrastructure needs remain constant regardless of demand, and even where system investments can be pared back over time in response to reduced demand, those components that have long service lives cannot be easily eliminated in the near term. As a result, water conservation can exacerbate financial gaps unless rates are strategically designed to recover costs in the face of reduced demands. Finally, protecting the affordability of water for basic needs (e.g. drinking, cooking, and sanitation) remains a key social function of water utilities, even as more discretionary uses are targeted for conservation.

In short, determining water prices and rate structures is a multi-faceted task that must simultaneously support several underlying goals. Fortunately, research, guidance, and rate design tools have substantially advanced in recent years, addressing these complexities. The standards and recommendations in this chapter reflect these advances and are intended collectively to support the development and adoption of water prices and rate structures that encourage water use efficiency and conservation, *as they*:

- Ensure the long-term sustainability of water supplies through appropriate cost recovery,
- Promote equitable distribution of costs among rate payers, and
- Protect affordability of water for essential needs.

The chapter also reflects increasing recognition of the importance of engaging rate payers and political leaders alike in rethinking water pricing. Establishing rates that promote conservation in an effective balance

[10] Pursuant to G.L. c. 164, § 94, G.L. c. 165, § 1, and G.L. c. 21G, § 19, pricing and rate design issues, as they pertain to privately held water suppliers, are regulated by the Department of Public Utilities (DPU). Accordingly, the standards that appear in this chapter do not apply to privately held water suppliers. However, in designing water rates, the DPU recognizes the importance of water conservation and is committed to working cooperatively with the Water Resources Commission and other regulatory agencies to achieve conservation goals.

with multiple goals requires ensuring that community members understand their water supply system's challenges and costs, as well as its critical role in supporting public health, safety, and economic development.

The standards and recommendations describe key principles and points of guidance, while the resources listed at the end of the chapter comprise more comprehensive guidance and specialized rate-setting tools.

4.1 Standards

1. **Recover the Full Cost of Water Service**. Communities and water suppliers should establish pricing and revenue structures that recover the full cost of operating, maintaining, and protecting the water supply system, and perform annual rate evaluations to adjust prices as needed.

   Full cost recovery can be achieved with any form of rate structure, as long as all costs are recovered, including primary costs (e.g. operations and capital expenses) and supporting costs (e.g. watershed protection and public education). Full cost recovery should ensure, at a minimum, recovery of the following costs, as applicable to each system:
   - Pumping equipment and distribution system operation, repair, and maintenance;
   - Water treatment;
   - Electricity and energy costs;
   - Capital investments, including planning, design, and construction;
   - Watershed land purchase/protection, well site purchase/protection, aquifer land purchase/protection;
   - Debt service;
   - Administration (including personnel and systems management, billing/accounting, customer service, cost of service studies, rate analyses, and long-range planning efforts);
   - A water conservation program that could include some or all of the following:
     - Water audits (utility audits and individual facility audits, including voluntary customer audits);
     - Leak detection equipment, services, and repair;
     - Meter replacement/repair program;
     - Automated meter reading equipment, including installation and maintenance;
     - Purchase of water conservation devices offered for free or at subsidized costs to customers (such as low-flow faucet devices and toilet leak-detection kits);
     - Customer rebate programs for water efficient fixtures and appliances and/or rainwater collection systems;
     - A public education program including, for example, educational components of water bills, school partnership programs, and public workshops;
   - Regulatory compliance, including mitigation of environmental impacts, permitting, and reporting expenses; and
   - Staff salaries, benefits, training, and professional development.

2. **Do not use decreasing block rates**. Decreasing block rates that charge lower prices as water use increases during the billing period should not be used. For water utilities operated by public entities[11], decreasing block rates are prohibited by Massachusetts General Law Chapter 40, Section 39L.

[11] Except those in Hamden County

4.2 Recommendations

1. **Use Price Signals to Reduce Inefficient and Nonessential Use.** Communities and water suppliers should adopt rate structures that encourage efficiency in essential[12] water use and reduction of nonessential[13] water use.

   One way this can be achieved is by setting uniformly high water rates. Such an approach is conceptually and administratively simple; however, it may present affordability concerns for customers even when they are using water efficiently.

   An alternative approach used more frequently targets inefficient and nonessential uses with higher per-unit charges. These types of structure are referred to as *conservation-oriented rates*, and they can be customized in a number of ways to fit a particular community and system and to be compatible with full-cost recovery. To be effective, a conservation-oriented rate should demonstrate: a) a mechanism that reasonably distinguishes water being used efficiently for essential purposes from water being used excessively, for discretionary purposes, or at times that place a particularly high burden on the system or environment; *and* b) a meaningful increase in unit price between the former and the latter. Examples – which can be combined and are not mutually exclusive – include, but are not limited to:

   - Seasonal Rates – unit charges increase to reflect seasonal peak demands and/or seasonal source stressors, such as naturally low flows
   - Tiered Rates – unit charges increase as a customer's usage crosses set volume thresholds within a billing period

     Note that simple increasing blocks, in which tiers are applied identically across a customer base, can promote conservation if structured appropriately and applied to a fairly homogeneous customer base. More tailored or customized tiers account for differences in customer type, such as single-family vs. multi-family units, household size (*budget-based* tiers), or other distinguishing factors. Such rates are more data and resource-intensive[14], but have been shown to be more effective at conservation, and generally more equitable, than simple increasing block rates.[15]
   - Drought or Scarcity Rates (unit charges increase based on drought triggers or other specific indicators of source stress, such as deteriorating water quality or decline in reservoir levels caused by increasing demands).

2. **Establish an Enterprise Fund.** Municipalities that operate as public water suppliers should establish an enterprise fund in accordance with Massachusetts General Law Chapter 44, Section 53F 1/2, or equivalent, to segregate water supply accounting from the municipal general fund and other governmental activities. Such a fund allows the water supplier to account for the total costs of operating

[12] Essential uses are defined by MassDEP as uses required: a) for health or safety reasons; b) by regulation; c) for the production of food and fiber; d) for the maintenance of livestock; or e) to meet the core functions of a business.

[13] Nonessential uses are those *other than* essential uses.

[14] To reduce the administrative burden of determining every household size, some suppliers implement budget based tiers by assigning tiers to all residential customers that presume a given household size (such as 4 people) and allow larger households to apply for adjusted tiers based on actual household size.

[15] Wang et al., American Water Works Association (2005). *Water Conservation-Oriented Rates: Strategies to Extend Supply, Promote Equity, and Meet Minimum Flow Levels*.

and maintaining the water supply system and ensures all revenues derived from water supply activities are retained for, and applied to, water supply expenditures.

3. **Engage in Long-term Planning and Budgeting.** It is recommended that water suppliers develop a long-term operating and capital improvement plan as the basis for establishing water rates and annual budgets. A planning horizon of ten or more years can help the water supplier: 1) educate customers and decision makers about the financial needs of the water supply system; 2) build in revenue streams to cover high-cost capital items; 3) provide justification for debt acquisition; and 4) avoid high costs of deferred maintenance by anticipating and budgeting for timely infrastructure repair activities.

4. **Customize Rate Structures to Address Revenue Stability, Affordability, and Equity**. Through customization of a variety of rate structure approaches, and through use of increasingly advanced rate-setting tools and resources, suppliers are encouraged to set rate structures that not only recover all costs and send conservation price signals, as described above, but that seek to:
   - Stabilize revenue streams;
   - Protect affordability for efficient, essential uses; and
   - Distribute costs fairly and equitably.

   Strategies to help stabilize revenue include, for example, maintaining a reserve fund and/or increasing fixed charges as a component of customer bills. Note that rate structures that include fixed charges can still send strong conservation signals by incorporating steep per-unit price increases for discretionary or excessive use. To ensure conservation signals are not weakened when fixed charges are increased or newly introduced, the volumetric portion of rates should be simultaneously re-evaluated and adjusted as needed.

   Protecting affordability can be achieved, for example, by employing discount rates for customers qualifying on the basis of income. Some suppliers address affordability by setting low (subsidized) per-unit charges across the full customer base for the first tier of use, intended to cover efficient water use for essential needs, although this approach can make full cost recovery more challenging.

   Mechanisms to distribute costs equitably might include allocating charges that reflect relative burdens on the system, such as fire protection charges based on infrastructure costs across the service territory, peak usage charges that apply during times when supplemental sources or treatment facilities are used to meet peak demands, or steep excess use charges for the highest exceedances over allotted volume to help recover (or better yet, ward off) costs associated with acquiring new sources.

   Resources listed at the end of the chapter provide additional guidance on these and many other strategies to address the above goals.

5. **Use Billing Practices that Support Price Signals.** Price signals are most effective when customers: a) understand the rates and the impact of their usage patterns on their bill; and b) receive bills frequently enough to respond in a relevant timeframe by adjusting their water use or investigating potential sources of water loss. It is recommended that suppliers adopt the following billing strategies that have been shown to increase the effectiveness of conservation price signals, recognizing that constraints in billing software and meter reading may require some of these practices to be phased in over time, as equipment and technology are updated:

- **Bill monthly (or at a minimum bi-monthly)**. This is particularly important in encouraging improved efficiencies or reductions in landscape irrigation and other seasonal discretionary uses and in identifying and repairing leaks in a timely fashion.
- **Use gallons as a billing unit.** This assists customers in visualizing their usage volumes in familiar terms and making adjustments that may meaningfully impact their rates.
- **Include educational components in bills.** Clear, education-oriented bills can help customers understand the rates, track their usage in relevant ways, and recognize the financial and environmental benefits of conserving water. Specific suggestions for improving the educational value of water bills can be found in Chapter 3, Metering. (Note that automatic bill payment systems can provide substantial convenience for customers, but may reduce customers' exposure to targeted price signals and key messages about their water use. Suppliers who offer the convenience of auto-pay billing should consider supplemental communications to ensure delivery of information specific to customers' usage and related educational messages.)

6. **Engage in Positive Messaging.** As the pricing and rate approaches outlined above may represent a departure from what customers have become accustomed to, suppliers, community leaders, and state policy makers are encouraged to proactively engage in messaging campaigns to help rate payers:
   - Recognize the value of reliable access to clean water for public health, safety, and the economy;
   - Understand the drivers of water utility costs (which may involve emphasizing that utilities maintain a safe and reliable water supply *system* in addition to delivering a *commodity*);
   - Appreciate the environmental and financial benefits of water conservation;
   - Appreciate the importance of long-range planning for water supply sustainability.

   Chapter 10, Public Education and Outreach, includes some useful strategies for communicating with the public.

7. **Engage the Public in Rate Making.** Public conversations and engagement can make a critical difference in setting effective water rates that rate payers and community decision-makers will understand and support, especially if substantial rate restructuring is needed. The resources listed at the end of the chapter provide some useful guidance for planning and structuring public engagement. Additional useful suggestions can be found in Chapter 10, Public Education and Outreach. Some key points of guidance include:
   - Incorporate broad community representation; vehicles such as mailed surveys and well-balanced advisory committees can help ensure inclusion of all perspectives.
   - Data can be a powerful engagement tool; for example, modeling the impact of various rate structures on different user groups can help the public evaluate trade-offs and hone in on solutions that fit the community's needs.
   - While the initial groundwork for setting up public engagement structures can be resource-intensive, once developed, these structures can be used repeatedly to evaluate progress, make necessary course corrections, or engage on newly emerging issues.

4.3 Resources

While the standards and recommendations above set broad guidelines, the following resources, which include more comprehensive information and advanced rate-setting tools, are provided to assist in implementation.

- American Water Works Association (2017). *Manual of Water Supply Practice M1 Principles of Water Rates, Fees and Charges 7th, edition* (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=61556627
- American Water Works Association (2017). *Manual of Water Supply Practice M54Developing Rates for Small Systems, 2nd edition* (or most recent edition).
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=43980741
- Alliance for Water Efficiency (2014). Handbook: *Building Better Water Rates for an Uncertain World: Balancing Revenue Management, Resource Efficiency, and Fiscal Sustainability;* and downloadable software tool and user guide: *AWE Sales Forecasting and Rate Model* and *Rate Model User Guide*.
  Available at: http://www.financingsustainablewater.org/tools/building-better-water-rates-uncertain-world
- Wang et al., American Water Works Association (2005). *Water Conservation-Oriented Rates: Strategies to Extend Supply, Promote Equity, and Meet Minimum Flow Levels*.
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=6544
- U.S. EPA Water and Wastewater Pricing Resources (manuals, tools, publications, case studies):
  https://www.epa.gov/sustainable-water-infrastructure/pricing-and-affordability-water-services
- Beecher, J.A. and T. Chesnutt, Alliance for Water Efficiency (2012). "Declining Water Sales and Utility Revenues: A Framework for Understanding and Adapting".
  Available at:
  http://www.allianceforwaterefficiency.org/uploadedFiles/Resource_Center/Library/rates/Summit-Summary-and-Declining-Water-Sales-and-Utility-Revenues-2012-12-16.pdf
- American Water Works Association (2013). *AWWA G480-13 Standard: Water Conservation Program Operation and Management*.
  Available at: https://www.awwa.org/store/productdetail.aspx?productid=36141161
- MA Clean Water Trust Best Management Practices: Full Cost Pricing:
  http://www.mass.gov/treasury/docs/mwpat/inthenews/full-cost-pricing.pdf
- MA Clean Water Trust Best Management Practices: Enterprise Funds:
  http://www.mass.gov/treasury/docs/mwpat/inthenews/entereprise-fund.pdf

5.0 Residential Water Use

This chapter applies primarily to:

- *Residential consumers*
- *Water suppliers*
- *Municipal boards and departments*
- *State facilities personnel*
- *State policy and regulatory entities*

Over sixty-seven percent of the metered public water supply in Massachusetts is used for residential purposes.[16] Therefore, any improvements in residential water efficiency will result in significant water savings. Residential water use consists of indoor and outdoor water use. Indoor use typically includes toilets, clothes washers, showers, faucets, dishwashers, and other domestic uses including cleaning and cooking (Figure 5-1).[17] Outdoor water use includes irrigation of lawns and gardens, filling and refilling swimming pools, car washing, and other cleaning. Leakage within the consumer-owned portion of the water system can be an additional and sometimes substantial component of indoor and outdoor water use.

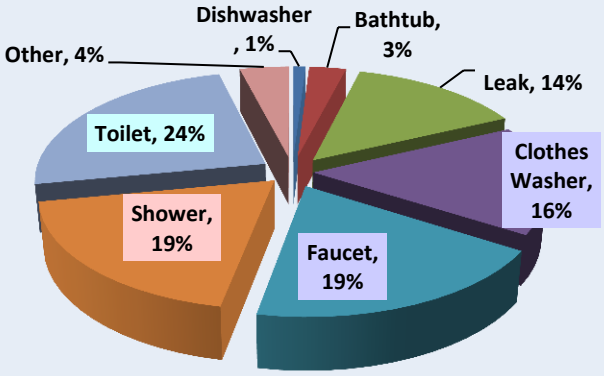


Figure 5-1. Daily household indoor water use (%) (737 homes, nationwide)

Data based on Residential End Uses of Water, Version 2. (DeOreo et al. 2016)

Higher Efficiency through WaterSense. In order to better educate the public and promote the use of water-efficient fixtures, the Massachusetts Water Resources Commission has partnered with the Environmental Protection Agency's WaterSense program and recommends that others do too. WaterSense-labeled products and services are certified to meet the program's rigorous water efficiency, performance, and testing requirements. Certified products must be at least **twenty percent more efficient** than standard products, while offering equivalent or superior performance.

WaterSense has certified products in seven categories: tank-type and flushometer-valve toilets, flushing urinals, bathroom (lavatory) faucets, showerheads, irrigation controllers, commercial pre-rinse spray valves, and new homes. The program also provides a label for certification programs for landscape irrigation professionals. More than 21,000 products carry the WaterSense label, and the program continues to certify new products and categories of products.[18] For the latest updates, see the WaterSense program website at http://www.epa.gov/watersense/.

[16] Based on MassDEP analysis of Annual Statistical Report data for 2011 and 2012 on water metered through service connections.

[17] DeOreo, W., P. Mayer, B. Dziegielewski, and J. Kiefer. 2016. Residential end uses of water, version 2. Denver: Water Research Foundation.

[18] The numbers of WaterSense-labeled models and categories of products are current as of 2016.

5.1 Standards

Standards specific to outdoor residential water use are presented in Chapter 9, Outdoor Water Use.

All Water Users:

1. **Use Residential Water Efficiently.** Keep year-round residential water use, including both indoor and outdoor use, to 65 gallons per capita per day (gpcd) or less.[19] During periods of drought or water system stress, communities may find an even lower target is needed.

Communities and Water Suppliers:

2. **Meet the residential performance standard of 65 gpcd**.[20] The residential performance standard of 65 gpcd is a system-wide average that represents a minimum level of efficiency, based on information in Appendices D and E.[21] If local environmental or operational conditions warrant higher efficiency (such as during times of drought), strive to achieve year-round residential water use of less than 65 gpcd.

3. **Implement a comprehensive residential water conservation program** that seeks to reduce residential water use by implementing applicable recommendations in this chapter and by meeting the standards on Outdoor Water Use (Chapter 9) and Public Education and Outreach (Chapter 10). The scope of the program will be specific to circumstances in each community, and the recommendations listed below provide a menu of options. If a community's water consumption is at or below 65 gpcd, that community should continue with efforts to remain at that level or reduce residential per capita water use.[22]

Ten Steps to a Comprehensive Water Conservation Program (Vickers, 2001)[23]

1. **Establish water-reduction goals**
2. **Develop water-use profile & forecast**
3. **Evaluate planned water & wastewater facilities**
4. **Identify & evaluate conservation measures**
5. **Identify & assess conservation incentives**
6. **Analyze benefits & costs**
7. **Select conservation measures & incentives**
8. **Prepare & implement the Conservation Plan**
9. **Integrate conservation & supply plans, modify forecasts**
10. **Monitor, evaluate, & revise program as needed**

[19] To convert household use to per person use, see the Gallons Per Capita Daily Lookup Table in Appendix C.

[20] The commonwealth recognizes the existence of circumstances, including large seasonal population fluctuations, that could affect a community's efforts to fully meet this standard. In such cases, the community should document all efforts that have been undertaken to comply with this standard.

[21] See Appendix D, Figure D-1, for national average indoor water use for single-family homes in North America. See Appendix E for residential water-use data and benchmarks.

[22] Vickers, Amy. 2001. *Handbook of water use and conservation.* Amherst, MA: WaterPlow Press. See Chapter 1 for details.

5.2 Recommendations

The following recommendations apply to indoor water use. Standards and recommendations for outdoor residential water use are presented in Chapter 9, Outdoor Water Use.

All Water Users:

1. **Choose high-efficiency plumbing products and appliances.** Look for the WaterSense label on plumbing products and the Energy Star label on appliances to find products that meet high standards for efficiency and performance. See Appendix D, Table D-2, for efficiency standards. Significant water and energy savings can be achieved by choosing high-efficiency residential products such as the following:

   a. High-efficiency toilets (HETs): Toilets account for twenty-four percent of indoor water use, the highest percentage of all indoor residential uses (see Figure 5-1). HETs use 1.28 gallons per flush (gpf) or less, or twenty percent less than conventional "low-flow" models (which use 1.6 gpf). Dual-flush models (averaging 1.28 gpf) and power-flush models (using as little as 0.8 gpf) are also available. Performance testing indicates that many HETs provide equal or greater flushing power than conventional toilets[23].

   b. High-efficiency clothes washers (HEWs): Clothes washers account for sixteen percent of residential indoor use (see Figure 5-1). Water efficiency in clothes washers is indicated by the Integrated Water Factor (IWF)[24]. A lower IWF indicates a more water-efficient clothes washer. Efficiency varies depending on the capacity (compact or standard) and configuration (front-loader or top-loader) of the clothes washer.

   Generally, front-loaders are more efficient, though the efficiency of top-loaders is improving.[25] For the greatest efficiency in both water and energy use, select products identified as CEE Tier 3 by the Consortium for Energy Efficiency[26] or Energy Star-labeled products.[27]

2. **Fix leaks as soon as possible.** Dripping faucets and leaking toilets, pipes, and appliances can add up to hundreds of gallons of water lost per week, representing dollars down the drain. For guidance on finding and fixing common leaks, see "Don't Waste a Drop: Finding, Fixing and Preventing Indoor Water Leaks" at http://www.ose.state.nm.us/FixALeak/add_info.php.[28]

3. **Reduce water use (and improve septic system function where applicable) by not running water continuously at sinks.** For kitchen waste, divert compostable waste to a compost pile instead of using a garbage disposal. Finished compost then can be added to the soil around the home or spread thinly on the lawn to boost its soil-moisture-retention capacity and reduce the need for watering.

[23] http://www.map-testing.com/

[24] For clothes washers, the next federal compliance date for more stringent energy and water efficiency standards is January 1, 2018. See 10 CFR 430.32(g)(4).

[25] Appliance Standards Awareness Project. Clothes Washers. Available at http://www.appliance-standards.org/product/clothes-washers (accessed January 20, 2017).

[26] See the Qualifying Products lists developed by the Consortium for Energy Efficiency (at http://library.cee1.org/content/qualifying-product-lists-residential-clothes-washers and http://library.cee1.org/content/qualifying-product-lists-residential-dishwashers).

[27] For the greatest efficiency, look for products listed as "Energy Star Most Efficient" (at www.energystar.gov/).

[28] Water Use and Conservation Bureau. New Mexico Office of the State Engineer. February 2002 (http://www.ose.state.nm.us/FixALeak/add_info.php).

Water suppliers, municipal officials, and state facilities managers:

4. **Promote the use of high-efficiency plumbing fixtures and appliances in retrofits and new construction** (see Recommendation 1 above).

5. **Offer rebates for replacing inefficient fixtures and appliances.** Consider implementing a wide-ranging program to replace older, high-water-use toilets and other fixtures and appliances through retrofit and rebate programs.

> **"This result suggests that leakage-reduction efforts should not be targeted at the general population but at the houses in the top 10% of the group….These top 10% of the houses account for 50% of the total leakage."**
>
> ***DeOreo and Mayer 2012 (see note 32)***

6. **Consider providing free or low-cost water audits to residential customers.** Analyze winter water-use data to identify customers who would benefit from an audit. A residential water audit should include the following components at a minimum[29]:

   - Indoors: Inspect toilets, showers, faucets, clothes washers, dishwashers, water filters, water softeners, evaporative coolers, spa/hot tub, and other fixtures or appliances for leaks, flow rate, presence of water-saving retrofit devices, and efficient use of fixtures and appliances by residents.
   - Outdoors: Evaluate outdoor water uses for efficient operation and leaks. See Chapter 9, Outdoor Water Use, and Appendix I: Guidelines for Efficient Irrigation.
   - Justify the investment in the recommended upgrades by conducting a payback analysis[30] that evaluates reductions in water costs.

7. **Facilitate Leak Repair –** Leaks can represent a substantial portion of indoor water use – fourteen percent of residential indoor water use (see Figure 5-1). Consider using metering technology to identify patterns of water use that indicate leakage in the customer's home. If leakage is suspected, notify the customer.[31] Communities should consider offering assistance or providing an incentive for customers to fix leaks that they might otherwise allow to run continuously. For leakage in service connections, see Chapter 2, Water Loss Control (Recommendation 3).

8. **Incorporate Alternative Technologies, where appropriate –** Those wishing to go beyond current standards and do more to conserve water should consider alternative technologies, such as composting toilets, waterless urinals, or water reuse systems. State and municipal buildings can serve as demonstration sites for these technologies, where appropriate.

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[29] For guidance, see "Residential Water Audits" in the series "Best Management Practice: Water Conservation." Available from the New England Water Works Association at http://www.newwa.org/MembershipResources/UtilityResources.aspx#96523-bmps-and-advisories. Sample worksheets for residential water audits are included in the *Handbook of Water Use and Conservation* (Vickers 2001, Appendix E (indoors) and Appendix F (outdoors)).

[30] A payback analysis calculates the amount of time needed for an upgrade to pay for itself in cost savings over time. The formula is:
Payback period = cost of upgrade / savings in water and energy costs per unit time

[31] Studies indicate that only 10% of the homes studied were responsible for 50% of leaks found. Identifying and targeting those customers for outreach is recommended. See DeOreo, W., and P. Mayer. 2012. Insights into declining single-family residential water demands. Journal – American Water Works Association. 104:E383 – E394. Available at http://dx.doi.org/10.5942/jawwa.2012.104.0080.

State Policy and Regulatory Entities:

9. **Update the State Plumbing Code.** The state, through the Water Resources Commission, should work with the state Plumbing Board to update existing water-use standards for plumbing fixtures to reflect current designs that allow for greater water-use efficiency, and with the state Plumbing Board and MassDEP to review current policies and regulations related to reclaimed water and recommend changes that would remove barriers to water reuse and facilitate (with considerations for water quality) the implementation of reuse systems.
10. **Create incentives, including rebates, for installing water-efficient plumbing fixtures and appliances.** The state should investigate opportunities to offer rebates on water-efficient appliances through energy utilities, since water-efficient appliances are also typically energy efficient.
11. **Incorporate water conservation into MEPA review for large new developments.** EEA should work with MEPA to develop a standard set of water conservation recommendations as part of the MEPA review for large new developments and redevelopments. The recommendations should include but not be limited to the installation of water-efficient plumbing fixtures and appliances and meeting all appropriate standards and recommendations for lawn and landscape water conservation, as included in Chapter 9, Outdoor Water Use.
12. **Periodically monitor the state-wide progress of communities in meeting water conservation standards using information provided in the Annual Statistical Report.**

5.3 Resources

- Alliance for Water Efficiency. Home Water Works Calculator. Available at http://www.home-water-works.org/
- EPA WaterSense. Detailed specifications for WaterSense-labeled products can be found at http://www.epa.gov/watersense/.
- EPA Energy Star. Product specifications for water-using appliances available at http://www.energystar.gov/products/spec/.

5.4 Related Appendices

- Appendix D, Improvements in Household Water Efficiency and Standards
- Appendix E, Residential Water-Use Data and Benchmarks
- Appendix I, Guidelines for Efficient Irrigation

6.0 Public Sector

This chapter applies primarily to:

- *Municipal bodies, boards, and departments*
- *Municipal facilities and public works personnel*
- *State facilities personnel*
- *Private and nonprofit organizations*
- *State policy and regulatory entities*

Municipal and state buildings, facilities, and landscapes should be at the forefront on indoor and outdoor water use efficiency. They should set an example and lead the way in water conservation, water-saving techniques, and concepts. These sites should serve as demonstration sites with signage to make the public aware that the state and municipalities are leaders in water conservation. The following standards and recommendations will help emphasize and implement water conservation and efficiency in government buildings, facilities, and landscapes. They will also help to accurately account for water use and serve as demonstrations of water saving techniques and concepts to the public.

6.1 Standards

1. Municipal and state buildings
   - **Conduct indoor and outdoor audits** and account for full use of water, based on full metering of public buildings, parks, irrigated playing fields, and other facilities.
   - **Analyze existing water-use data** to spot trends, patterns, and unexplained increases that could indicate leaks or inefficient use of water.
   - **Identify** measures where the **greatest efficiencies** and potential savings can be realized.
   - Build new public buildings with **equipment that reduces water use**, such as faucet aerators, low-flow showerheads, composting or high-efficiency toilets (HETs) (or "dual-flush" models),[32] and self-closing faucets. Water-saving devices and measures should be well identified to users of public buildings and facilities.
   - **Focus on replacing/retrofitting** water-consuming equipment in buildings (e.g. bathrooms, boilers, chillers).
   - **Practice good, efficient lawn and landscape water-use** techniques and meet the standards as described in Chapter 9.0 on Outdoor Water use.
2. **Meter or estimate contractor use of water** from fire hydrants for pipe flushing and construction.
3. **Strictly apply plumbing codes** and incorporate other conservation measures in new and renovated buildings.

6.2 Recommendations

1. Outdoor Water Use – **Adopt outdoor water-use strategies** as per recommendations in Chapter 9.0.
2. **Create Demonstration Sites –** Use public buildings as demonstration sites for innovative water conservation techniques such as composting, foam-flush and dual-flush toilets, cisterns for rain collection, and water-wise landscaping.

[32] High-efficiency toilets (HETs) have an effective flush volume of 1.28 gallons per flush or less.

7.0 Industrial, Commercial, and Institutional (ICI)

This chapter applies primarily to:

- *Commercial facilities*
- *Industrial facilities*
- *Institutional facilities*
- *Municipal facilities*
- *State facilities*

Water is crucial for the functioning of industrial, commercial, and institutional (ICI) facilities (including hospitals, schools, prisons, universities, and colleges). It may be used for heating, cooling, and processing, and includes an appreciable sanitary and landscaping component. In many communities, ICI facilities can use more gallons per day than any other individual water user. Instituting water conservation measures will help reduce the overall community water use significantly and result in appreciable monetary savings. The measures must be tailored to reflect the type of water use and characteristics of individual facilities (see Appendix F for BMPs). They can be built into an industry's strategy to comply with local sewer and National Pollutant Discharge Elimination System (NPDES) discharge requirements. The following standards and recommendations increase the efficiency of water use through use of best available technologies.

7.1 Standards

1. **Carry out a water audit** to determine the location and amount of water used for heating, cooling, processing, sanitary use, and outdoor use (see Appendix G for sample ICI water audit). Use the findings from the audit as the basis for actions to conserve water such as:
   - Recycling and reusing cooling waters to achieve greatest water-use efficiency (cycles of concentration). Consider switching evaporative to dry cooling in cooler weather.
   - Reuse of process waters sequentially in applications on-site with lower quality requirements.
   - Using non-potable water (in conformance with the plumbing code and MassDEP regulations[33] to assure safe drinking water and to avoid cross-connections).
   - Using heat-sensitive controls and valves with cooling equipment.
   - Replacing water cooling with air cooling (where feasible within air quality standards).
   - Installing or retrofitting efficient sanitary water devices, performing scheduled meter maintenance and calibration, and
   - Xeriscaping.
2. Significant users (i.e. those using greater than 50,000 gpd) **install separate meters for process water** so that water can be accounted for and appreciated as a raw material in production and for sanitary use.
3. **Develop and implement a water savings strategy**, addressing among other items: demand management, leak detection and repair, a program of preventive maintenance, and a program of employee education.
4. In new and renovated buildings, comply with plumbing codes, **use the best available technologies for water conservation, and reuse treated wastewater** within the facility to the extent possible.
5. **Practice good lawn and landscape water-use techniques** and meet the standards described in Chapter 9 of these Standards.

[33] See 314 CMR 20.00. Reclaimed Water Permit Program and Standards.

7.2 Recommendations

1. The EEA Office of Technical Assistance (OTA) should continue to **provide technical assistance to companies and large water users** and work with industry groups and suppliers.
2. **Significant users should aim, wherever possible, to decrease their average water use by 10%**. The investment will pay back in the form of lower water, wastewater, and energy bills.
3. **All ICI users should install/retrofit water-saving sanitary devices**, including but not limited to low-flow showerheads, faucet aerators, toilet displacement devices, and low-flow or high-efficiency toilets and urinals. Guidelines on efficient products can be found on the WaterSense program website at www.epa.gov/watersense/.
4. **Industrial and commercial users should work with code officials, standards committees, state programs, manufacturers, and legislators to promote water conservation and efficient use**.
5. **Increase the amount of pervious areas on property**. ICI facilities often include large areas of impervious surfaces (building rooftops, parking lots, etc.) which offer excellent opportunities for replacement with pervious materials, installation of green roofs, porous pavement and bioretention areas in parking lots, and rainwater harvesting. Rainwater harvesting can serve as a supplemental water supply source and can infiltrate clean runoff into the ground where it can replenish aquifers and streamflow.
6. See Chapter 9 for lawn and landscape recommendations.

7.3 Resources

- EPA WaterSense. October 2012. WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities. Available at https://www.epa.gov/watersense/best-management-practices.

8.0 Agricultural Water Use

This chapter applies primarily to:

- *Agricultural and horticultural entities*
- *State policy and regulatory entities*

Commercial agriculture is highly water dependent and economically sensitive to water availability and quality. Water is essential to the success and livelihood of an agricultural operation, and it is in the operator's best interest to protect and maintain water resources. In Massachusetts, agricultural water users tend to be self-suppliers with wide-ranging needs for water. Water is used i) for irrigation of crops and nursery stock; ii) for harvesting of crops (cranberries); iii) as the medium for aquaculture; iv) for washing and processing of commodities; v) as a drinking source for livestock; and vi) for cleaning and cooling of animals.

Agricultural needs for water vary by type of enterprise and on a seasonal basis. Water demands are site specific and, depending on the enterprise, affected by multiple factors, including climate and weather, number and type of animals, the water-holding capacity and infiltration rate of the soil, and crop needs.

Any conservation approach to agriculture should strike an appropriate balance between both agricultural needs for water and the need to conserve water. Examples of conservation approaches include proper irrigation scheduling, in both timing (daily and seasonal) and volume; control of runoff; the uniform application of water; irrigation technologies, such as drip irrigation (where appropriate) and automated irrigation systems; and the use of tailwater recovery systems for cranberry operations.

The standards and recommendations in this chapter reflect general agricultural water conservation approaches that growers are encouraged to adopt. Agricultural water conservation practices frequently change as new technologies are developed and as efficiencies are improved. The University of Massachusetts maintains industry specific best management practices that include the most accepted water conservation technologies and practices available. Agricultural entities should adopt practices that are environmentally and economically appropriate for their specific operation and site conditions.

8.1 Standards

1. **Use water in a planned and efficient manner with appropriate amounts and frequency to meet needs without excessive water loss**. Over-irrigating can damage crops and increase runoff, washing nutrients and minerals out of the soil and damaging soil in the long run. Establish an irrigation schedule based on the needs of the crop.

2. **When applicable, develop a soil health management system to improve the health and function of the soil**. Soils are an ecosystem that can be managed to provide nutrients for plant growth, absorb and hold rainwater for use during dryer periods, filter and buffer potential pollutants from leaving fields, serve as a firm foundation for agricultural activities, and provide habitat for soil microbes to flourish.

ENVIRONMENTAL ENHANCEMENT
Improvements on the Farm

About 70% of cranberry growers have participated in water conservation programs like the Environmental Quality Incentive Program, administered by USDA Natural Resources Conservation Services. In five years alone, growers have made conservation improvements valued at $12,500,000, chiefly in improving how water is used on the farm. This includes the installation of flumes for controlling the flow of water, installation of more efficient irrigation components, building by-pass canals, which allow water to pass around a cranberry bog system, and creating tail-water recovery ponds which allow for storage of water exiting a bog system, conserving the water to be used for irrigation.

Another program, the Agricultural Environmental Enhancement Program, run by the Massachusetts Department of Agricultural Resources, provides those farmers who are selected and pledge to make matching investments, with a reimbursement for project costs up to $25,000 to install best management practices that improve water quality or conserve water.

Since 1999, cranberry growers have received over $1.8 million dollars to match their investments. These projects help to conserve water and to maintain the high quality water vital to growing cranberries. These improvements enhance the natural environment in the region and provide a cranberry grower with new tools to manage their farm.

Adapted from "With an Eye Toward the Future: Sustainable Cranberry Growing in Massachusetts" – Cape Cod Cranberry Growers' Association - 2011

8.2 Recommendations

1. Commodity specific agricultural industry member associations and grower groups are encouraged to continue to **maintain and promote industry-specific best management practices** that are dynamic, adaptable to new technology, and selected based upon both economic and environmental concerns.

2. Where applicable, **develop and implement a conservation plan based on guidance from the Natural Resources Conservation Service (NRCS)**[34]. This plan is a written record of conservation practices for the agricultural operation that, when implemented, will help achieve the goals of protecting the environment and natural resources. As part of this, an Irrigation Water Management Plan can be developed for site-specific needs. This plan can determine the amount of water required for each irrigation cycle, including leaching needs; how to recognize and control erosion caused by irrigation; how to determine the uniformity of application; and develop how and when to perform system maintenance to assure efficient operation.

3. **If supplemental irrigation is needed, micro-irrigation systems, such as subsurface drip irrigation, should be adopted where suitable.**

4. **Where sprinkler systems are used for irrigation, the systems should be capable of uniform application of water with minimal evaporative loss and minimal surface run-off.** The amount of water applied should be sufficient to fill the effective crop root zone. Irrigation during hot or windy conditions or during the peak of the day should be avoided in order to minimize evaporation.

5. **Irrigation system efficiency should be evaluated on an annual basis before each growing season.**

6. **Growers should maintain adequate soil moisture** based on crop needs for optimum plant

[34] Contact your local NRCS office: www.nrcs.usda.gov/wps/portal/nrcs/main/national/contact/local/

growth without causing excessive water loss, erosion, or reduced water quality.

7. **Organic matter, such as manure or compost, should be added to the soil** to enhance its moisture retention capacity and soil structure, thereby reducing irrigation needs and reducing runoff by allowing rainwater to soak into the ground. For every one percent of organic matter content, the soil can hold 16,500 gallons of plant-available water per acre of soil down to one foot deep[35].
8. **Production soils should be kept covered throughout the year** with harvestable crops during the growing season and cover crops and/or plant residues during the off season. Cover crops can build moisture reserves better than row crops, and they open pores and channels in the soil for water infiltration; the organic matter they build helps to retain both moisture and nutrients.

8.3 Resources

- Agricultural Best Management Practices: www.mass.gov/eea/agencies/agr/about/divisions/massachusetts-ag-bmps.html
- Greenhouse Best Management Practices
- Nursery Best Management Practices
- Cranberry Best Management Practices
- Dairy Best Management Practices file size15MB
- Orchard Best Management Practices
- Small Fruit Best Management Practices
- Vegetable Best Management Practices
- Agricultural Environmental Enhancement Program: www.mass.gov/eea/agencies/agr/about/divisions/aeep.html
- NRCS Soil Resources: www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health
- Conservation Planning: www.nrcs.usda.gov/wps/portal/nrcs/main/ma/technical/cp
- NRCS Funding Programs: www.nrcs.usda.gov/wps/portal/nrcs/main/ma/programs

[35] Scott, H.D., L.S. Wood, and W.M. Miley. 1986. *Long-term effects of tillage on the retention and transport of soil water*. Arkansas Water Resources Research Center. Publication Number 125. 39 p.24.

9.0 Outdoor Water Use

This chapter applies to all water users.

It is the policy of the Commonwealth that water used for maintaining landscapes and lawns should not be used at the expense of public health and safety or the environment. Water use for maintaining landscapes and lawns should be minimized through the implementation of sound water conservation and water-efficiency practices.

Sources of inefficiency in outdoor water use include applying more water than is needed to maintain healthy turf and plants and watering in the middle of the day, when evaporation rates are highest. In addition to wasting water, inefficient watering practices can lead to runoff of nutrients and pollutants, contributing to water quality problems.

Spikes in water demand may lead to water delivery problems and potential water quality, water pressure, or public safety concerns, such as diminished fire-fighting capabilities. Large peak demands may also compel managers of water systems to find new sources or increase the capacity of water systems, resulting in potential environmental impacts and higher costs for water system customers.

The standards and recommendations in this section provide guidance to all water users on practices that will reduce waste and improve efficiency in the use of water for lawns, landscapes, and other outdoor uses.

9.1 Standards

All Water Users

1. **Minimize lawn or landscape water needs by following established water-smart principles** (see sidebar). In most years, Massachusetts receives enough rainfall to naturally supply the water needs of a healthy, mature lawn or landscape, designed to be drought-resistant, *without the need for supplemental watering*.
2. **Maximize efficiency of irrigation.** If conditions warrant use of an irrigation system, use best management practices (see Appendix I) and the best available technology along with regular system evaluation to ensure maximum efficiency of water use.[36] If using a manual sprinkler or hand-held device,

Water-Smart Principles

- ***Maintain healthy soils.***

Healthy soils retain water, cycle nutrients, minimize runoff, and absorb pollutants. For healthy turf, provide a minimum 6-inch depth.

- ***Choose native plants or plants and turf that need less water.***

Once established, native and low water-using plants require little water beyond normal rainfall.

- ***Group plants with similar water needs.***

This reduces water use by targeting water to each zone's specific needs.

- ***Be selective when adding turf areas.***

Turfgrass receives the highest percentage of irrigation in traditional landscaping. Plant turfgrass only where it has a practical function.

- ***Water wisely.***

Avoid watering during the heat of the day (9:00 AM to 5:00 PM). If using an irrigation system, make regular adjustments to ensure efficiency.

- ***Use mulch.***

Use mulch around shrubs and garden plants to help reduce evaporation, inhibit weed growth, moderate soil temperature, and prevent erosion.

- ***Provide appropriate maintenance.***

Allow turfgrass to reach 2 to 3 inches before mowing. Leave grass clippings on the lawn to return nutrients to the soil. Prune in the dormant season.

Adapted from Water-Smart Landscapes Start with WaterSense (EPA WaterSense) and Water-Wise Landscaping & Watering Guide (from WaterUseItWisely).

[36] Massachusetts law requires system interruption devices for newly installed or renovated irrigation systems and inspection every three years by a certified irrigation contractor (MGL ch.21 sec. 67). For best available technology, see Smart Water

follow best management practices to maximize water efficiency (see Appendix I).

3. **During a drought or extended period of dryness,** all users should follow state guidance for limiting nonessential[37] outdoor water use during droughts (see Appendix J). Be aware that turf may become dormant (turning brown) during dry periods, but should green up again with the return of wetter conditions (see Figure 9-1).[38]

Figure 9-1. Left: Lawn in drought dormancy in July. Right: The same lawn, recovered by October. (*Photos courtesy of P. Lauenstein, Massachusetts*)

Municipal Governments and Water Districts

4. **Adopt and implement a water-use restriction bylaw, ordinance, or regulation,** which applies to both municipal water customers and, where warranted, those with private wells. This should limit the number of watering days per week and hours per day. To protect public health and the environment, this bylaw, ordinance or regulation should outline a set of increasingly stringent restrictions on nonessential outdoor water use, with associated triggers based on the specifics of the community's water supply. Triggers can be calendar based (such as May 1 through September 30), or identify water supply and environmental indicators (such as streamflow or reservoir levels). Drought triggers with increasingly stringent restrictions, depending on drought severity, should also be included. **During a state-declared drought, follow state guidance on watering restrictions**.[39] The bylaw, ordinance, or regulation should provide the community government or designee (e.g., water supplier, police department) with the ability to implement mandatory water-use restrictions and empower authorities to enforce these rules through increasingly stringent citations and penalties, culminating with potential shut-offs. See Appendix B for model water-use restriction bylaws/ordinances and links to sample bylaws/ordinances.

9.2 Recommendations

These recommendations summarize best management practices for using water efficiently outdoors. They are accompanied by the following appendices, which provide further detail and resources:

- Appendix H summarizes recommendations for lawns and landscapes
- Appendix I outlines best management practices for watering and for irrigation system efficiency

All Water Users

1. **Plan landscapes** with the understanding that many communities limit nonessential outdoor water use to one or two days a week, with water bans possible during drought conditions.

Application Technologies (SWAT), including EPA WaterSense-labeled irrigation products (available at https://www.epa.gov/watersense/watersense-products).

[37] Essential uses are defined by MassDEP as uses required: a) for health or safety reasons; b) by regulation; c) for the production of food and fiber; d) for the maintenance of livestock; or e) to meet the core functions of a business. Nonessential uses are those *other than* essential uses.

[38] For details on managing turf to minimize water input, maximize water-use efficiency, and manage drought dormancy, see section 6 of *Best Management Practices for Lawn and Landscape Turf* (available from the UMass Extension Turf Program at https://ag.umass.edu/turf/publications-resources/best-management-practices).

[39] See Appendix J for statewide guidance on watering restrictions at different levels of drought.

2. **Cover swimming pools when not in use** to prevent evaporative losses.[40]
3. **Sweep driveways, walks, patios, and other outdoor areas with a broom rather than hosing them off**. If water is necessary, use a water-conserving pressurized cleaning device.[41]
4. **Wash vehicles using a bucket and sponge, employing a hose with a shut-off nozzle for rinse only, or, if available, use a commercial car wash that recycles water (most do)**.
5. **Do not divert water directly from any water sources**, including ponds, lakes, streams or rivers, or groundwater, without first obtaining approval from the local Conservation Commission or the Massachusetts Department of Environmental Protection.[42]

Municipal Governments and Water Suppliers

6. **Adopt bylaws/ordinances, policies, or regulations** that include some or all of the following provisions:

To address water-use efficiency of irrigation systems:[43]

- require registration, inspection, and audits of automatic irrigation systems;
- prohibit the operation of, and authorize fines for, irrigation systems that spray and/or run off significant amounts of water onto unplanted surfaces such as sidewalks and driveways, or that operate during or after rainfall;
- require water conservation equipment, including system interruption devices, on automatic irrigation systems;[44]
- where water resources are limited, prohibit the installation of automatic irrigation systems.

To minimize water use through land use planning [45]

- minimize installation of high water-use landscape areas[46]
- limit land clearing and loss of vegetated cover and preserve natural vegetation;
- prohibit topsoil stripping and earth removal and require a minimum 6-inch depth of topsoil[47] on all cleared areas to help retain moisture;
- restrict topographic alterations and require that natural topography be maintained to the maximum extent feasible;
- preserve or restore a site's natural hydrology (by using techniques such as low-impact development and open-space design);
- require the use of low water-use/drought-resistant plants, turf, and landscaping techniques; and
- encourage or require the use of native, noninvasive plants,[48] appropriate for the site and selected for their ability to adapt to the local climate;

[40] See "Water Efficiency Measures for Swimming Pools" in section 4.6.1 of *Handbook of Water Use and Conservation* (Amy Vickers. 2001. Amherst, MA: WaterPlow Press).

[41] A water-conserving pressurized cleaning device is one that either (a) discharges water at a minimum of 1,000 pounds per square inch (psi), or (b) is rated at using less than three gallons of water per minute.

[42] Water used for agricultural operations (as defined in MGL Chapter 128 section 1A) is considered an essential use. However, a Water Management Act permit may still be required if withdrawals exceed certain thresholds. Agricultural operations should confirm permitting requirements with MassDEP.

[43] See Appendix B, DEP Model Outdoor Water-Use Restriction Bylaw/Ordinance.

[44] System interruption devices are required by Massachusetts law (MGL chap. 21 sec. 67) for new or renovated systems.

[45] See links to bylaws/ordinances and regulations containing these provisions in Appendix B.

[46] EPA's WaterSense Water Budget Tool can be used to guide landscape design and calculate an efficient allotment of water for a landscape in a specific climate. See resources at the Tool's webpage: http://www.epa.gov/watersense/water_budget/.

[47] Generally, a sandy loam with 5% organic content is recommended for turf grass and landscapes. See more tips in Appendix H.

To address protection of surface water sources:

- control withdrawal of water from any surface water source by requiring advance written approval from the Conservation Commission. Such a bylaw/ordinance would help control the problem of unauthorized withdrawals directly from local waterways, taking water without permission or paying for it, and sometimes contaminating the body of water from which the water was withdrawn.

7. **Maintain an inventory of automatic irrigation systems**. This can help prevent and better respond to backflow problems or performance issues resulting from improperly installed systems, and supports identifying customers who may benefit from an irrigation audit or education on how to more efficiently use their system.
8. **Provide outdoor water-use audits** for residential, industrial, commercial, and public properties that are large water users.[49]
9. **Raise public awareness through an education and outreach program on outdoor water use**, featuring demonstrations of water-smart landscaping and efficient irrigation practices on municipal properties (including school departments and recreation and athletic fields). Inform customers through water bills or other means of their obligation to comply with the provisions of bylaws/ordinances outlined in Recommendation 6.
10. **Calculate a summer-to-winter water-use ratio** as a benchmark for evaluating the community's outdoor water use. Use the following formula:

    Total water use in May through September (summer)/total water use in November through March (winter)

    Track trends; if the ratio trends upwards, determine the cause and take appropriate action to reduce summer water use.

Managers of Recreational Fields, Parks, Golf Courses, and Institutional and Commercial Landscapes

11. **Consider using the WaterSense Water Budget Approach**[50] to designing landscaped areas that will use water efficiently.
12. **If irrigation is necessary to maintain turf health and functionality, follow best management practices outlined in Appendix I to minimize water use**.
13. For those in areas where water resources are limited or who desire to eliminate potable water use outdoors, first **design the landscape to take advantage of natural rainfall to satisfy watering needs**. If watering needs cannot be met by rainfall, consider other sources (such as rainwater harvesting or treated wastewater), where feasible. [51]
14. **In procuring services for lawn and landscape maintenance**, ensure that the appropriate lawn and landscape design, irrigation design, and maintenance and construction

Rainwater harvesting using a rain barrel

[48] A list of native plants can be found in Appendix 1 of EEA's *More than just a yard: Ecological landscaping tools for Massachusetts homeowners* (2004). Available at http://www.mass.gov/eea/docs/eea/wrc/morethanjustyard.pdf.

[49] See Appendix I for guidelines on irrigation audits and best management practices for irrigation system efficiency.

[50] See link to the Water Budget Tool in note 46.

[51] See the Alternative Water Sources tab on the Commercial Buildings, Best Management Practices page at https://www.epa.gov/watersense/best-management-practices).

guidelines for minimizing outdoor water use are included in the procurement bid documents and bid evaluation criteria.[52]

Public Property Managers

15. **Use public properties to demonstrate the development and management of water-smart landscapes** and the use of native and drought-tolerant vegetation to reduce outdoor watering. Public education and outreach programs and signage should accompany these efforts.

16. If irrigation is used on public properties, **demonstrate the advantages of efficient irrigation practices** (e.g., drip irrigation).

9.3 Resources

- EEA (Executive Office of Energy & Environmental Affairs). Tips for Saving Water. Available at http://www.mass.gov/eea/docs/eea/eea-tips-for-saving-water.pdf
- EPA WaterSense. August 2012. *Water-Smart Landscapes: Water-Efficient Landscapes Start with WaterSense*. Available at http://www.epa.gov/watersense/docs/water-efficient_landscaping_508.pdf
- EPA WaterSense. July 24, 2014. WaterSense Water Budget Approach. Version 1.02. Available at https://www.epa.gov/watersense/water-budget-tool

9.4 Related Appendices

- Appendix B, Model Bylaws
- Appendix H, Summary of Water Conservation and Water Quality Recommendations for Lawns and Landscapes
- Appendix I, Guidelines for Efficient Irrigation

[52] Links to EPA's WaterSense specifications, the Water Budget Tool, and other resources on landscape design and irrigation system design can be found on the WaterSense Homes page at https://www.epa.gov/watersense/homes, and on the Outdoors page at https://www.epa.gov/watersense/outdoors.

Case Study

Scituate reduces per capita use by targeting water conservation program to largest users

In 2011, the town of Scituate found that high demand for water in the summer was placing a strain on its water sources, wells and water treatment plant and sometimes reduced its capacity to respond to emergencies. The Scituate Water Division wanted to figure out what was driving this high demand. With assistance from the North & South Rivers Watershed Association (NSRWA) and Massachusetts Bays Program, the Water Department first analyzed data that was readily available: its own customer accounts.

Solution

Using a simple Excel spreadsheet, the Water Department found that the top ***5% of its residential customers were responsible for 20% of total water use and these customers increased their use by 25% in the summer***. The water commissioners felt this usage was being driven by automatic lawn irrigation systems and adopted a restriction that limited the use of lawn irrigation systems connected to the municipal water supply to one day per week. Each voting precinct is assigned a lawn irrigation day. The restriction also requires property owners with private wells supplying their irrigation systems to register their wells with the Water Department.

Results

Scituate ***reduced water use on average by 310,000 gallons per day*** in the summer months, and has **lowered its residential per capita use from 77 gpcd** (in 2007) **to an average of 63 gpcd** (2013 to 2014). The summertime conservation savings has allowed Scituate to begin to restore streamflow and herring populations to the First Herring Brook and its reservoir system by following an operational plan that includes seasonally adjusted streamflow releases.

Scituate: http://www.scituatema.gov/sites/scituatema/files/file/file/water-restrictions-notice-2012.pdf
NSRWA: http://www.nsrwa.org/environment/restoring-fish-streams/first-herring-brook/

10.0 Public Education and Outreach

This chapter applies primarily to:

- *Water suppliers*
- *Municipal bodies, boards, and departments*
- *Municipal facilities and public works personnel*
- *State policy and regulatory entities*

The responsibility for ensuring a sustainable water future lies with the community as a whole; everyone has a role to play to make sure that all water (rainwater, stormwater, public water supply, etc.) is handled responsibly and planned for properly.

Education of the public at large, municipal officials, and water suppliers is crucial to generating an understanding of the issues and implementing and creating acceptance of water conservation activities. It is important to provide to the public the basic understanding of sound water resources management and planning and explain the associated economic and environmental benefits.

Public education and outreach can facilitate the successful adoption and implementation of conservation measures. For example, public acceptance of and compliance with outdoor watering restrictions can be enhanced if they are preceded by an outreach effort that clearly establishes the need for such restrictions in terms of maintaining system reliability, avoiding or postponing expensive system expansion, safeguarding aquatic habitats, etc.

Potential areas of emphasis for an educational program include:

- Highlighting the environmental benefits of reducing water demands and preserving the hydrologic balance (the natural volumes of water moving through stream systems and the surrounding landscape) – a.k.a. "keeping water local." Key education points might include the connection between ground water and surface water; the potential impacts of withdrawals on streamflow and instream uses such as habitats for fisheries and other wildlife, water-based recreation, pollution dilution; and the relationship between pumping and salt water intrusion for coastal areas.
- Explaining that water conservation helps preserve water quality. Both ground and surface water sources can face deteriorating water quality if pumped excessively. Conservation also helps septic systems and wastewater treatment plants work better and last longer. Water conservation also keeps more water in the natural environment where it helps dilute pathogens and other pollutants and buffers waterways from excessive heating or freezing that can harm aquatic life.
- Showing that investments in efficiency and conservation will provide water users with long-term savings compared to the cost of developing and treating new water supply sources and expanding wastewater treatment facilities. Domestic fixture retrofit programs can provide a good opportunity for this message.
- Educating water users on all the costs involved in providing water, including planning, engineering, construction, source protection, operation, maintenance, treatment, wastewater facilities costs, distribution, metering, leak detection, compliance costs, personnel costs, and public outreach.
- Making the connection between water use and energy costs. For water utilities, the energy required to pump, treat, and distribute water and collect wastewater is significant.[53] Implementing improvements in

[53] See EPA, 2008: Ensuring a Sustainable Future: An Energy Management Guidebook for Wastewater and Water Utilities. Available at https://nepis.epa.gov/Exe/ZyPDF.cgi/P1003Y1G.PDF?Dockey=P1003Y1G.PDF

both energy and water efficiency can reduce operating costs, providing an opportunity to redirect funds to other needed water system improvements. Reducing water use at the household level can also reduce energy use and the costs associated with heating water and operating water-using appliances.

10.1 Standards

1. Each community and water supplier should **develop and implement an education plan**, including elements in the following list, as applicable:
   - **Billing**: Help customers track, compare, and make meaning of their use through their water bills (see Chapters 3 and 4 for specific billing suggestions). Specialized billing software is available to help track individual customer use and even target outreach to customers who may have a leak or who are using significantly more water than similar customers.
   - **Indoor Retrofit/Rebate Programs:** Offering indoor low-flow retrofit devices or rebates for water-efficient appliances provides opportunities to educate customers on the financial and environmental benefits of water conservation.
   - **Lawn and Landscaping Programs:** Information on "water-wise landscaping", gardening, efficient irrigation, and lawn care practices can be provided through model landscapes, workshops, online information, and partnerships with local garden clubs, lawn and landscape retailers, and environmental organizations.
   - **Local Schools:** Partnering with teachers and school administrators to develop age-appropriate curricula on the local water system and the importance of water conservation can help bring these messages back home and integrate them into the community.
   - **Diverse Outreach Tools:** Use social media, online tools, public service announcements, local events, etc. to communicate water conservation messages and alerts, incorporating multilingual materials as needed.
   - **Partnerships:** Partner with garden clubs, farmers' markets, environmental organizations, energy utilities, and others on campaigns promoting wise water use.
2. For communities in which some homes or businesses rely on private wells, **help those users understand, where appropriate, the impacts of their withdrawals on the public water supply system and local aquatic habitat and the importance of their own efforts at water conservation.**

10.2 Recommendations

1. Communities/water suppliers should **hire or contract with a water conservation coordinator or circuit rider** shared among several water systems or partner with a local advocacy or educational organization to help advance water conservation goals.
2. Water suppliers and the state should **consider using social marketing to help build public support for water conservation**. Social marketing is a valuable technique that focuses on the most effective ways to change behavior, leading people to adopt and implement sustainable practices.[54]
3. **Other town boards should get involved in water conservation**, especially those regulating land use (Planning and Zoning Boards), managing Town property (park and recreation departments, cemetery departments, and schools), protecting water resources and aquatic habitats (Conservation Commissions, Boards of Health), Open Space Committees, and Community Preservation Committees. These entities can help promote water conservation as well as restore the hydrological balance by enhancing infiltration of clean water into the ground, thus replenishing aquifers and streamflow.

[54] Fostering Sustainable Behavior through Community-Based Social Marketing http://www.cbsm.com. "Community-based social marketing draws heavily on research in social psychology, which indicates that initiatives to promote behavior change are often most effective when they are carried out at the community level and involve direct contact with people."

APPENDICES

A) Water Bank Guidance

B) Model Bylaws

C) Example Water Bill Insert

D) Improvements in Household Water Efficiency and Standards

E) Residential Water-Use Data and Benchmarks

F) BMPs for Selected Industries

G) Sample Worksheet for Industrial / Commercial / Institutional Water Audit

H) Summary of Water Conservation and Water Quality Recommendations for Lawns and Landscapes

I) Guidelines for Efficient Irrigation

J) Massachusetts Drought Management Outdoor Water Use Restrictions Guidelines

A) Water Bank Guidance

Demand reduction is an effective way to increase efficiency and sustainability of water systems. A water bank can help finance actions that directly reduce demand.

What is a 'Water Bank'?
Over the years, a "water bank" has come to mean different things to different people. In the western states, water banks are typically systems of valuing, trading, buying or selling water rights. Permanent water banks have been established in Idaho and Texas. The state of California, in 1991, 1992 and 1994, set up emergency drought water banks to reallocate water. Water was purchased from those farmers who were willing to leave their lands idle or were willing to use groundwater instead of surface water. This was then sold to either cities or farms or used for instream uses or to dilute pollutants (Frederick 1998).

In Massachusetts, the term water bank is evolving to mean a system of accounting and paying for measures that offset or mitigate water losses. Losses could be due to water withdrawals, sewering, and/or increased impervious areas that prevent aquifer recharge. The primary goals of a water bank are to balance the water budget, reduce water losses, increase water efficiency, and keep water local.[55] There is no "one size fits all" approach, and municipalities should have the flexibility to adopt a program that best fits their particular circumstances.

The Benefits of a Water Bank
Water banking can be an effective management tool for "water-short" communities where development pressure is exceeding the carrying capacity of water resources. It is also a good option for communities concerned about their ability to meet projected water demand and to protect the environment. A water-banking program can free up water and ensure that there is an adequate supply of water for competing uses – i.e., instream flow and habitat, recreation, wetlands, water supply, and economic development. It can mitigate, or offset, the impacts of water withdrawals, balance the water budget, assist in restoring and protecting instream flow, promote water conservation, and ensure an adequate supply of potable water. Massachusetts' communities are beginning to use this tool to accommodate future growth while ensuring the sustainability of their water resources.

Key Principles
There are some key organizing principles that communities should follow when developing an effective water-banking program. They are:
1. A dedicated fund, or banking mechanism is necessary
2. At least a 2:1 ratio of water saved or returned to the basin per unit of water lost should be the goal in flow-depleted basins
3. If fee-based, the fee charge must bear a reasonable relation to the cost of implementing the offset and the program's administrative costs, and
4. If the work is performed by the developer, documentation must be provided and there must be verification by the local department or board administering the program.

Because a 1:1 ratio only preserves the status quo in already degraded watersheds, and because measuring the gains from individual water offset measures is often imprecise, to protect or restore water resources especially in medium- or high-depleted basins, a ratio of at least 2:1 is recommended. In other words, for every gallon

[55] Interbasin transfers, for example, are not subject to inclusion in a water bank as they by definition do not keep water local. However, reductions in the amount of water transferred out-of-basin, via sewers for example, would qualify as mitigation. See the Water Resources Commission's Offsets Policy Regarding Proposed Interbasin Transfers (October 11, 2007).

of new water demand projected for development, redevelopment or expansion projects, the goal should be saving or retaining at least two gallons in the basin where the water is being withdrawn.

While water conservation measures, i.e., retrofits of public buildings and older residences with low-flow toilets, showerheads and faucet aerators, have been the primary currency of Massachusetts' water banking programs to date, there are a variety of other techniques that can be used. These can return water or prevent water loss in the basin, such as reduced infiltration and inflow, recharge of stormwater, and retrofit of existing development using low-impact development (LID) principles. Additional capacity can also be gained through groundwater recharge of locally treated wastewater formerly exported out of the basin, and through reuse of grey water.

There are also a host of water conservation measures – such as rebate programs for high-efficiency plumbing fixtures and appliances, xeriscaping, and installation of rainwater collection systems – that can be used in a water-banking program. Many communities now require infiltration/inflow (I/I) mitigation for both new and redevelopment projects, and a water bank can be set up in a similar way. Due to the difficulty of accurately measuring and ensuring the longevity of I/I reductions, ratios of estimated I/I reduction to unit of new water demand typically range from 4:1 to 10:1 in I/I mitigation programs. These programs can help to create capacity or fulfill regulatory requirements for regional wastewater systems. The work can be performed either by the developer, or a fee can be charged and the I/I can be removed by the municipality's DPW. A water bank can also be structured to include market mechanisms in which those seeking new or increased water use could buy credits previously banked in excess of the 2:1 ratio in lieu of performing the work themselves. A water bank can involve multiple towns or be organized on a regional or watershed basis.

If a municipality opts to charge a per gallon fee, either to perform the work itself, or to contract it out, the fees should be deposited in a dedicated enterprise fund and used solely to accomplish the offset measures, and to fund the program's administrative expenses. However, adequate documentation is critical for tracking and reporting on the measures to ensure that the savings are in fact being achieved. Documentation, review and verification by the municipal department or the public water supplier administering the program assures that the work has been performed.

CASE STUDY - Town of Acton's Water Neutral Growth Initiatives

The Town of Acton is protecting its water balance through several mechanisms. The town's groundwater protection overlay district within the zoning bylaw and wetlands bylaw require that all new development document that post-construction conditions represent no net loss of groundwater recharge relative to pre-construction conditions. Note, the MA Wetlands Protection Act already requires this safeguard for all new development on land jurisdictional under the Act, but Acton's bylaws extend this requirement town-wide. Acton's bylaws also require a 50-foot natural buffer and a 75-foot no-development zone around wetlands, further protecting water quality and recharge. In addition to these town bylaws affecting all new development in Acton, the Water District requires certain development projects to offset their water demands through either direct mitigation efforts or by contributing mitigation fees into a fund dedicated to water demand offset projects.[56]

CASE STUDY – Town of Danvers, Program to Offset New Water Demand

The town of Danvers established a Water Use Mitigation Program (WUMP) in 2009 to offset water demand from new development. Projects that produce new or increased water demand pay an impact fee. The fee is

[56] See the Acton Water District's rules and regulations at:
http://www.actonwater.com/assets/media/documents/AWD%20Rules%20and%20Regs%20Revised%2004.26.2016.pdf

based on the calculated cost to remove two gallons of water from the town's water system for every gallon of water that the project adds to the system. The WUMP fee applies to residential projects with three or more dwelling units and all commercial projects. In addition, these projects must use water- and energy efficient plumbing fixtures and appliances. The program also requires any in-ground irrigation systems to include a rain- and moisture-sensing device.

Danvers uses program fees to reduce water demand by offering rebates and implementing conservation measures. The water conservation program in Danvers has several components. Rebates are offered to Danvers residents for upgrades to more efficient water-using products, including toilets, clothes washers, showerheads, and faucets, as well as rain sensors. In addition, rebates are offered to commercial and municipal facilities. Rain barrels are offered to residents, and the program helped fund the rain water reuse system at Danvers High School. Leak detection and leak repairs, both on the system and in homes and businesses, are also important components of the conservation program. For 2018, in addition to offering water-use audits to large water users in the commercial sector, the town plans to identify opportunities to assist commercial customers in reducing the use of water for irrigation.

Since the program's inception, Danvers has collected impact fees totaling nearly a million dollars, has processed approximately 2,000 rebates, and has estimated water savings ranging from 1.07 to 2.5 million gallons annually.

The Danvers WUMP policy and fee calculation forms can be found on the Danvers Department of Public Works website at https://www.danversma.gov/water-use-mitigation-program-wump/.

B) Model Bylaws[57]

This appendix contains information about – and links to – examples of local bylaws and/or model bylaws that can be used to provide structure and legal mechanisms to implement certain elements of the Water Conservation Standards.

1. BYLAWS ADDRESSING PRIVATE WELLS

Falmouth, Article 17, section 223-4 pertains to the Board of Selectmen's authority to declare a state of water supply conservation and provides in pertinent part as follows: *However, if the Board of Selectmen makes a specific finding that the shortage of water exists because of a clear and imminent threat to the sole source aquifer underlying Falmouth, such threats to include severe drought, environmental pollution or salt water intrusion, the restrictions adopted pursuant to Section 223-5 shall apply to all citizens, water users, and consumers regardless of the source of water supply.*

Hamilton, Chapter 25: The purpose of this By-law is to protect, preserve and maintain the public health, safety and welfare by creating a balance between the needs of the environment, our ground water supply, the citizens of Hamilton and Hamilton's public water distribution system, and by addressing concerns about lower ground water levels and the potential demand on its water sources during the dry summer months, while recognizing the therapeutic, esthetic and environmental benefits that gardening and landscaping bring to our community. The provisions of this By-law are applicable only to the use of water supplied by the Town's public water system or withdrawn from the same water sources as the Town's public water system and do not apply to the use of recycled water, storm water run-off, gray water or water from cisterns or rain barrels that derive their water directly from precipitation. For the full bylaw, click here.

Topsfield, Chapter 57, Section 58-2.3 pertains to the definition of "water users" in the town, specifically including users who obtain water from a source other than the public water supply: Water Users shall mean all persons, regardless of their geographic location, using water withdrawn from water sources located within the Town of Topsfield.

Topsfield, Chapter 57, Section 58-2.5 outlines the water conservation measures to be applied to water customers on the town public supply or all water users, including private wells: A declaration of a State of Water Supply Conservation shall specify one or more of the following conservation measures and shall specify whether the measure(s) are voluntary or mandatory and whether the measure(s) apply to water customers only or to all water users. For the full bylaw, click here.

Wenham, Chapter 21, Section 3 defines "water users" in the town, to specifically also include private well users as water users subject to water restrictions: Water Users or Water Consumers shall mean all public and private users of the Town of Wenham's public water system, and/or of groundwater within the borders of the Town of Wenham and extracted from the Ipswich River Watershed. The restrictions shall apply to all water used in the town of Wenham, to include Town water and water supplied by private wells, irrespective of any person's responsibility for billing purposes for water used at any particular facility. Seasonal Restrictions shall prohibit outdoor watering through a sprinkler or lawn irrigation

[57] The information in this appendix is based on research conducted by staff and by Gabby Queenan from the Massachusetts Rivers Alliance.

system between the hours of 9 am to 5 pm between May 1 and September 30 of each year using town water or private well water. For the full bylaw, click here.

Wrentham, Article 6.30, Section 4 on *Water Use Restrictions* pertains to water use restrictions on all water users, including private well users, during a "State of Water Supply Conservation" or a "State of Water Supply Emergency". "All users of the public water supply system of the Town of Wrentham and private well users within the Town of Wrentham shall be subject to this bylaw. This bylaw shall be in effect year round." For the full bylaw, click here.

2. MASSDEP OUTDOOR WATER USE MODEL BYLAW/ORDINANCE:

   http://www.mass.gov/eea/agencies/massdep/water/regulations/model-water-use-restriction-bylaw-ordinance.html

3. EXAMPLES OF LAND USE PLANNING BYLAWS/ORDINANCES THAT HELP REDUCE THE NEED FOR WATERING:

   Devens Enterprise Commission: Site Plan requirements and design standards in 978 CMR 3.00:
   http://www.devensec.com/rules-regs/decregstoc.html

   Cape Cod Commission Model Land Clearing, Grading and Protection of Specimen Trees Bylaw:
   http://www.capecodcommission.org/index.php?id=154&maincatid=21

   Model bylaws/ordinances for Low-Impact Development and Open Space Design/Natural Resource Protection Zoning: http://www.mass.gov/envir/smart_growth_toolkit/index.html

C) Example Water Bill Insert

Courtesy, Sharon Water Department

OUR REBATE PROGRAM

Get a $100 credit on your water bill for installing a high-efficiency toilet!

Get a $200 credit on your water bill for installing a front load washing machine!

These advanced devices deliver many benefits. They reduce your water bill and may extend the life of your septic system.

Gallons Per Capita Daily (GPCD) Lookup Table*

GALLONS USED IN 6 MONTHS (for annual GPCD, average your last two water bills)	NO. OF HOUSEHOLD OCCUPANTS 1	2	3	4	5	6	7	8
4,000	22	11	7	5	4	4	3	3
6,000	33	16	11	8	7	5	5	4
8,000	44	22	15	11	9	7	6	5
10,000	55	27	18	14	11	9	8	7
12,000	66	33	22	16	13	11	9	8
14,000	77	38	26	19	15	13	11	10
16,000	88	44	29	22	18	15	13	11
18,000	99	49	33	25	20	16	14	12
20,000	110	55	37	27	22	18	16	14
22,000	121	60	40	30	24	20	17	15
24,000	132	66	44	33	26	22	19	16
26,000	142	71	47	36	28	24	20	18
28,000	153	77	51	38	31	26	22	19
30,000	164	82	55	41	33	27	23	21
32,000	175	88	58	44	35	29	25	22
34,000	186	93	62	47	37	31	27	23
36,000	197	99	66	49	39	33	28	25
38,000	208	104	69	52	42	35	30	26
40,000	219	110	73	55	44	37	31	27
42,000	230	115	77	58	46	38	33	29
44,000	241	121	80	60	48	40	34	30
46,000	252	126	84	63	50	42	36	32
48,000	263	132	88	66	53	44	38	33
50,000	274	137	91	68	55	46	39	34
52,000	285	142	95	71	57	47	41	36
54,000	296	148	99	74	59	49	42	37
56,000	307	153	102	77	61	51	44	38
58,000	318	159	106	79	64	53	45	40
60,000	329	164	110	82	66	55	47	41
62,000	340	170	113	85	68	57	49	42
64,000	351	175	117	88	70	58	50	44
66,000	362	181	121	90	72	60	52	45
68,000	373	186	124	93	75	62	53	47
70,000	384	192	128	96	77	64	55	48
72,000	395	197	132	99	79	66	56	49
75,000	411	205	137	103	82	68	59	51
80,000	438	219	146	110	88	73	63	55
85,000	466	233	155	116	93	78	67	58
90,000	493	247	164	123	99	82	70	62
95,000	521	260	174	130	104	87	74	65
100,000	548	274	183	137	110	91	78	68

**The state water use planning goal for Massachusetts is 65 GPCD.*

Save Water! Save Money!

Get Valuable Rebates

for installing

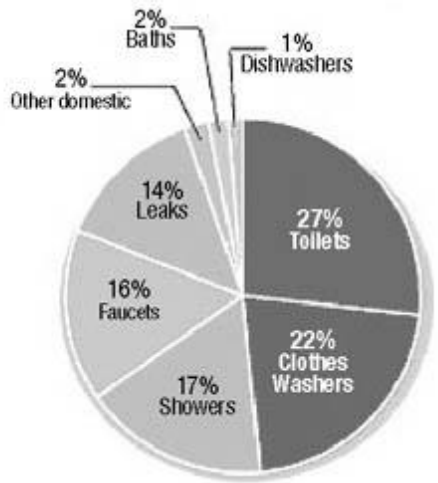
High-Efficiency Toilets

and

Washing Machines

Sharon Water Department
and
Water Management Advisory Committee

Toilets and clothes washers are the top two indoor water guzzlers in a typical home*:



High-efficiency toilets and front load clothes washers help keep your water use under **65 GPCD** (see the handy GPCD lookup table on the reverse to find out your water use). Thanks to innovative engineering, they also function better than older models.

*Sources: American Water Works Association and AWWA Research Foundation

TOILET TIPS

- Install advanced High Efficiency Toilets (HETs) that average less than 1.3 gallons per flush. HETs are powerful and less prone to overflow. HETs may save 15,000 gallons per year compared to old 3.5 gallon models.
- Avoid flushing the toilet when not absolutely necessary, and don't use your toilet as a wastebasket.
- Toilet leaks cause high water bills. Check for toilet leaks by putting food coloring in your toilet tank. Do not flush. If dye appears in the bowl within 10-15 minutes, check the flapper in your toilet tank to see if it has deteriorated and needs to be replaced.
- Don't put strong cleaning chemicals in your toilet tank. They may corrode the rubber and plastic parts in your toilet tank and cause leaks.

FRONT LOAD WASHERS

Front load washing machines use less than 15 gallons per load, far less than the 35 to 50 gallons per load used by older top load models, and may save 10,000 gallons per year.

Front-load washing machines:

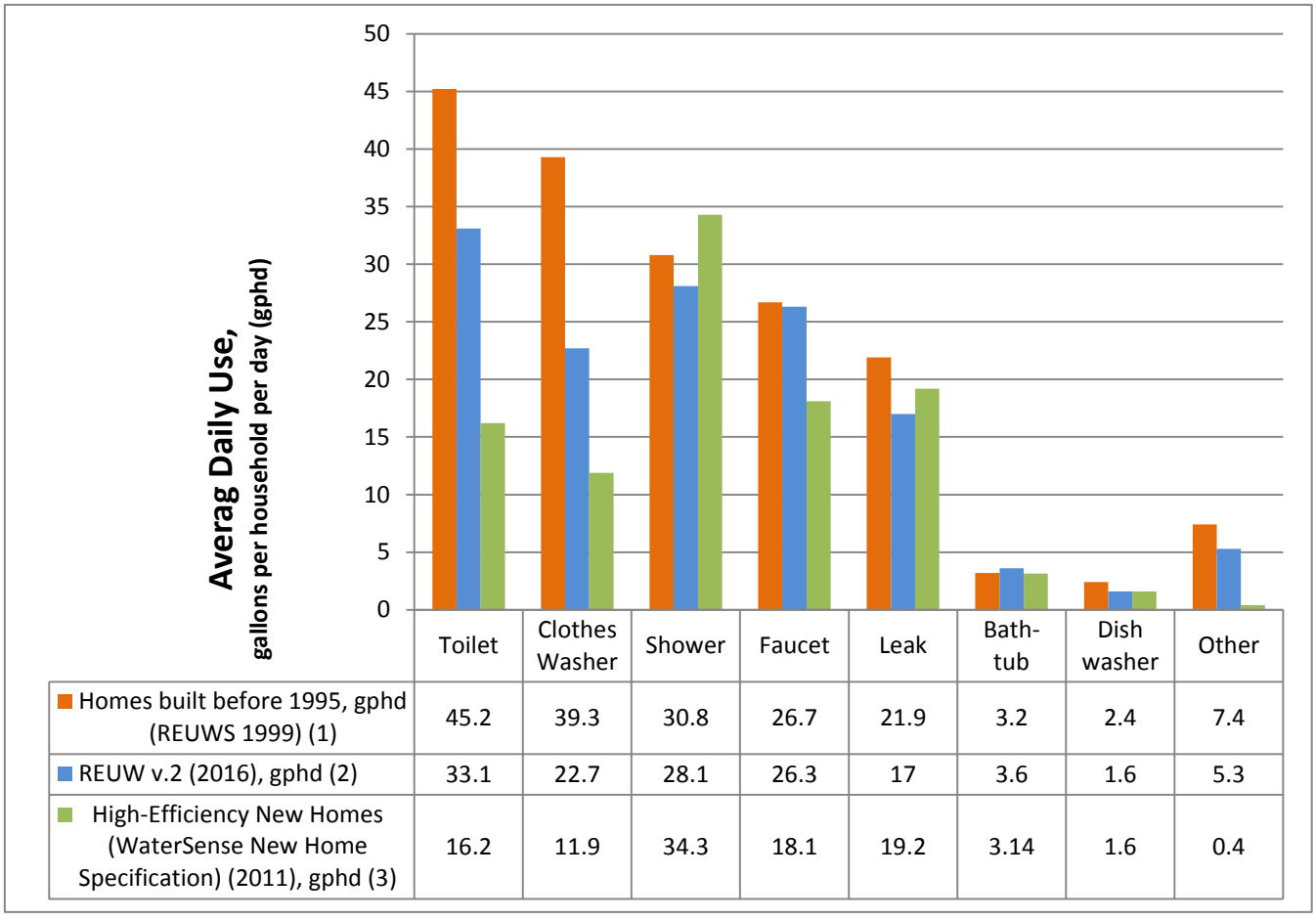
- Conserve heated water and lower your energy bills.
- Wring out more moisture in the spin cycle, reducing drying time and energy costs.
- Decrease wear on clothes so they last longer.
- Require less detergent.
- Help extend the life of your septic system.

D) Improvements in Household Water Efficiency and Standards

Since 1992, average total household water use in Massachusetts and across the United States has declined. Figure D-1 shows how **the installation of high-efficiency plumbing fixtures and appliances has contributed to water savings** in North America over the past twenty-five years. Significant water savings result from the installation of high-efficiency toilets and clothes washers. Table D-1 compares flow rates of older fixtures and appliances with flow rates in high-efficiency homes.

How much water do you use? Try the **Home Water Works Calculator** at **http://www.home-water-works.org/calculator**

Figure D-1. Indoor Water Use, Single-Family Homes in North America



	Toilet	Clothes Washer	Shower	Faucet	Leak	Bath-tub	Dish washer	Other
Homes built before 1995, gphd (REUWS 1999) (1)	45.2	39.3	30.8	26.7	21.9	3.2	2.4	7.4
REUW v.2 (2016), gphd (2)	33.1	22.7	28.1	26.3	17	3.6	1.6	5.3
High-Efficiency New Homes (WaterSense New Home Specification) (2011), gphd (3)	16.2	11.9	34.3	18.1	19.2	3.14	1.6	0.4

Sources:

(1) Residential End Uses of Water Study (REUWS) (Mayer et al. 1999). Analysis of water consumption by end uses (residential plumbing fixtures and appliances) in 1,188 single-family homes in 12 North American cities. Data collected 1996 to 1998. REUWS data were later normalized to a family of 3 in the REUWS2 study (see Note 2).

(2) DeOreo, W., P. Mayer, B. Dziegielewski, and J. Kiefer. 2016. Residential end uses of water, version 2. Denver: Water Research Foundation.

(3) DeOreo, William B. 2011. Analysis of Water Use in New Single-Family Homes. Boulder, CO: Aquacraft Water Engineering and Management. Measures water use in 25 new homes built using criteria equivalent to the WaterSense New Home Specification or better.

Table D-1. Average Flow Rates in Residential End Uses of Water Studies

	Toilet (gal. per flush)	Clothes Washer (gal. per load)	Shower (gal. per min.)
Homes built before 1995 (REUWS1) (measured flow rates)	3.48	40.9	2.22
High-Efficiency New Homes (flow rates based on WaterSense specifications)	1.28	15	1.6

Water-Use Standards

Table D-2 lists water-use standards currently in effect through codes as well as the higher efficiency standards available to consumers who select WaterSense-labeled plumbing fixtures and Energy Star-labeled appliances.

How much water would you save by upgrading to more efficient fixtures? Try the WaterSense calculator at https://www.epa.gov/watersense/watersense-calculator.

Table D-2. Water-Use Standards for Selected Plumbing Fixtures and Appliances

Fixture or Appliance	Federal and MA Water-Use Standard[58]	WaterSense or Energy Star Standard
Toilets	1.6 gpf	≤1.28 gpf
Urinals, residential & commercial	1.0 gpf	≤0.5 gpf
Showerheads, residential	2.5 gpm at 80 psi	2.0 gpm maximum[1]
Lavatory faucets & replacement aerators, residential	2.2 gpm at 60 psi	1.5 gpm at 60 psi, max. & 0.8 gpm at 20 psi min.
Kitchen faucets & replacement aerators, residential	2.2 gpm at 60 psi	no standard
Faucets, commercial	Private[2]: 2.2gpm at 60 psi Public restroom: 0.5 gpm at 60 psi Metering (auto shut-off): 0.25 gpc	no standard
Clothes Washers, residential (standard size) [3] Top-loading: Front-loading:	6.5 IWF 4.7 IWF	Current: 4.3 IWF 4.4 3.7 IWF as of 2/5/18: 4.3 IWF 3.2 IWF
Dishwashers, residential	Standard: 5.0 gpc or less Compact: 3.5 gpc or less	Standard: 3.5 gpc or less Compact: 3.5 gpc or less

gpc = gallons per cycle
gpf = gallons per flush
gpl = gallons per load
gpm = gallons per minute
IWF = Integrated Water Factor (gallons/cycle/cubic foot)
psi = pounds per square inch

[58] Federal regulations: 10 CFR Part 430.32. Massachusetts Uniform State Plumbing Code: 248 CMR 10.

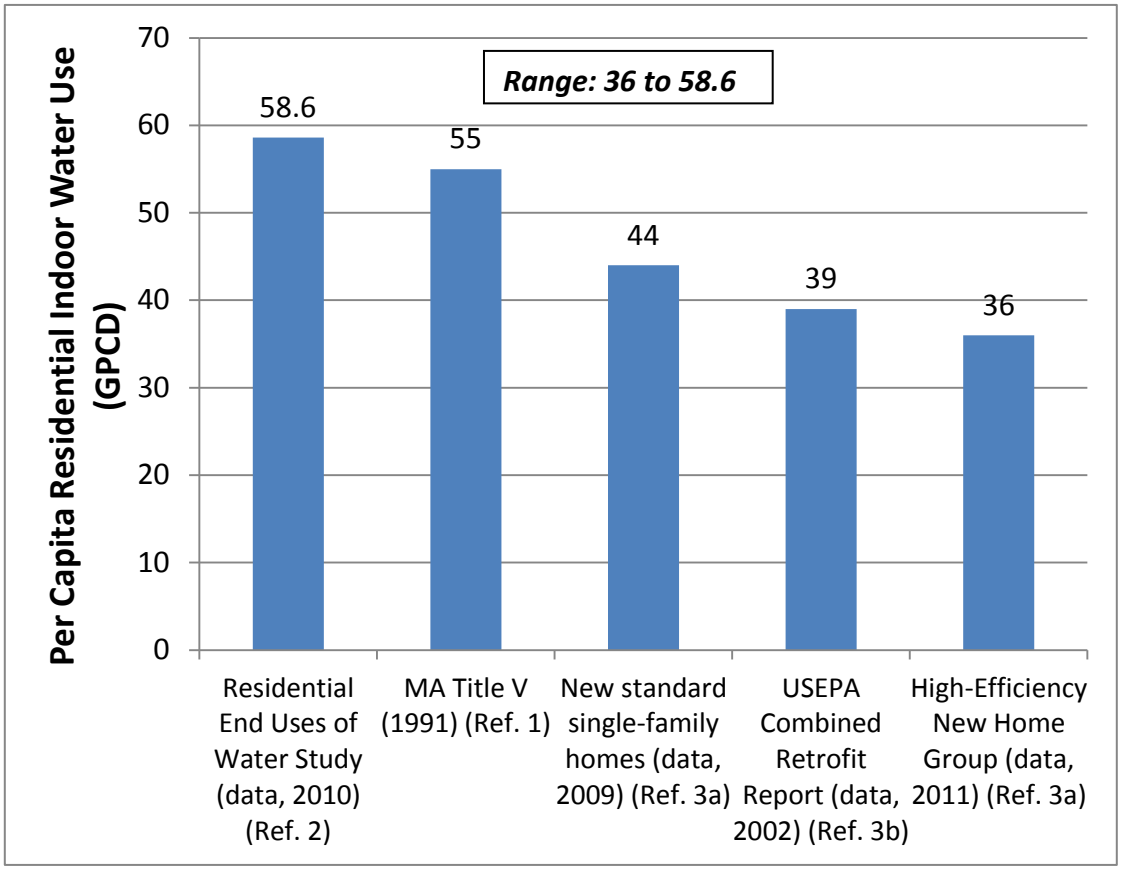
1. The WaterSense specification for showerheads also includes standards for spray force and coverage.
2. "Private" defined as residential, hotel guest rooms, and health care patient rooms.
3. New, more efficient federal standards for clothes washers went into effect on January 1, 2018, and include standards for compact as well as standard-size clothes washers. See 10 CFR 430.32(g). Updated Energy Star standards (Version 8.0) for clothes washers will go into effect on February 5, 2018 (https://www.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20Final%20Version%208.0%20Clothes%20Washer%20Partner%20Commitments%20and%20Eligibility%20Criteria.pdf).
4. See also Energy Star, http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers. For products with even greater efficiency, see the Consortium for Energy Efficiency's (CEE) Super Efficient Home Appliances Initiative at https://library.cee1.org/content/cee-super-efficient-home-appliance-initiative-january-2016/. The Energy Star criteria for dishwashers became effective January 29, 2016.

E) Residential Water-Use Data and Benchmarks

The amount of water consumed by a residential population is commonly used as a benchmark to evaluate the success of water conservation efforts. Water use is typically measured in gallons and reported as gallons per capita per day (gpcd), representing both indoor and outdoor water use for an individual. Measured and estimated numbers for residential gpcd vary throughout the state, the country, and the world.

Data considered in developing and evaluating benchmarks for efficient residential water use in Massachusetts are presented below, along with several theoretical water budget scenarios.
Note: all numbers are residential gallons per capita per day (rgpcd) unless otherwise noted.

INDOOR WATER USE



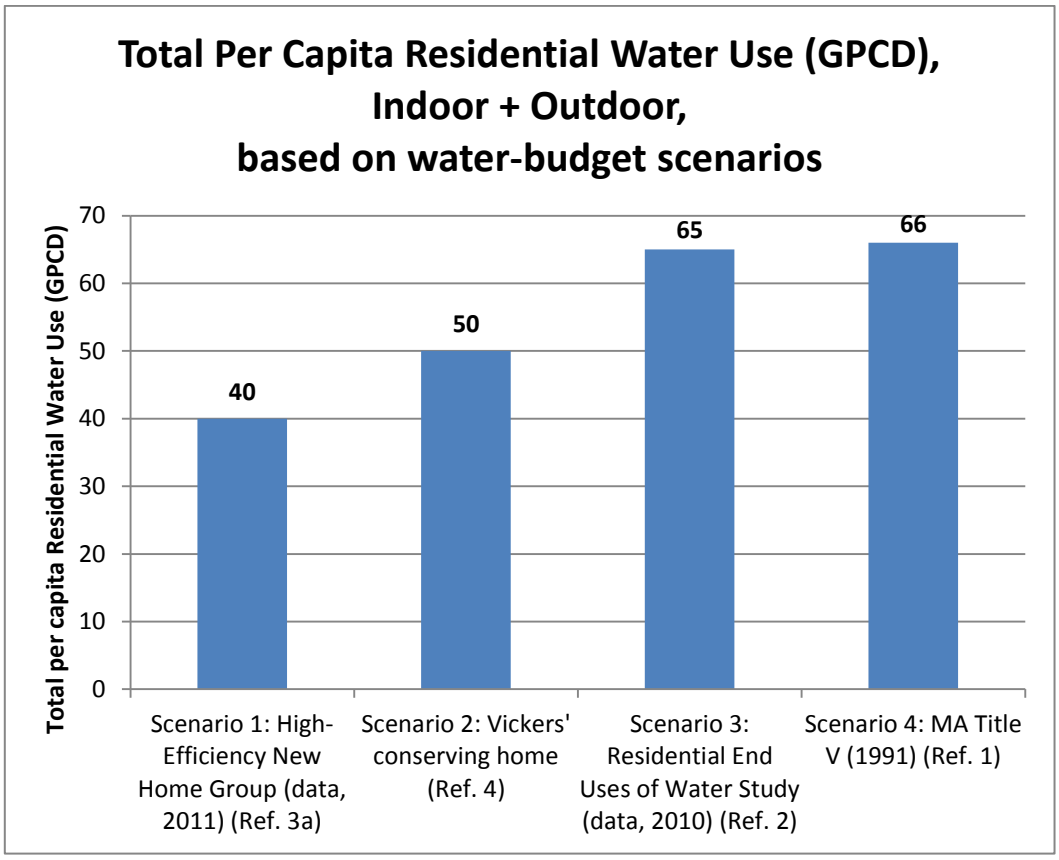
Base indoor water use does not vary significantly over the year or across the country and continues to go down on average. Improvements in base indoor water use efficiency help reduce water use in summer when it matters the most.

OUTDOOR WATER USE

Outdoor water use varies significantly over the year and across the country and has been going up on average. In New England, outdoor water use during the months of May through September typically increases by approximately 25% to 50% over base indoor use from November through March.[59]

THEORETICAL WATER BUDGET SCENARIOS

Following are some residential water-use scenarios that were considered in developing annual water consumption benchmarks:



Scenario 1: High-Efficiency New Homes (Reference #3a)
Assumes homes meeting the WaterSense new home specification (as of 2009) and high-efficiency Energy Star-rated clothes washer, for indoor use, and 25% increase over base for outdoor use

Assume 36 for indoor (months of October through April)
Assume 45 during the months of May through September (36 indoor + 25% increase over base)
Annual avg. = 40 gpcd

[59] The peak irrigation season is typically between June and August

Scenario 2: Full Conservation 2001 (Reference #4, Figure 2.4)
Vickers' conserving household numbers for indoor use, and 25% increase over base for outdoor use

Assume 45 for indoor (months of October through April)
Assume 56 during the months of May through September (45 indoor + 25% increase over base)
Annual avg. = 50 gpcd

Scenario 3: U.S. Average 2010 (Reference #2)
Updated Residential End Uses of Water Study numbers for average indoor use and 25% increase over base for outdoor use

Assume 58.6 for indoor (months of October through April)
Assume 73 during the months of May through September (58.6 indoor + 25% increase over base)
Annual avg. = 65 gpcd

Scenario 4: Massachusetts Title 5 1991 (Reference #1)
MA Title 5 numbers for indoor use and 50% increase over base for outdoor use

Assume 55 for indoor (months of October through April)
Assume 82.5 during the months of May through September (55 indoor + 50% increase over base)
Annual avg. = 66 gpcd

STATUS OF MA COMMUNITIES IN RELATION TO MassDEP BENCHMARK OF 65 RGPCD

MassDEP, 2011 – 2015 ASRs (DEP-accepted values, Ref. #6):

- Average = 58 rgpcd
- 77% were 65 rgpcd or lower in 2015

Massachusetts Water Resources Authority (MWRA), 2008 – 2012, communities (minus Boston) entirely served by the MWRA:

- Average = 64 rgpcd

REFERENCES

1. MassDEP and DeFeo, Wait & Associates, Inc. 1991. Technical Evaluation – Title 5 the state environmental code, 310 CMR 15.00. Boston, MA: Commonwealth of Massachusetts.
2. DeOreo, W., P. Mayer, B. Dziegielewski, and J. Kiefer. 2016. Residential end uses of water, version 2. Denver: Water Research Foundation.
3. DeOreo, W.B., and P. Mayer. 2012. Insights into declining sing-family residential water demands. Journal American Water Works Association. 104: E383 – E394. Available at http://www.awwa.org/publications/journal-awwa/abstract/articleid/31472016.aspx. This article compares four key end-use studies, including the following:
   a. DeOreo, W.B. 2011. Analysis of water use in new single-family homes. Report to Salt Lake City Corporation and U.S. EPA. Boulder, CO: Aquacraft.
      - High-efficiency new home group: data collected 2008 and 2009

- Standard new home group: data collected between 2006 and 2008

b. Aquacraft. 2005. US EPA—Combined Retrofit Report. Water and Energy Savings from High Efficiency Fixtures and Appliances in Single Family Homes. Boulder, CO: Aquacraft. (Data collected between 2000 and 2002).

4. Vickers, Amy. 2001. Handbook of Water Use and Conservation. Amherst, MA: WaterPlow Press. See Figure 2-4
5. Mayer, P.W., W.B. DeOreo, E.M. Opitz, J. C. Kiefer, W.Y. Davis, B. Dziegielewski, and J.O. Nelson. 1999. Residential End Uses of Water. Denver, CO: AWWA Research Foundation and American Water Works Association.
6. MassDEP Public Water Supply Annual Statistical Report Data, 2011 – 2015. Email correspondence from Jen D'Urso, MassDEP, January 23, 2017.

F) BMPs for Selected Industries[60]

Water consumption in the Semiconductor, Metal Plating, Paper, Food and Plastics industries is quite high. Knowledge of water balance for the entire facility and specifications for individual streams and processes are useful for a program on water conservation. Simple engineering systems such as countercurrent rinsing, high-pressure low volume water cleaning, low-volume atomized or fog spray rinsing systems, tying dumping of baths to measurement of critical bath parameters, installing essential instrumentation (e.g. flow restrictors, conductivity controllers, pH meters, etc.) and installing filtration/screening and cooling systems to extend bath life are all options to reclaim, refine, and reuse water continuously.

WATER CONSERVATION PLANS (general)

Water is an important resource or raw material in the manufacturing of various products; however, for many facilities water is usually considered an overhead cost. In most municipalities in the Commonwealth of Massachusetts, facilities pay a contracted rate for the volume of water supplied and a sewer cost, typically at a higher and different rate. To appreciate the contribution of water to the operation of any plant, there should be a cost value assigned to its input, whether it is a solvent, cleaning agent, used for cooling, a convenient means to transport other resources, or a way to store intermediate or final products.

Controlling the use and cost of water is the responsibility of everybody in the company. A policy statement with clear objectives that is supported by top management will define the company's position on water use. The objectives serve as guidelines to develop goals that all employees can work towards. Included in this policy, a management team should be established and a continuous program for educating employees should be implemented.

The management team monitors the use of water in the facility and to formulate an equitable means of allocating cost to the use of water and its disposal. For a small facility, these responsibilities may be assigned to an individual with the additional authority to enforce viable and cost-effective changes.

Basic Program

Outlined below are some simple, practical and general measures and procedures that may promote water conservation and optimal uses in some industry sectors. The list is by no means exhaustive. The peculiarities of an individual facility may make some of the suggestions impractical - ideally, such peculiarities should be viewed as opportunities to develop viable alternatives.

Water Budget

Measurements should be taken to establish a water budget for all operations. Inputs and effluents from all processes should be assessed. The flow of water within the facility should be measured, documented and continuously monitored. Water meters may be installed for the most significant water uses. Simple methods to estimate flow rates, e.g. using a bucket and a timer, can be adequate to get reasonable flow rates at individual steps in the production process.

Cost Centers

A realistic cost value based on volumes used should be assessed to the most significant process steps. Major consumers may be considered cost centers and the cost to supply water and to dispose of wastewater should be documented regularly.

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[60] Best Management Practices for Selected Industries and Additional Resources. Gus Ogunbameru, PhD. Ch. E. - Massachusetts Office of Technical Assistance.
See also the Alliance for Water Efficiency, "Water Saving Tips: Commercial, Industrial, and Institutional Water Use," at http://www.allianceforwaterefficiency.org/CII-tips.aspx

Monitor and Audit

At established periodic intervals, flow rates should be measured and compared with those established through the water balance.

Maintenance

All fresh water and wastewater leaks should be logged on a daily basis. Maintenance should be carried out to fix leaks within 24 hours of their discovery.

Energy Savings

In many operations, water conservation will reduce energy costs as well as water costs.

More Information

For further information on BMPs and case studies on successful water reduction efforts in each of the following industrial sectors, please visit the OTA website at: https://www.mass.gov/how-to/request-water-conservation-and-wastewater-recommendations

- Semiconductors
- Metal Plating
- Paper Mills
- Rubber and Plastics

G) Sample Worksheet for Industrial / Commercial / Institutional Water Audit[61]

AUDIT COMPLETED BY (NAME): **DATE:**

GENERAL INFORMATION

Customer/Account Name:
Address:
Facility contact person:
Product(s) or services(s):

SIC category(ies)

Facility dimensions (for each building) in sq ft:	No. floors		Width	Height	Age of facility(years)
Avg. no. of occupants (employees and nonemployees):	Female:		Male	Total	
Avg. no. of days facility occupied/year	Avg. no. hours occupied/day:		Weekdays	Weekends	Holidays
Is recycled water currently used on site?	Yes	No	If yes, describe and give amount used (e.g. gallons per year):		
Building wastewater is:	Treated on site	Connected to municipal/off-site system		Other (describe)	

METER INFORMATION

	Meter No. 1 ID No.	**Meter No. 2 ID No.**	**Meter No. 3 ID No.**	**Meter No. 4 ID No.**	**Meter No. 5 ID No.**
Meter location					
Meter type					
Reading frequency					
Units of register					
Multiplier (if any)					
Meter size					
Connection size					
Meter installation date					
Testing frequency					
Last service (date)					
Last test/calibration (dates)					

Note: The complete ICI water audit worksheet is five pages and covers an ICI building/facility water-use inventory, recommended efficiency measures, potential water savings from ICI efficiency measures, and potential benefit and costs from ICI efficiency measures. For details, see Vickers 2001, Appendix G.

[61] Source: Vickers, Amy. 2001. *Handbook of water use and conservation.* Amherst, MA: WaterPlow Press.

H) Summary of Water Conservation and Water Quality Recommendations for Lawns and Landscapes

SOILS	
Care and Maintenance Components	**Water Conservation Recommendations**
Soil Health	• Ensure adequate depth and type of soil (at least 6 inches of good topsoil). Generally, a sandy loam with 5% organic content is recommended for turf grass and landscapes. The texture, organic content, pH level, drainage, salinity and fertility are important characteristics of soil that should be considered before planting anything. • Aerate the soil. Look for areas where soil may be compacted. • Use peat moss, well-rotted manure, or compost to improve moisture retention. Peat moss must be thoroughly mixed with the soil in order to be effective at improving drainage characteristics. If used as a topdressing or over aeration holes, it can actually wick water away from the soil and roots. Choose manure and composts that are well decomposed. Manure and compost can be a source of weed seeds if not well decomposed. • Use cultural and fertility practices that increase water infiltration, reduce runoff, reduce leaching, eliminate waste of water, encourage extensive root growth and maximize efficiency of plant water uptake. Use organic or organic-based fertilizers whenever possible (see Ref. 5below). • Test soil for nutrients, pH, heavy metals and other soil factors as appropriate, using a soil testing laboratory that provides testing appropriate for Massachusetts soils. Adjust soil pH and provide fertility according to soil test results. • Avoid pesticides that also kill beneficial organisms such as earthworms that aerate and fertilize the soil naturally. Choose proven biological pest management materials whenever possible.
Soil Moisture	Test soil for dryness. Water should soak down deeply enough to re-moisten the root zone, about 4-6 inches. This encourages deep root growth.

PLANTS	
Care and Maintenance Components	**Water Conservation Recommendations**
Plant Species	Choose plant species appropriate to the soil and sun exposure in the yard (see Ref. 1, 2, 5below).
Design & Layout	Group plants with similar watering requirements
Mulch	• Make sure smaller trees, shrubs and beds of plants are properly mulched; this saves water, keeps the weeds down and is good for the plants. • Use mulch to retain soil moisture and reduce the need for watering. The mulching material should allow for water infiltration into the soil/root zone. Be careful not to apply too much, because the soil does require some heat (see Ref. 7 below).

GRASS	
Care and Maintenance Components	**Water Conservation Recommendations**
Size of Grass Area	• Minimize lawn size and maintain/enhance existing native vegetation. Plant turf grass only where it has a practical function. • Understand that some areas may not grow turf, and watering a lot might not help. Where there are large trees, the combination of shading and the tree roots may make grass sparse.
Grass Species	Use drought-resistant/low-water-use grass species and cultivars. Fine fescues, including creeping red fescue, chewings fescue, and hard fescue, are drought tolerant and low maintenance in their needs, and are recommended low-water-use species (see Ref. 5 below).
Grass Height	Mow lawns at the highest recommended height (at least 2.5 to 3 inches).
Pest Control	Practice Integrated Pest Management. Choose proven biological pest management materials whenever possible (see Ref. 3, 1, 5 below).
Fertilizing Grass	Follow Massachusetts regulations (330 CMR 31.00) on the use of plant nutrients (see Ref. 4 below). Application of phosphorus may not actually be necessary, based on the soil. Fertilizing for phosphorus and potassium should be done based on a soil test through a laboratory that conducts tests appropriate for Massachusetts soils. Don't fertilize unless recommended by a soil test. Adjusting pH (usually by liming) should also be done based on a soil test. If fertilizer is needed, applications are best made in late summer-early fall and in mid-spring. Check weather forecasts before application and do not apply if heavy rain is forecasted (a light rain can substitute for recommended watering-in of a nutrient-containing material). Organic and organic-based fertilizers are recommended whenever possible. Where organic materials are the principal nutrient source being used over time, soil phosphorus levels should be monitored (see Ref. 4, 6 below).
How much water?	• Massachusetts generally has enough rainfall (49 inches annually and 3 to 4 inches in July) to naturally supply the water needs of most healthy mature lawns with good soil, without the need for watering. • In years of drought and/or high heat, lawns may enter drought dormancy, turning brown and stopping growth. Turf should recover with the return of cooler weather and more moist conditions. When drought is severe and heat is extended for a long period of time, lawn managers should plan to overseed their lawns with desirable, drought tolerant grasses when cool, moist weather returns in late summer – early fall. Watering at overseeding and renovation is needed to establish healthy, weed-, pest- and drought-resistant lawns and fields. • Athletic fields and recreational areas that are used during drought dormancy will experience severe loss of turf, as the crowns of the grass plants will be unprotected by living foliage. It is best to keep traffic and play off drought dormant grass. If it is necessary to use such areas, especially if heat and drought are prolonged, the managers of those properties should plan to overseed or renovate the fields as necessary. Watering at overseeding and renovation is critical to successful establishment of healthy and weed-, pest-, and drought-resistant lawns and fields. • During non-drought conditions, watering (**if necessary at all**) should be done to re-moisten the root zone (4-6 inches). The amount will depend on the soil and many other site factors. A general rule of thumb is one inch per week **including rain**, but some sites will need less and some may need more.

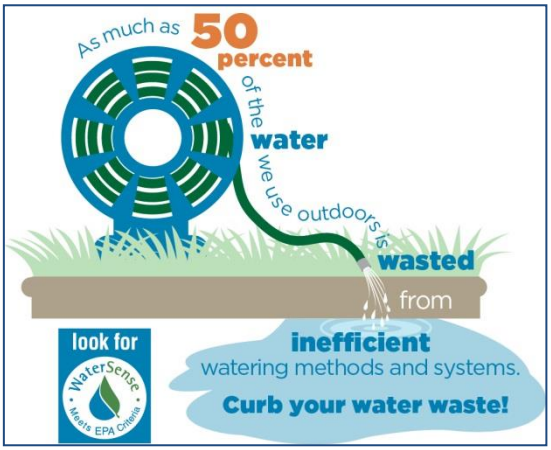
REFERENCES

1. Executive Office of Environmental Affairs. 2004. *More Than Just A Yard, Ecological Landscaping Tools for Massachusetts Homeowners*. (https://www.mass.gov/files/documents/2017/11/07/morethanjustyard.pdf)
2. Greenscapes Massachusetts. *Greenscapes Guide* (available for download at http://greenscapes.org/)
3. MA Department of Agricultural Resources, Integrated Pest Management (IPM) Six Step Approach. Available at http://www.mass.gov/eea/agencies/agr/pesticides/ipm-six-step-approach.html
4. MA Department of Agricultural Resources, Plant Nutrient Management. Available at https://www.mass.gov/plant-nutrient-management
5. University of Massachusetts Extension Turf Program. 2013. Best Management Practices for Lawn and Landscape Turf. Ver. 1.51. (http://ag.umass.edu/turf/publications-resources/best-management-practices)
6. University of Massachusetts Extension Turf Program. Nutrient Best Management Practices. Available at https://ag.umass.edu/turf/publications-resources/nutrient-management-information
7. Vickers, Amy. 2001. *Handbook of Water Use and Conservation.* Amherst, MA: WaterPlow Press.

I) Guidelines for Efficient Irrigation

Common-Sense Guidelines for Watering Landscapes
For hand watering, manual sprinklers, or more complex irrigation systems, observe these five common-sense principles:

1. Water only when needed. Rainfall in Massachusetts generally provides enough water for landscape needs.
2. Water early in the day. Do not water between 9:00 AM and 5:00 PM.
3. Water deeply and less often to encourage deep root growth.
4. Know the water needs of each part of your landscape and water accordingly.
5. Direct water to vegetated areas; avoid spraying sidewalks, driveways, decks, and other hard surfaces.



Automatic Irrigation Systems
Consult WaterSense or Irrigation Association guidelines (see References below) for irrigation system design, installation, operation, auditing, and maintenance. Irrigation systems should:

- Be designed or installed and audited by an irrigation professional certified by a WaterSense labeled program
- Be designed and installed to sustain the landscape without creating runoff or direct overspray
- Achieve at least a 65 percent distribution uniformity
- Be equipped with technology that inhibits or interrupts operation during periods of rainfall or sufficient moisture, **as required by Massachusetts law** (MGL ch.21 §67); this includes Smart Water Application Technology (SWAT), such as WaterSense-labeled irrigation controllers meeting specified criteria
- Use fixed-spray irrigation on turfgrass only; use drip or micro-irrigation on all plants other than turfgrass

Guidelines for Irrigation System Audits
WaterSense guidelines for irrigation audits are reproduced in Attachment I-1 to this appendix. The Irrigation Association also provides audit guidelines and worksheets at http://www.irrigation.org/IA/Resources/Technical-Resources/Irrigation-Auditing/Audit-Guidelines/IA/Resources/Audit-Guidelines.aspx.

References
Irrigation System BMPs:

- EPA WaterSense. July 24, 2014. Section 4.2, "Irrigation System," in WaterSense New Home Specification (available at https://www.epa.gov/watersense/homes-specification)
- Irrigation Association. May 2014. Landscape Irrigation Best Management Practices (available for download on this page: https://www.irrigation.org/IA/Advocacy/Standards-Best-Practices/Landscape-Irrigation-BMPs/IA/Advocacy/Landscape-Irrigation-BMPs.aspx?hkey=93b546ad-c87a-41b8-bf70-8c4fd2cff931)
- University of Massachusetts Extension Turf Program. 2016. Best Management Practices for Lawn and Landscape Turf. Ver. 1.51. Section 6, "Irrigation and Water Management" (available at http://ag.umass.edu/turf/publications-resources/best-management-practices)

Irrigation Controllers, best available technology:

- EPA WaterSense. Specification for Weather-Based Irrigation Controllers. Ver. 1.0, November 3, 2011 (or as updated) (available on the Specifications tab at https://www.epa.gov/watersense/irrigation-controllers)

Alternative sources of water:

- EPA WaterSense. October 2012. Section 8, Onsite Alternative Water Sources, in WaterSense at Work: Best Management Practices for Commercial and Institutional Facilities (available at https://www.epa.gov/watersense/best-management-practices; scroll down to "Alternative Water Sources" link)

Attachment I-1. Guidelines for Irrigation Audits

Source: https://www.epa.gov/sites/production/files/2017-01/documents/ws-homes-irr-audit-guidelines.pdf

Audit checklist at: https://www.epa.gov/sites/production/files/2017-01/documents/ws-homes-irr-audit-checklist.pdf

Guidelines for Irrigation Audits on WaterSense® Labeled New Homes

After the irrigation system is installed, an irrigation professional certified by a WaterSense labeled program must conduct an audit of the system. EPA prefers that the auditor be independent of the professional who designed and installed the system. If this is not the case, please indicate on the *WaterSense Labeled New Home Irrigation Audit Checklist* what the certified irrigation professional's role was during design and installation. EPA recommends that the certified irrigation professional conduct the audit according to the Irrigation Association's Certified Landscape Irrigation Auditor Training Manual (2004). The audit shall include, but is not limited to, the following components:

A. Distribution Uniformity Calculation (Section 4.2.5)

The *WaterSense New Home Specification* requires that irrigation systems achieve a lower quarter distribution uniformity (DU_{LQ}) of 65 percent or greater and that distribution uniformity be measured on the largest spray-irrigated area during the post-installation audit.

- Determine the DU_{LQ} of the system using the catch-can method. This test shall be conducted according to the Irrigation Association's *Recommended Audit Guidelines* located at www.irrigation.org/Resources/Audit_Guidelines.aspx. The test shall include areas of turfgrass only and shall be conducted on the largest spray-irrigated area. Verify that the $DU_{LQ} \geq 65\%$.

B. Irrigation System Design (Sections 4.2.3 through 4.2.10)

Conduct a visual inspection to verify the following specification criteria are met. The results of the visual inspection shall be recorded by the certified irrigation professional on the irrigation audit checklist.

- The irrigation system operates without leaks (Criterion 4.2.3).
- There is no runoff or overspray from the irrigation system that leaves the property during a minimum operating duration determined to be appropriate for the system by the certified irrigation professional (Criterion 4.2.4).
- The irrigation system includes a technology that inhibits or interrupts operation of the irrigation system during periods of rainfall or sufficient moisture (e.g., rain sensors, soil moisture sensors) (Criterion 4.2.6).
- The irrigation system is equipped with a WaterSense labeled weather-based irrigation controller or a soil moisture senor-based irrigation controller that contains the following capabilities in both smart and standard mode (Criterion 4.2.7):
  1. Preserves the contents of the irrigation program settings when the power source is lost without relying on external battery backup.
  2. Has independent, zone-specific programming or the ability to store a minimum of three different programs to allow for separate schedules for zones with different water needs.
  3. Indicates to the user when it is not receiving a signal or local sensor input and is not adjusting irrigation based on current weather or soil moisture conditions.
  4. Interfaces with a rainfall device.

5. Accommodates watering restrictions as follows:
   - Operation on a prescribed day(s)-of-week schedule (e.g., Monday-Wednesday-Friday, Tuesday-Thursday-Saturday; any two days; any single day).
   - Either even-day or odd-day scheduling, or any day interval scheduling between two and seven days.
   - The ability to set irrigation runtimes to avoid watering during a prohibited time of day (e.g., between 9:00 a.m. and 9:00 p.m.).
   - Complete shut-off (e.g., on/off switch) to accommodate outdoor irrigation prohibition restrictions.
6. Includes a percent adjust (water budget) feature. The percent adjust (water budget) feature is defined as having the means to increase or decrease the runtimes or application rates for zones by means of one adjustment without modifying the settings for each individual zone.
7. Reverts to either a proxy of historical weather data or a percent adjust (water budget) feature if the primary source of weather or soil moisture information is lost.
8. Allows for a manual operation troubleshooting test cycle and automatic return to smart mode within some period of time as designated by the manufacturer, even if the switch is still positioned for manual operation.

- Sprinkler heads, other than as part of a micro-irrigation system, have a 4-inch or greater pop-up height and matched precipitation nozzles (Criterion 4.2.8).
- Sprinkler irrigation, other than as part of a micro-irrigation system, is not used to water plantings other than maintained turfgrass (Criterion 4.2.8).
- Sprinkler irrigation, other than as part of a micro-irrigation system, is not used on turfgrass strips less than 4 feet wide nor on slopes in excess of 4 feet of horizontal run per 1 foot vertical rise (4:1) (Criterion 4.2.8).
- Micro-irrigation systems include, at a minimum: pressure regulators, filters, and flush end assemblies (Criterion 4.2.9).
- Two schedules have been created and are posted by the irrigation controller (Criterion 4.2.10):

  1. A schedule for the initial grow-in phase
  2. A schedule for the established landscape

  Irrigation schedules shall vary according to the seasons, reflecting the varying irrigation needs throughout the year. In addition, schedules shall comply with local water restrictions.

C. Verification of Operating Pressure

Verify that the station or zone pressure based upon emission device or product being used (spray head, rotor head, drip emitter) is within +/- 10 percent of manufacturer-recommended operating pressure. Test this on a representative zone of each irrigation type (e.g., spray, rotor, drip, etc.).

J) Massachusetts Drought Management Outdoor Water Use Restriction Guidelines

The actions below are statewide guidance under conditions of regional drought and represent one of the most important steps that can be taken to minimize the impacts of drought on water supply and the environment.

State Drought Condition	Nonessential Outdoor Water Use Restrictions
Level 1 (Advisory)	1 day per week watering, and only after 5 p.m. or before 9 a.m. (to avoid evaporative losses)
Level 2 (Watch)	Outdoor watering should be limited to hand-held hoses or watering cans, to be used only after 5 p.m. or before 9 a.m.[62]
Level 3 (Warning)	Ban on all nonessential[63] outdoor water use
Level 4 (Emergency)	Ban on all nonessential[64] outdoor water use

[62] Watering of municipal parks and recreation field with irrigation systems and sprinklers may continue, at the water supplier's discretion, after 5 p.m. and before 9 a.m.

[63] Essential uses are defined by MassDEP as uses required: a) for health or safety reasons; b) by regulation; c) for the production of food and fiber; d) for the maintenance of livestock; or e) to meet the core functions of a business. Nonessential uses are those *other than* essential uses.

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