Water Efficiency Manual

for Commercial, Industrial and Institutional Facilities

BY:
N.C. Department of Environment and Natural Resources
Division of Pollution Prevention and Enviornmental Assistance
Division of Water Resources
Land-of-Sky Regional Council, Waste Reduction Partners

Water Efficiency Manual

for Commercial, Industrial and Institutional Facilities

A joint publication of the Division of Pollution Prevention and Environmental Assistance and Division of Water Resources of the N.C. Department of Environment and Natural Resources, and Land-of-Sky Regional Council.

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When to Use This Guide

Now, to determine what you can do to reduce water use, improve efficiency and save money in your operation.

As you plan and budget for next year, to determine what programs, equipment and employee participation will be necessary to use water more efficiently.

Before you purchase any new water-using domestic fixtures, cooling, heating, processing, landscaping and facility support equipment and service contracts.

Before you seek buy-in and support from your management, maintenance and production personnel. They also should read this manual.

Before any facility upgrading, new construction, processing expansions and new product manufacturing.

During unforeseeable water shortages, drought conditions or voluntary/mandatory water conservation requirements.

Contents

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- Chris Frazier
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- Don Rayno

Mauri Galey, Nalco, Burlington, North Carolina
James Manning, Fluidyne International, Asheville, North Carolina
Dr. Charles Peacock, N.C. State University, College of Agriculture and Life Science, Raleigh
Dr. John Rushing, N.C. State University, College of Agriculture and Life Science, Raleigh
Dr. Brent Smith, N.C. State University, College of Textiles, Raleigh

1 Reasons for Water Efficiency Efforts

Water Issues in North Carolina

North Carolina is generally considered to have abundant water resources. However, water resources are becoming a major concern in North Carolina.

The state's rapidly growing population has increased the demand for water and the state's recent drought conditions have caused many public water supply systems to experience limited availability of raw water.

From 1990 to 2007, statewide population increased by approximately 38 percent from 6.6 million to 9.1 million. This trend is expected to continue with the state's population projected to grow to 12 million by 2030.

Using water more efficiently will be a major part of the solution to the state's water dilemma. By using water more efficiently, existing supplies can be used to meet additional demands. Water efficiency programs will help North Carolina meet water resource challenges of the future.

Surface sources include reservoirs, lakes, streams and rivers. According to the U.S. Geological Survey, 94 percent of water withdrawn in North Carolina for all uses is taken from surface sources.

As the state's demand for water has increased, development of new water supply reservoirs has not kept up with the rate of demand growth. From 1910 to 1965, reservoir storage was added at the rate of about 1.9 acre-feet for each new resident. Since 1965, the rate has decreased to about 0.19 acre-feet per new resident, or one-tenth the rate from 1910 to 1965.

Areas within the state are already facing water supply infrastructure challenges. Some water systems are experiencing seasonal demand that approaches the limits of their available raw water supply. While some systems are limited by watershed capacity, especially during low precipitation periods, others are limited by inadequate system capacity to meet peak demands. In many areas the ability to produce additional potable water is constrained.

The importance of water for the vitality of the state cannot be overstated. All consumers must use water more efficiently in order to maintain adequate water availability. Water efficiency is a means by which an adequate reserve water supply capacity can be maintained in order to make do during cyclical periods of drought.

Benefits of Water Efficiency Programs

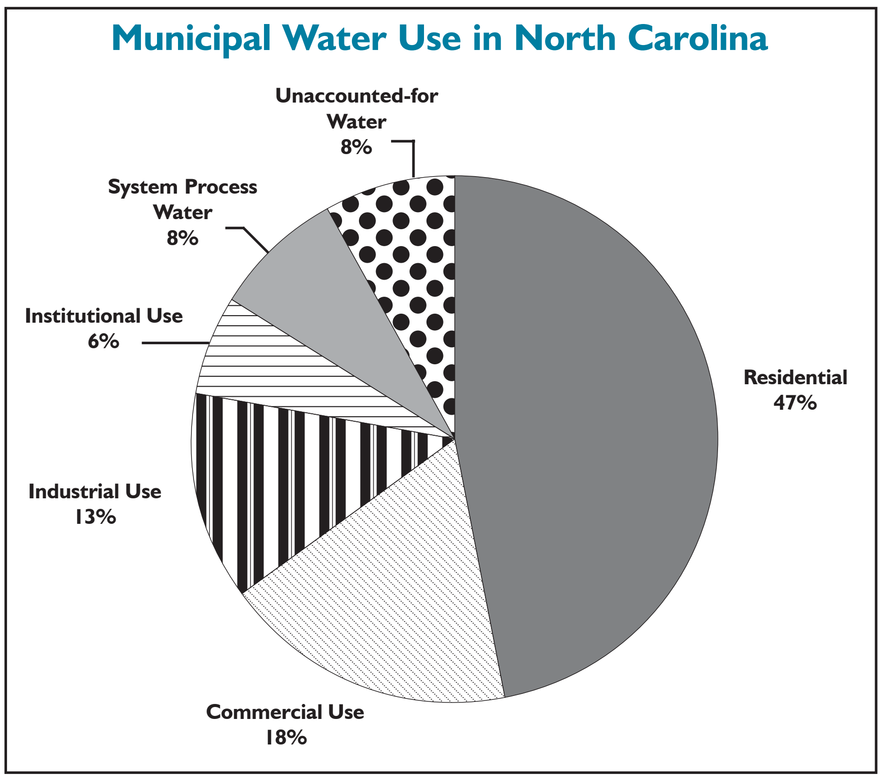
- **Reduced Water Demand**
  Generally faster, cheaper and easier than supply-side programs.
- **Water and Wastewater Treatment Saving**
  Reduces costs and defers plant expansion.
- **Less Environmental Impact**
  Due to fewer surface and subsurface withdrawals.
- **Sustained Water Quality**
  Reduces groundwater's contaminant intrusion and curtails demand for new supplies that are of lower quality.

Industrial, Commercial and Institutional Water Use

Non-residential users of publicly-supplied drinking water have a significant impact on public water system demand. Information submitted to the Division of Water Resources by more than 520 water systems in the most recent local water supply plans indicates that non-residential users in these systems account for about 37 percent of total water use in these systems. These systems provide water to about 6.6 million people or about 73 percent of the population (*see Figure 1-1*). ICI water demand may make up a larger percentage of total water demand for some public water supply systems, depending on their mix of residential and non-residential customers.

Some ICI facilities withdraw and treat water from privately owned wells and/or surface water intakes to supply their own needs. Self-supplied users can benefit from reduced demand from water efficiency improvements within their facilities by reducing costs and reducing the uncertainty of raw water availability. Operating a privately-owned water system does not diminish the need for water efficiency within these ICI facilities because raw water availability is linked to other users regardless of the source.

FIGURE 1-1



Data reported in 2006 and 2007 local water supply plans submitted to the N.C. Division of Water Resources.

Local and State Responses to Water Supply Issues

As a result of increasing water supply demand and the limited quantity of available treatable raw water, public water supply systems are implementing water efficiency programs. These programs range from including water efficiency tips in water bills to having specialized staff available to actively promote and implement demand management and water conservation/efficiency programs, as well as to provide customer assistance. Demand-side management programs are designed to control growth in demand for water to levels that can be supported by current PWS system capacity, thus postponing investment in infrastructure or source expansion. These same strategies can reduce drought-induced detrimental impacts on water customers. Water efficiency programs that reduce water demand can also result in significant savings in water and wastewater treatment costs (energy, chemicals, etc.), thus reducing environmental impacts associated with process inputs such as electricity and chemicals.

Water rates can have a significant impact on the effectiveness of water efficiency programs and the effects of the programs on the fiscal stability of a water system. Building a successful program will require municipalities to abandon traditional "declining block rate" structures that charge less per unit as users consume more. The use of rate structures designed to encourage water conservation, such as "uniform" and "increasing block" structures, can make investments in efficiency improvements more attractive for water customers. The feasibility of capital investments necessary for implementation of water efficiency options depends largely on the analysis of the expected payback period, a key component of which is the cost of water.

North Carolina requires local governments that supply water to the public and large community water systems to prepare a local water supply plan and to update the plan at least every five years. Local water supply plans include evaluations of current and future system demands, current and future raw water supplies, and an accounting of water use by sector for the reporting year. Preparation of these plans provides PWS system managers and community officials the opportunity to evaluate the ability of their water system and supply sources to meet current and future demands.

The N.C. Division of Water Resources is responsible for approving local water supply plans. As a planning tool, DWR encourages systems whose average daily demand exceeds 80 percent of their available supply to actively manage growth in water demand, implement a water conservation program and investigate options for obtaining additional water supplies. Systems with demands in excess of this threshold may be susceptible to shortages during drought or peak demand periods. In evaluating options for meeting future demand, DWR strongly encourages systems to incorporate ways to use available water supplies more efficiently.

efficiency vs. conservation

"Water efficiency" means using improved technologies and practices that deliver equal or better service with less water. For example, the use of low-flow faucet aerators can be more powerful than no aerators for washing hands. "Water conservation" has been associated with curtailment of water use and doing "less" with less water, typically during a water shortage, such as a drought; for example, minimizing lawn watering and automobile washing in order to conserve water. Water conservation also includes day-to-day "demand management" to better manage how and when water is used, so it is common to hear the words "water conservation" used synonymously with "water efficiency."

Coordinating Efficiency Efforts

In light of cyclical drought conditions and recognition of our finite water supply, North Carolina is placing a greater emphasis on water efficiency as an alternative to developing additional water supply sources. Following the 1998-2002 drought, the General Assembly charged the Environmental Management Commission with developing rules to govern water use during droughts. The resulting rules became effective in March 2007, and can be found in the North Carolina Administrative Code as 15A NCAC 02E .0600 – Water Use During Droughts and Water Supply Emergencies.

The sudden return of exceptional drought conditions again in 2007 and 2008 compelled the governor and the General Assembly to pass legislation improving drought management, which included additional water use reporting and requirements for improved water use efficiency for water systems applying for state funds for system expansions. Session Law 2008-143 reinforces the necessity for municipal water systems to develop and implement a plan for water conservation measures to respond to drought or other water shortages.

Water systems required to prepare a local water supply plan must include a water shortage response plan as part of their local plan. These plans must be approved by the N.C. Division of Water Resources. Passage of this legislation provided statutory authority and more specificity to the requirements for water shortage response plans contained in the drought rules developed in response to Session Law 2002-167. Water shortage response plans must meet the following criteria:

- Include tiered levels of water conservation measures or other response actions based on the severity of water shortage conditions.
- Each tiered level of water conservation must be based on increased severity of drought or water shortage conditions and will result in more stringent water conservation measures.
- All other requirements of rules in accordance with Session Law 2002-167.

Tree ring data studies conducted by Jason Ortegren indicate that North Carolina's climate has alternating cycles of adequate rain and drought. Currently, the links within this cycle are unpredictable, and depend greatly on global hemispheric circulation patterns. Information is still being gathered on the interrelationship between these global patterns. Ortegren discovered, using his models, that over the past 317 years the occurrences of sustained summer droughts (four or more years) in central portions of North Carolina, South Carolina and Georgia have been very prevalent; 11, to be exact. In addition, the frequency of sustained summer droughts increased a lot over time. For example, five of the 11 occurrences were in the 20th century and the other six were spread over the previous ~210 years. For the period 1950-2006, the probability of a sustained summer drought in a given decade was more than 70 percent. This probability is far higher than in previous recorded periods. Since the 1980s, North Carolina has experienced droughts that lasted a year or two. Given the water resource impacts of one- or two-year droughts, the cumulative effects of sustained summer droughts could be devastating in the absence of a sound water resources management strategy.

Source: *Tree-Ring Based Reconstruction of Multi-Year Summer Droughts in Piedmont and Coatal Plain Climate Divisions of the Southeastern U.S., 1690-2006*. Jason A. Ortegren, UNC-Greensboro, 2008.

The N.C. Department of Environment and Natural Resources may require water systems to implement more stringent measures included in their water shortage response plan if the system is in:

- Severe, extreme or exceptional drought, and the department finds all of the following:
  - The water system has not implemented the appropriate level of water conservation measures as written in the water shortage response plan.
  - Implementation of water conservation measures is necessary to minimize the harmful impacts of drought on public health, safety and the environment, including potential impacts of drought or other water shortage on interconnected water systems and other water systems withdrawing from the same source of raw water.
- Extreme or exceptional drought and the department finds the water system has already implemented the appropriate measures under the water shortage response plan for 30 days or more but has not reduced water use enough to minimize the harmful impacts of drought on public health, safety and the environment.

Please note that Session Law 2008-143 does not contain any provision that requires metering or regulation of withdrawal by private drinking water wells.

Water Efficiency Demand-Side Programs

Across America, water efficiency programs for various industrial, commercial and institutional sectors have been established by various states and municipal water systems. These programs have achieved much success in cumulative water savings and have proven to be cost-effective to both the public and private sectors. These programs include activities such as on-site audits, guidebooks, seminars, conservation planning, employee education, advisory committees, trade show expositions, awards, financial incentives/assistance, ordinances, regulations, research studies and industrial reuse programs.

Roles and Responsibilities in Water Efficiency

When water systems are reaching capacity limits of water availability and/or treatment infrastructure, both public and private sectors have important roles to play. Comprehensive water management programs must address leaks and "unaccounted-for" water use, water shortage planning and water efficiency improvements, as well as implement customer education programs and conservation-oriented billing structures. Government buildings and publicly-owned facilities should serve as role models for water use efficiency in the community.

The private sector can do its part to conserve and use water more efficiently. When industrial, commercial and institutional facilities use water more efficiently, it saves everyone money while also helping to reduce environmental impacts.

Many facility managers may view water conservation measures as actions necessary only in droughts, but there are many important reasons to continually improve water use efficiency. Driving factors include: preservation of the quality of surface and ground water supplies; cost avoidance of water and wastewater treatment by reductions in chemical usage and energy consumed; and meeting increased future demands without increased overall water use, thus delaying the need for development of infrastructure for new raw water supplies and treatment facilities.

2 Sound Principles of Water Management

Optimizing facility water use means more than conducting an in-plant study and preparing a report. Water efficiency measures must be viewed holistically within a business' strategic planning. Firms that use water more efficiently now will have a competitive advantage over companies that choose to wait. A successful program must prioritize needs, set well-informed goals, establish current performance minimums and carefully plan a course for action. Consider these principles when establishing water efficiency initiatives.

Categories of Water Efficiency Measures

- Reducing losses (e.g., fixing leaking hose nozzles)
- Reducing overall water use (e.g., shutting off process water when not in use)
- Employing water reuse practices (e.g., reusing washwater)

changing behavior vs. equipment

Equipment changes may be viewed as a "permanent fix" to achieve water efficiency. Changing employee behaviors, such as an operating procedure, may be viewed as a quick and inexpensive way to achieve similar savings without up-front capital expense. In reality, both the technical and human side of water management issues must be addressed. Consistent training and awareness in combination with proper tools and equipment will achieve more permanent water savings.

Prioritizing Needs and Setting Goals

Before considering any water efficiency measure, management must first ensure water use performance is consistent with:

- Public health sanitation requirements such as the U.S. Department of Agriculture, the Food and Drug Administration and state and local health regulations.
- Environmental requirements such as water quality reuse rules and criteria.
- Other health and safety requirements, such as state and local building codes and fire safety codes.
- Customer quality expectations, such as product cleanliness specifications.

Closer examination of the above requirements may lead to more water-efficient ways to achieve and exceed health, safety and customer quality requirements. With the above priority established, consider the following suggestions before embarking on program goal setting.

- Any program should include water supply and wastewater utilities in the process. Involving utilities can help align water use goals for both water users and suppliers. Utilities may have demand-side management concerns such as meeting summer's increased demands or meeting a peak hourly demand. These specific concerns can be factored into a facility water management program.
- Anticipate increased water and wastewater service costs when considering options. Ask utilities to provide any expected increases.
- Anticipate future increases in production or number of employees that will influence water consumption.
- Use total cost accounting methods to perform economic comparison of water-efficient techniques. Consider water and wastewater costs, on-site pretreatment costs, marginal cost for capacity expansion and energy savings (especially heat).
- Encourage water and wastewater utilities to provide rebates and other financial incentives to offset the cost of implementing a water conservation measure. Use the efficiency/conservation plan as a bargaining point.
- Program goals should not only consider the technical side for water efficiency, but also should consider the human side, such as changing behaviors and attitudes toward water use.
- Do the simple tasks first to gain acceptance and positive feedback for the program.

Use internal and external benchmarking techniques to help optimize water consumption.

Typical Water Balance Findings

Understanding water use at a facility is imperative to appropriately prioritize areas to focus time and resources. Figures 2-1 through 2-6 show examples of water use distribution (water balances) for common commercial, industrial and institutional settings. Each facility should determine its own unique water balance to best target opportunities.

Figure 2-1

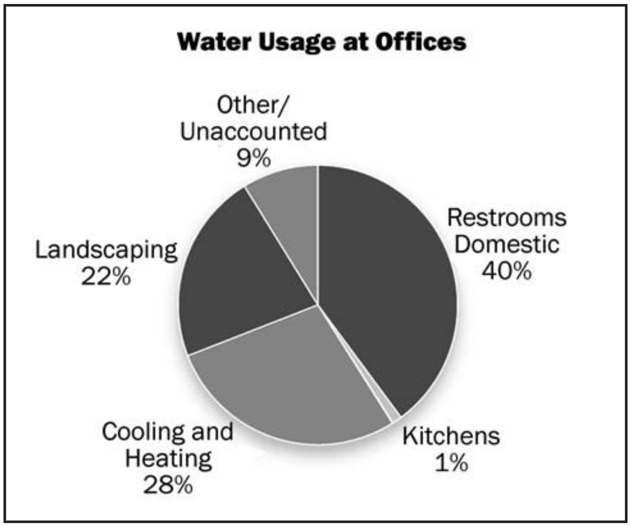


Figure 2-2

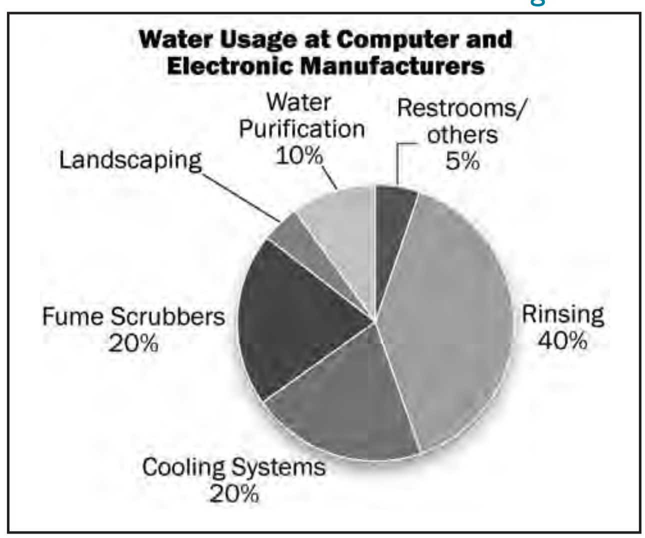


Figure 2-3

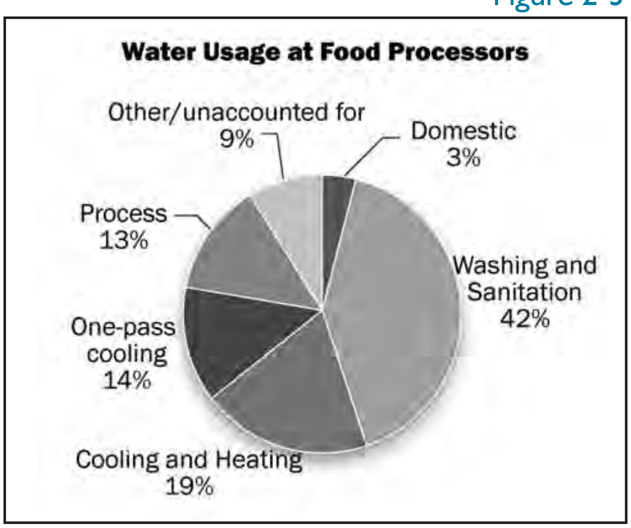


Figure 2-4

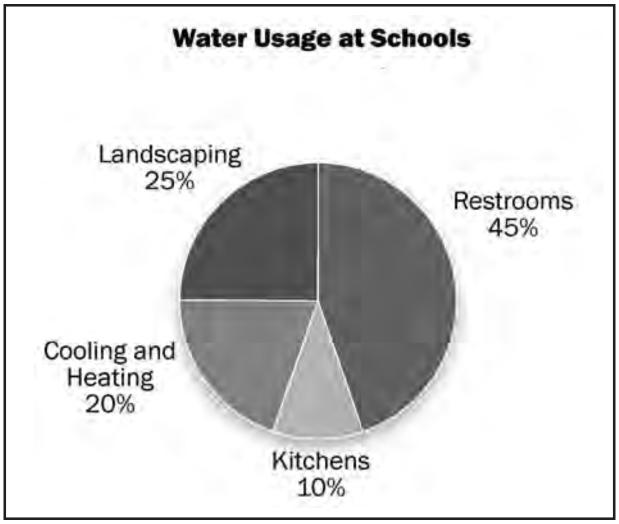


Figure 2-5

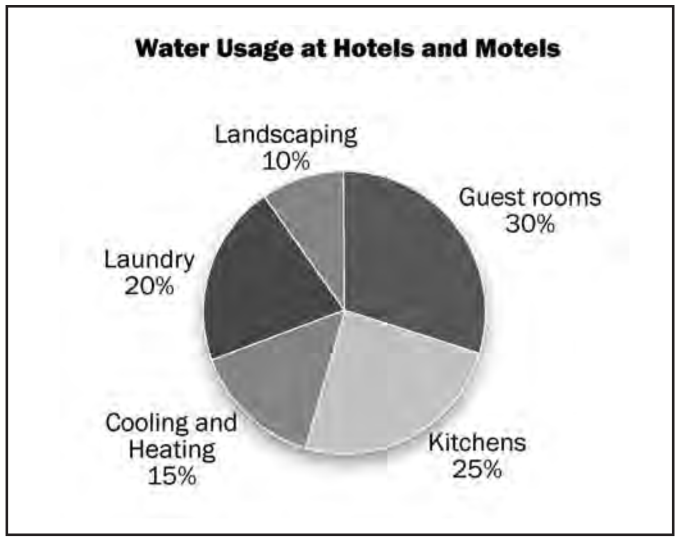
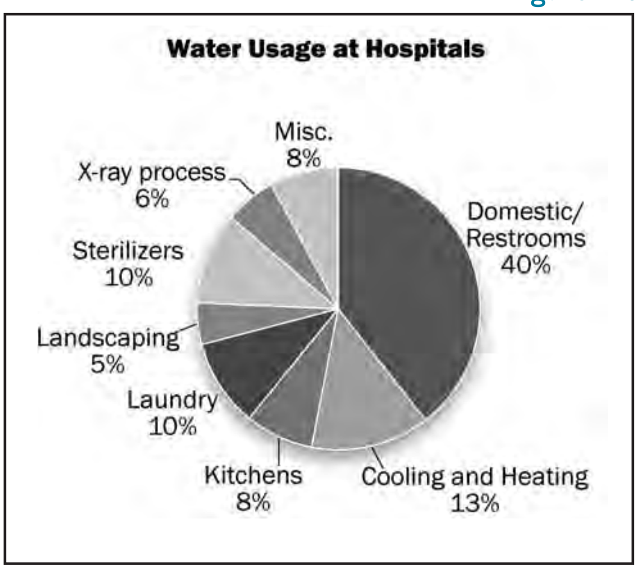


Figure 2-6



The guidance presented in this chapter provides the framework to pursue water efficiency measures. Chapter 3 presents a six-step process to guide facility staff through the details of enacting a successful water efficiency program.

Using TQM and Benchmarking Tools

Facility managers have a variety of total quality management tools to help plan, develop and implement water efficiency measures. These tools include self assessments, statistical process control, ISO 9000 and 14000, process analysis, quality circle and many others. Benchmarking, too, can be an important TQM tool to improve water use efficiency. Benchmarking is a process of comparing one's own operational performance to other organization's to become "best in class" and make continual improvements. Benchmarking is more than simply setting a performance reference or comparison, it is a way to facilitate learning for continual improvements. The key to the learning process is looking outside one's own business to other industry sectors that have discovered better ways of achieving improved performance. Benchmarking can be performance-based, process-based or strategic-based and can compare financial or operational performance measures, methods or practices or strategic choices.

Benchmarks (Annual Basis)

Hotels/Motels	0.079 - 0.165 thousand gals. (Kgal)/sq. ft.
	30.2 - 39.5 Kgal/room
Nursing/ Assisted Living	0.062 - 0.101 Kgal/sq. ft.
	32.8 - 40.7 Kgal/bed
	25.4 - 39.6 Kgal/apartment
Restaurants	0.17 - 0.21 Kgal/sq. ft.
	10.6 - 14.3 Kgal/seat
Schools	0.012 - 0.019 Kgal/sq. ft.
	1.7 - 2.7 Kgal/student

Source: *Benchmarking Task Force Collaboration for Industrial, Commercial & Institutional Water Conservation*, Colorado Waterwise Council, June 2007.

Five Steps of a Benchmarking Process

Planning

Managers must select a process to be benchmarked. A benchmarking team should be formed. The process of benchmarking must be thoroughly understood and documented. The performance measure for the process should be established (i.e. cost, time and quality).

Search

Information on the "best-in-class" performer must be determined. The information can be derived from the company's existing network, industry experts, industry and trade associations, publications, public information and other award-winning companies. This information can be used to identify the best benchmarking partners with which to begin cooperative participation.

Observation

The observation step is a study of the benchmarking partner's performance level, processes and practices that have achieved those levels and other enabling factors.

Analysis

In this phase, comparisons in performance levels among the facilities are determined. The root causes for the performance gaps are studied. To make accurate and appropriate comparisons, the comparison data must be sorted, controlled for quality and normalized.

Adaptation

This phase is putting what is learned throughout the benchmarking process into action. The findings of the benchmarking study must be communicated to gain acceptance, functional goals must be established and a plan must be developed. Progress should be monitored and corrections in the process made accordingly.

The benchmarking process should be interactive. It should also recalibrate performance measures and improve the process itself.

Self-Assessment Checklist

What efforts has your facility already made in water efficiency? Several questions for facility managers are listed below to help gauge a facility's present water efficiency performance.

Top Management Commitment and Resources

- *Is water efficiency included in the company's environmental policy statement?*
- *Are water efficiency responsibilities delegated?*
- *Are quantitative goals established and tracked?*
- *How are water efficiency goals communicated to employees?*
- *What incentives and feedback loops exist for employee participation, suggestions and increased awareness?*
- *Has your facility taken advantage of available help and resources from your utilities, assistance programs, vendors or consultants?*

Water Efficiency Survey

- *Do you know the actual breakdown of your water uses: cooling and heating, domestic uses, process rinsing, cleaning activities, kitchens, laundries, landscaping, water treatment regeneration, evaporation, leaks and others?*
- *Do you know your life cycle water costs for supply water, wastewater treatment, sewer/discharge and heat and mechanical energy losses?*
- *Are you doing simple things such as leak inspections, eliminating unnecessary uses and using timers? Are these practices institutionalized?*

Identifying Opportunities - Target Areas for Water Reduction

DOMESTIC

- *Are code-conforming 1.6 gpf commodes, 0.5 to 1.0 gpm faucet aerators and low-flow 1.5 to 2.5 gpm showerheads in use?*

HEATING/COOLING

- *Has once-through cooling water used in air conditioners, air compressors, vacuum pumps, etc., been eliminated with the use of chillers, cooling towers or air-cooled equipment?*
- *Has blow-down/bleed-off control on boilers and cooling towers been optimized?*
- *Is condensate being reused?*

PROCESS RINSING AND CLEANING

- *Have you considered improved rinsing techniques such as counter-current systems, sequential use from high quality to lower quality needs, conductivity flow controls, improved spray nozzles/pressure rinsing, fog rinsing or agitated rinsing?*
- *Is water turned off when not in use by flow timers, limit switches or manually?*
- *Is the life of an aqueous bath being maximized via filtration and maintenance control?*
- *Are "dry clean-up" practices used instead of hosing down, and is first-pass pre-cleaning conducted with squeegees, brushes or brooms?*

ON-SITE WATER REUSE

- *Is water quality matched with water quantity?*
- *Have reuse applications been examined for process water, landscaping irrigation, ornamental ponds, flush water and cooling towers?*

LANDSCAPING

- *Are low-flow sprinklers, trickle/drip irrigation, optimized watering schedules and water placement, preventive maintenance and xeriscaping techniques in place?*

KITCHENS

- *Are "electric eye" sensors for conveyer dishwashers installed?*
- *Have new water and energy efficient dishwashers been examined?*

Water Efficiency Action Plan

- *Have you performed a cost analysis on water efficiency opportunities?*
- *Do you have a prioritized implementation schedule?*
- *Are water users informed of the changes and communication channels open for feedback?*

Tracking and Communicating Results

- *Do you post monthly water usage rates to employees and management?*
- *Are your water efficiency achievements being recognized in case study articles, media coverage, mentoring to other businesses, business environmental exchange programs or in award programs?*

3 Conducting a Successful Water Efficency Program

A successful water efficiency program should begin with a well-thought-out plan. Crucial to the development and use of this plan are management's commitment; sufficient technical staff and financial resources; employee awareness and participation; and well-publicized results. Water efficiency measures may very likely be just one part of an integrated energy management, pollution prevention or other cost-reduction program or environmental management system. Regardless the driving factors, a heightened awareness and road map to water efficiency opportunities and cost savings will help management make sound choices to optimize operational efficiency, improve economic competitiveness and conserve quality water resources for the future.

Steps for a successful water efficiency program

Step 1 - Establish commitment and goals

Step 2 - Line up support and resources

Step 3 - Conduct a water audit

Step 4 - Identify water management options

Step 5 - Prepare a plan and implementation schedule

Step 6 - Track results and publicize success

Step 1

Establish Commitment and Goals

At first, water efficiency goals may be qualitative and included in statements of commitment, environmental policies, budgetary planning or other external awareness measures. Initial commitments should allocate staff and resources to assess the current water use baseline and explore water efficiency opportunities. With additional information, realistic goals of quantitative water efficiency can be established. For example, goals could include establishing a percent reduction goal in overall water consumption (such as a 10 percent overall reduction in water use next fiscal year) or establishing a gallon-per-year reduction goal in water consumption (such as reducing consumption by 20,000 gallons per year). Even better goal setting uses industry benchmarking information based on an operating index (such as gallons per pound of product manufactured or gallons consumed per client served). Remember, goal setting is an ongoing process requiring periodic review and revisions for continual improvement.

Step 2

Line Up Support and Resources

Designate a Conservation Manager

A conservation manager, coordinator or team leader also may have responsibilities for energy management and/or environmental management. The conservation manager should:

1. Review effectiveness of present water efficiency measures for further improvements.
2. Establish a budget and funding.
3. Evaluate regulatory constraints and local water supply issues.
4. Seek outside funding, grants and available technical assistance.
5. Coordinate a water efficiency audit.
6. Establish implementation criteria for designing water efficiency measures.
7. Develop a plan.
8. Encourage employee participation and create awareness.
9. Oversee implementation of efficiency measures and activities.
10. Periodically review program progress and make modifications for continuous improvement.

Achieve Employee Participation

The importance of employee awareness and cooperation in the water conservation program cannot be overemphasized.

- Establish and promote the water efficiency/conservation program for employees. Provide background information about the water conservation policy and its implications for company operations.

- Initiate the employee awareness program with a letter directed to each employee from the head of the organization, such as the CEO, president, owner, mayor, city manager, governor or chief administrator. The letter should describe the established conservation policy, identify the water efficiency coordinator, express full support for the plan and invite feedback.

- Emphasize the need for individual responsibility as part of a team effort to achieve efficiency and environmental goals.

- Establish a "water-saving idea box" and encourage employees at all levels to submit water-saving ideas. Respond to each suggestion offered.

Communicate Water Conservation Awareness

- Incorporate water conservation policies and procedures into employee training programs.
- Use bulletins, e-mail, newsletters, paycheck stuffers or other appropriate methods to transmit policies, programs, ideas, announcements, progress reports and news of special achievements.
- Schedule staff meetings to communicate the organization's water-conservation plan and progress in water savings.
- Establish charts that graphically show the financial savings.
- Use audiovisual programs, outside speakers and other means for employee meetings.
- Post water-conservation stickers, signs and posters in bathrooms, kitchens, cafeterias, conference rooms and other places where employees congregate.

Check out these water efficiency Web sites

SaveWaterNC.org
www.savewaternc.org

N.C. Division of Pollution Prevention and Environmental Assistance
www.p2pays.org

N.C. Division of Water Resources
www.ncwater.org

N.C. Division of Water Quality
http://h2o.enr.state.nc.us

N.C. Drought Management Council
www.ncdroughtcouncil.org

EPA Office of Water
www.epa.gov/ow

Water Librarian's Home Page
www.interleaves.org/~rteeter/waterlib.html

EPA WaterSense
www.epa.gov/watersense

Establish Employee Incentives

- Recognize and reward those employees who submit water-saving ideas.
- Include water consumption measures in employees' job performance reviews.
- Motivate employees by rewarding them with a percentage of the first year's direct savings.
- Allocate water and sewer costs to each individual department to create responsibility for water efficiency.
- Organize and promote competition between shifts.

Use Outside Assistance

Outside organizations are available to assist with water conservation activities. Assistance should be solicited wherever feasible as a resource for the promotion of water conservation. Some suggestions are listed below.

- Take advantage of free or low-cost technical assistance organizations such as EPA's WaterSense program, N.C. Division of Pollution Prevention and Environmental Assistance, N.C. State University's Industrial Extension Service, NCSU's Industrial Assessment Center, Waste Reduction Partners in western and central North Carolina, and energy utilities assistance programs (i.e., Progress Energy and Duke Energy).
- Water and wastewater utilities are vitally interested in assisting customers conserve water. They can provide information, contacts with other industries and advice. Water suppliers may even assist customers with leak-detection programs or water audits of facilities. Some utilities nationwide offer rate reductions and financial incentives for water efficiency investments.
- Participate in any water conservation advisory group, or similar organization, generally sponsored by local water authorities. If such a group does not exist, help the utility establish one.
- Consider hiring private consultants to help develop water efficiency programs and conduct audits. Ensure professionals have adequate experience and proper certifications for their field (i.e., certifications for landscaping include certified landscaping irrigation auditors, certified irrigation designers and certified irrigation contractors.).
- Work with local wastewater utilities and wastewater discharge regulators. As conservation measures are put into effect in industrial processes, wastewater pollutant concentration may increase, although the same mass of these pollutants have stayed the same. These increased concentrations may alter a facility's ability to meet local, state or federal effluent discharge limits. Request wastewater regulators to recognize conservation efforts by amending the wastewater discharge permits to address total mass of pollutants instead of concentration levels.

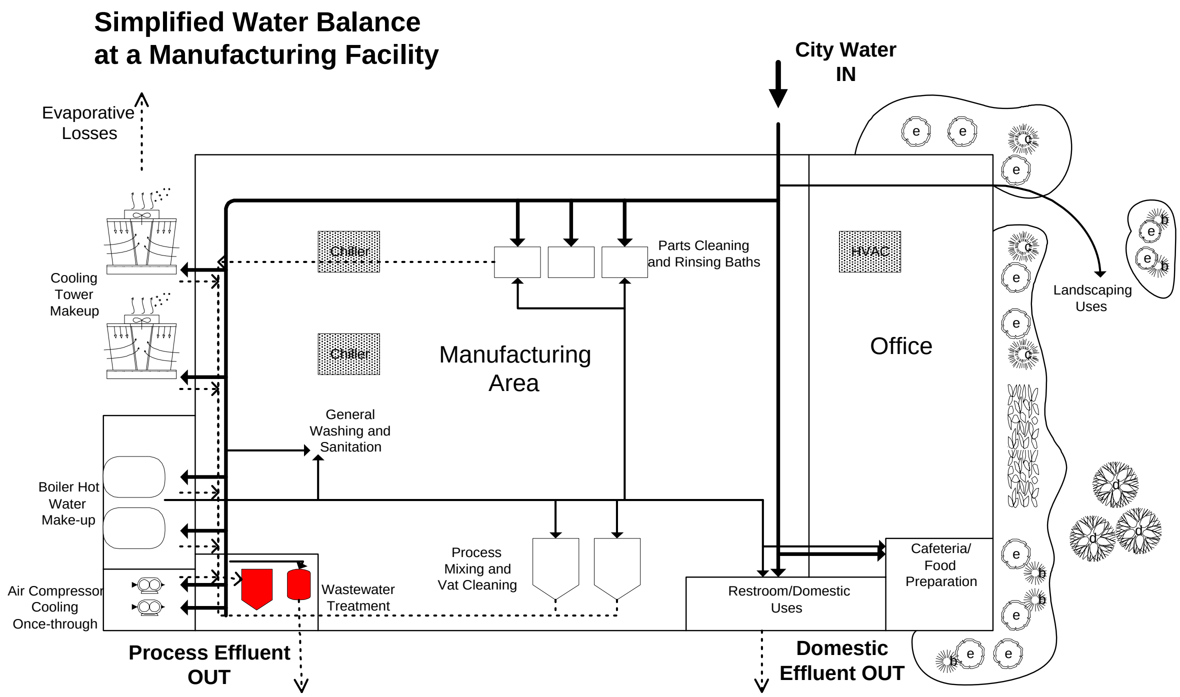
Help Take the Message Home

Develop an employee education program that will encourage employees to save water at home, as well as in the workplace. Some suggestions are:

- Offer home water-saving devices to employees free or at cost.
- Sponsor demonstrations that will educate employees how to water landscapes

[cont'd p. 22]

FIGURE 3-1



Water Balance Summary

Sources of water use	Gallons per year	Percent of total
Cooling: tower make-up and boiler make-up	7,966,000	38.3
Process use: parts and mixing vat cleaning	3,848,000	18.5
Domestic: faucets, toilets and showers	3,536,000	17
Once-through cooling: air compressors and pumps	2,388,000	11
Landscaping	832,000	4
General washing, sanitation and maintenance	561,600	2.7
Leaks (detected)	416,000	2
Food preparation: dishwasher	312,000	1.5
SUBTOTAL	19,859,000	95.5
TOTAL WATER PURCHASED	20,800,000	100.0
UNACCOUNTED FOR	941,000	4.5

efficiently, plant seeds for water-thrifty plants, install low-flow plumbing fixtures and improve water-use habits. Device manufacturers, local hardware stores or your water utility may be happy to assist with such a program.

- Distribute home water conservation booklets.

Step 3

Conduct Water Audit to Assess Current Water Uses and Costs

To identify potential water efficiency opportunities, it is first necessary to gain a thorough understanding of the site's water uses through a water audit. A water audit is defined as the process by which all uses of water on a site are characterized as to flow rate, flow direction, temperature and quality requirements (*see Chapter 6*).

Water Balance

An important task is to construct a water balance diagram or summary chart, which identifies all water use from its source through the on-site processes, machines, buildings and landscape irrigation to evaporation and wastewater discharge. To account for all uses in the water balance, the total inflow should equal the total outflow plus irrigation, evaporation and other water losses (*see Figure 3-1*).

Select a Water Audit Team

Include the following representatives:

- Water efficiency coordinator
- Personnel familiar with the operations
- Facility management/plant manager
- Maintenance
- Possible outside auditors

Collect Background Site Information and Records

- Water bills (previous full year to three years) – note rate structures
- Water meter sizes and locations
- All sources of potable and non-potable water
- Process sub-metering data
- Wastewater treatment
- Sewer bill
- Production process sheet
- Plumbing diagram
- Irrigation drawing/plan and existing irrigation control program
- Number of employees
- Number of shifts, work and clean-up schedules
- Facility description – square footage, functions
- Products and services preformed at the site
- Production rates or client service rates
- List of known water-consuming processes and uses
- Prior water use or energy survey
- (Preventive) maintenance schedules

Walk-Through Survey

The next step is to conduct a walk-through survey with the audit team. Use direct observation and measurements, and ask questions. Talk with equipment operators who may have important first-hand information. Use the following procedure to conduct the survey.

- Identify all water-consuming equipment
- Confirm plumbing diagrams
- Quantify water flow rates and usage
- Determine water quality needs for each process
- Review current water-saving measures
- Observe shift clean-ups (third shift), and process change-overs
- Also note all water losses, evaporative losses and water incorporated in product; excessive water pressure; and leaks
- Judge current water use efficiency and potential for each operation

Determine the True Cost of Water Use

The true cost of using water may include several factors other than the actual water utility fees. Examples of costs include water heating, chemical agents, electrical pumping, on-site pretreatment and related labor *(see Figure 3-2).*

To calculate the dollar savings resulting from reduced water use, a value for each unit of water used must be derived. One approach is to divide the total costs of water used per year by the total amount of water used. For facilities engaged in production of "widgets," the total cost of water used for a production run should be divided by the total number of widgets produced to get a "cost per widget" of water use.

In calculating the total cost of water use and the many components that go into the total cost, current prices of all these elements is a good starting point. However, a more mean-

Key areas to check during a walk-through survey

Process and Equipment Use
- *Cleaning, washing, rinsing*
- *Metal finishing*
- *Painting*
- *Dyeing and finishing*
- *Photo processing*
- *Reuses*
- *Product fluming (water transport)*
- *Water use in products*

Cooling and Heating
- *Single-pass cooling*
- *Cooling tower/chillers*
- *Boiler, hot water, steam systems*
- *Air washers*
- *Boiler scrubber*

Sanitary and Domestic
- *Toilets*
- *Urinals*
- *Faucets*
- *Showers*
- *Wash-up basins*

Kitchen Food
- *Cafeteria uses*
- *Dishwashers*
- *Ice machines*
- *Faucets*

Other Facility Support
- *Floor washing*
- *Air emission wet scrubbers*
- *Building washing*
- *QA/QC testing*
- *Laboratories*
- *Wastewater treatment*

Outdoor Uses
- *Landscaping*
- *Irrigation*
- *Particulate emission control*

Decorative fountains/ponds

Vehicle washing

Personnel
- *Medical*

ingful comparison can be made using future rates and prices for these elements after the efficiency measures are put into effect. These major cost elements include:

1. Water purchased from utilities. Billing normally consists of a fixed service cost and water rate cost. The fixed charge should be excluded from the analysis.
2. Wastewater sewer rate and surcharges.
3. Total cost of on-site water softening or treatment before use.
4. Cost of energy for heating water.
5. Total cost of pretreating wastewater effluent, including labor, chemical, energy and residual disposal.
6. Cost of maintenance personnel performing preventive or reactive maintenance on water-using components.
7. If water demand is increasing, determine the marginal costs of increasing effluent treatment capacity.
8. Energy costs for pumping water from wells or pumping water within the facility itself.

When comparing efficiency options, first consider reducing consumption of the most expensive components of water use.

FIGURE 3-2

True Cost of Water
Example: Metal Finishing Operation (not heated)

Activity	Unit Cost ($/CCF)	Total Unit Cost ($/CCF) 1 CCF = 748 gallons
City water purchase		$2.11
Sewer rate		$2.43
Deionized using reverse osmosis		
Equipment	$0.41	
Energy	$1.07	
Labor	$1.23	
Total deionized water (flexible cost)*	$2.71 x 40%	
Deionized water (flexible cost)*	40% x $2.71	$1.08
Wastewater treatment		
Sludge disposal	$3.78	
Treatment chemicals	$2.64	
Energy	$0.25	
Labor	$6.01	
TOTAL wastewater treatment	$12.69	
Wastewater treatment (flexible cost)*	40% x $12.69/CCF	$5.07
TOTAL cost of water		$10.69/CCF ($14.29/1,000 gallons)

If a metal finisher consuming 35,000 gallons per day reduces use by 10 percent, estimated savings using water and sewer cost only = 250 days/yr x 0.1 x 35,000 gpd x (2.11/784 + 2.43/784) = $5,310/year

Estimated savings using total cost of water =
250 days/yr x 0.1 x 35,000 gpd x $14.29/1,000 gallons = $12,503/year

*Flexible cost savings of conserved water estimated to be 40 percent of total treatment cost.

Step 4

Identify Water Management Opportunities in Plant and Equipment

Many general approaches exist for identifying water-saving opportunities. The approaches listed below can be applied to water uses at any site.

General Approaches for Water-Saving Opportunities

- Identify unnecessary uses and fix leaks.
- Use minimum amounts of water to accomplish the task.
- Recirculate water within a process or group of processes.
- Reuse water sequentially.
- Treat and reclaim used water.
- Displace potable water supplies with water from non-potable sources where appropriate.
- Install meters at high-flow processes and equipment.
- Pressure-reducing valves.

This manual provides a detailed discussion about water reduction options in Chapters 4 and 5.

Step 5

Prepare a Plan and Implementation Schedule

Develop an action plan that outlines and lists all proposed water efficiency measures resulting from the facility audit. Include the following items in the plan:

1. State the company policy regarding conservation and water efficiency, reflecting the commitment of company management.
2. Quantify your goals. Establish the amount of water to be saved throughout the entire facility, as well as by each organizational unit. Also, set deadlines by which these savings are to be achieved.
3. Summarize all efficiency measures identified during the water audit and by employee suggestions.
4. Evaluate each of these measures. Be sure to include all costs and benefits including capital costs, operating costs, projected savings and payback periods. Do not forget to include cost of energy consumption, treatment of water, chemical costs, creation of solid and toxic wastes and wastewater discharge.
5. Prioritize the measures in the following order:
    - Those that are most cost-effective and should be put into practice as soon as possible.
    - Those measures that should be evaluated through a trial period to collect meaningful data.
    - Those measures that are not cost-effective, but could be implemented in times of drought or emergency situations.
6. Identify need for any engineering design changes.
7. Establish the schedule for implementing each specific measure.
8. Identify the employee responsible for implementing each measure; continuously monitor the effectiveness and performance of each measure.
9. Identify funding sources for specific measures that will require capital expenditure. Consider loans and rebates that may be available from energy and water utilities.
10. Review periodically, and revise plan appropriately.

Step 6

Track Results and Publicize Success

Publicize the success of your program. Positive publicity promotes good relations with employees, the community, other businesses and organizations that support economic development. It also helps to stimulate similar water management efforts. Some publicity options include internal memos, company newsletters, brochures, trade publications, news releases to local media, letters to public officials, talk radio and interviews with the media. Many water utilities will help publicize good results to encourage others to develop similar plans. A good water efficiency program is news because it means more water will be available to the community.

Businesses with successful water management programs deserve recognition by the public. Likewise, the public should be informed that businesses are socially and environmentally responsible partners in the community. These steps can help businesses make their publicity efforts more visible and successful:

1. Encourage company conservation team members to participate in:
    - Community conservation seminars to share program results, as well as obtaining useful information from other companies' efforts.
    - Water conservation committees sponsored by local water utilities.
2. Present savings in relevant terms such as dollars, water savings per unit of product, earnings per share or annual consumption per household.
3. Prepare, display and promote the company's water conservation successes by means such as:
    - Display the company's water conservation results in public reception areas.
    - Place posters and other exhibits in public buildings and art fairs.

    - Post signs on water-thrifty landscapes to identify types of plants that require little water.
    - Once the plan has shown significant savings, develop a public relations program, including interviews with local radio and TV stations and newspapers, about the company's successes.
4. Sponsor water conservation projects such as a public xeriscape demonstration garden.
5. Sponsor water conservation contests in schools. For example, encourage students to create posters to be displayed in the community and at company work sites.

4 Water Management Options

Sanitary/Domestic Uses

Cooling and Heating

Kitchen and Food Preparation

Boilers

Commercial Laundries

Cleaning and Rinsing Applications

Reuse and Reclamation

Landscaping

SANITARY/DOMESTIC USES

Often overlooked are the water and cost savings achievable in the domestic water usage by commercial and industrial facilities. While water efficiency measures should begin with the highest water use operations such as cooling, cleaning, rinsing, heating, etc., many facilities miss the easy improvements that can be made in domestic water devices such as toilets, urinals, sink faucets and showers. Domestic water use at industrial and commercial facilities may range from a few percent at a food processing industry to more than 50 percent in an office setting. Average daily domestic demands in commercial/industrial settings range between 20 and 35 gallons per day per employee, and a savings of 25 to 35 percent in this domestic usage is readily achievable.

Toilets

Americans consume almost 4.8 billion gallons of water daily by flushing toilets and urinals. In a business office setting, toilet water usage alone can account for approximately one-third of all water used. A number of water efficiency options exist for toilets in most facilities constructed before 1994 that have not been renovated recently.

FIGURE 4-1

Typical Water Consumption for Toilets

Years Manufactured	Gravity Tank Style	Flush Valve Style
Pre-1977	5.0-7.0 gpf	4.5-5.0 gpf
1977 to mid 1990s	3.5 (some 5.0 gpf)	3.5 gpf
Mid 1990s	1.6 gpf maximum	1.6 gpf maximum
2003+ best in class	1.3 gpf maximum	1.3 gpf maximum

The three major types of toilets include gravity flush, flush valve and pressurized tank type. Dual flush toilets also are gaining in market share. Pre-1977 gravity toilets will consume five to seven gallons per flush. Pre-1977 flush valve toilets use 4.5 to 5.0 gallons per flush. Gravity and flush valve style toilets manufactured between 1977 and the mid-1990s mostly use 3.5 gallons per flush. High efficiency toilets began appearing on the market in the mid 2000s. HETs use less than 1.3 gallons per flush.

Code Compliant 1.6 Gallons Per Flush Toilet

In the 1990s, toilet manufacturers introduced ultra-low-flush toilets that use 1.6 gallons per flush. Federal regulations require that all toilets manufactured after Jan. 1, 1994, consume no more than 1.6 gpf. Some of the original ULF models encountered performance problems, but more recent models have improved designs and performance.

High-Efficiency Toilets

The most efficient commercial toilet on the market is the high efficiency toilet. HETs use less than 1.28 gallons per flush. This performance is achieved by an improved flush and fixture design. Early user satisfaction studies show positive customer feedback. HETs combine high efficiency with advanced design for high performance. Manufacturers are striving to avoid the issues experienced with some of the first-generation 1.6 gpf models. Since 2003, most manufacturers have offered HET toilets. In 2007, the EPA WaterSense program began performance qualifying HETs and other water fixtures with the WaterSense label. An HET replacement program offers the highest water savings potential. Facility owners should be aware of factors that will make the HET or ULF toilet replacement program successful (*See Figure 4-5 on p. 33*).

HETs are available in the following configurations:

- Single-flush, tank-type gravity toilets
- Dual-flush, tank-type gravity toilets
- Dual-flush, tank-type flush valve toilets

FIGURE 4-2

Maintenance Checklist for Gravity Flush and Flush Valve (flushometer) Toilets

Check for leaks every six months.

Encourage employees to report leaks promptly.

Adjust float valve to use as little water as possible without impeding waste removal or violating the manufacturer's recommendations.

Periodically replace valves and ballcocks.

Consider dual-flush retrofit valves for 1.6 gpf flush valve models.

- Tank-type pressure-assisted toilets
- Battery-powered, sensor-activated dual-flush toilets

Dual-Flush Toilets

Dual-flush toilets employ a dual-action flush valve or two-button system; one for a full flush (1.6 gpf to eliminate solid waste) and the second button for a reduced flush (1.1 gpf for liquid waste). An electronic sensor-activated dual-flush unit also is available, in which the sensor activates the appropriate flush, depending on the length of time the user remains seated. Dual flush retrofit valves are available for existing 1.6 and 3.5 gpf units. Dual flush technology has been popular in Australia and Europe for the past 20 years.

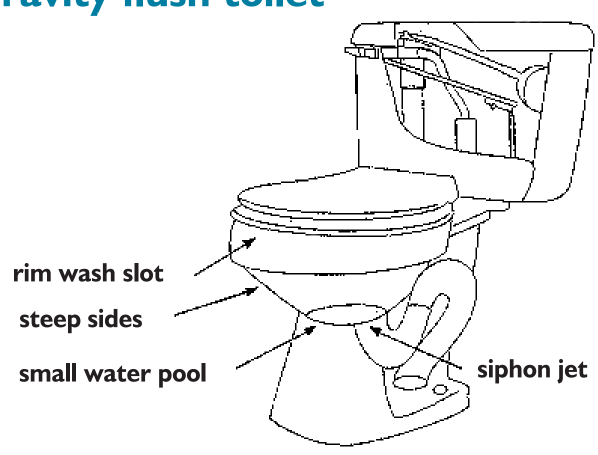
Gravity Flush Toilets

Gravity flush toilets are the most common of all toilets. Gravity flush toilets most likely are found in medium- to light-use business applications.

Water efficiency options for gravity flush toilets include improved maintenance, retrofit and replacement options.

For a maintenance checklist, see Figure 4-2.

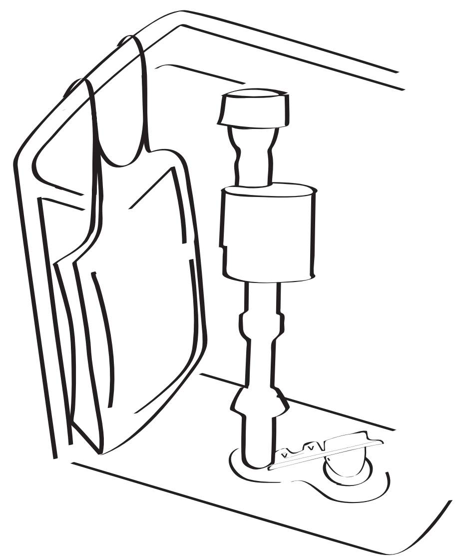
Gravity flush toilet



Retrofit

Retrofit options of gravity flush systems are most effective on units that consume more than 3.5 gpf (pre-1980s models). For toilets that consume 3.5 gpf or less, some retrofit options may hamper toilet performance or increase maintenance cost. Most retrofit options are available for less than $20.

Toilet Displacement Bag



Displacement devices, including bags or bottles, can reduce water flow by approximately 0.75 gpf. They function by displacing flush water stored in the tank. The devices are inexpensive and easy to install, but do require regular maintenance. Bricks or other friable objects should never be used as displacement devices because granular contaminants can prevent proper closure of the flapper and damage flow valves.

Toilet dams are flexible inserts placed in a toilet tank to keep 0.5 to 1 gallon out of each flush cycle. Dams will last five to six years. A plumber should be consulted before installing such devices.

Early closure flapper valves replace the existing flush valve in the tank. These devices are adjustable to optimize performance and can save 0.5 to 2 gpf. Early closing flappers are inexpensive and usually can be installed in 10 to 15 minutes, barring other problems with the toilet's mechanisms.

Dual-flush adapters allow users to use a standard flush for solids removal or a modified smaller flush for liquid and paper. Dual-flush adapters have been more popular in Europe than the United States. Dual-flush adapters can save between 0.6 to 1.2 gpf. For this retrofit option, facility managers should provide user instructions about the proper use of these dual-flush systems.

Replacements

Replacing older commodes with HET or 1.6 gpf models will provide the most water savings. Most HET or 1.6-gpf replacements will offer a payback period of less than three years. Facilities may achieve quicker payback in these situations:

- Experience high water and/or sewer costs.
- Have a relatively high number of users per toilet.
- Currently use high water-consuming (5 to 7 gpf) toilets.

See Figure 4-3 for typical simple payback periods for 1.3 gpf toilet retrofits.

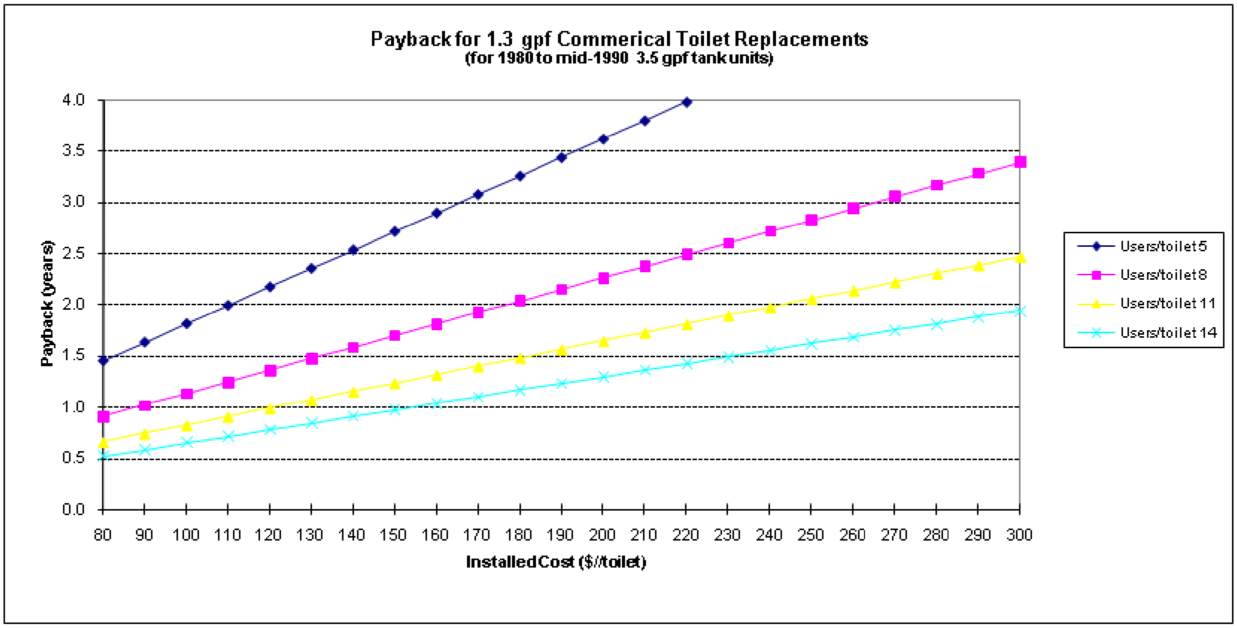
Flush Valve (Flushometer) Toilets

Flush valve, or flushometer, toilets use water line pressure to flush waste into the sanitary sewer system. They consist of a valve and a toilet bowl fixture. Most commercial/industrial facilities use flush valve toilets, especially in higher-use areas. (*For maintenance checklist, see Figure 4-2.*)

Retrofits

An economical water-saving opportunity exists to retrofit 1.6 gpf flush valve toilets with a dual flush valve. The valve is actuated upwards to flush liquid waste and downward to flush solids. These valves cost as little as $40 and offer a 20 percent water savings with a simple payback in three to four years in an office setting.

FIGURE 4-3



For 3.5 gpf flush valve toilets, valve inserts are available that can reduce flush volumes by 0.5 to 1 gpf. Some of these devices consist of plastic orifices, perforated with holes in a wheel and spoke pattern. Others actually replace the existing valve mechanisms of a 5 gpf unit with a 3.5 gpf valve without changing the toilet bowl fixture. Do not retrofit ultra-low valves (1.6 gpf) without changing a fixture bowl.

Replacements

Replacing inefficient units with a HET or ultra low (1.6 gpf) flush valve mechanism and toilet bowl will result in the maximum water savings. It is important to note that both the

Energy Policy Act of 1992

The Energy Policy Act established water efficiency plumbing standards for certain plumbing devices. Prior to 1992, many states and municipalities concerned about water conservation were setting unique standards, which created difficulty for manufacturers and distributors trying to meet these numerous standards. The Energy Policy Act created a set of unified national standards.

Effective Jan. 1, 1994, federal standards set for maximum water usage are:

Toilets	1.6 gpf
Urinals	1 gpf
Showerheads	2.5 gpm @ 80 psi or 2.2 gpm @ 60 psi
Lavatory Faucets	2.5 gpm @ 80 psi or 2.2 gpm @ 60 psi
Kitchen Faucets	2.5 gpm @ 80 psi or 2.2 gpm @ 60 psi

The water efficiency standard was established to:

- Preserve and protect water supply sources, both surface and groundwater.
- Ensure water availability for all beneficial uses.
- Reduce water and energy costs.
- Regulate and standardize plumbing fixture trade.
- Protect health and the environment.

The American Water Works Association estimates nationwide savings of 6.5 billion gallons per day will be achieved by the year 2025 through these standards.

As of the date of this publication, several trade associations and local jurisdictions have proposed further water conservation fixture standards. Revisions to these federal requirements are expected over the next five years.

low-flow valves and bowls should be replaced simultaneously. A 1.6 gpf valve must be used with an appropriately designed 1.6 gpf bowl, or the unit will not perform adequately.

Pressurized Tanks System Toilets

An effective commercially-designed toilet currently on the market is the pressurized tank toilet. These units perform very well at removing waste, but also are more costly. These toilets use water line pressure to compress air in a specially sealed tank in the toilet. When flushed, the compressed air greatly increases the flush water force. Noise was a complaint with early models, but present models are markedly quieter.

Figure 4-4 shows examples of water savings from implemented ULF retrofit programs in both public and commercial settings.

Other options: Composting Toilets

Where sewers or septic tanks are not available, composting and incinerating toilets are available. Before purchasing any of these toilets, make sure building inspection programs can approve such toilet systems.

FIGURE 4-4

Commercial/ Business Sector	Est. Water Savings (gpd per toilet)
Wholesale	57
Food Stores	48
Restaurants	47
Retail	37
Automotive	36
Multiple Use	29
Manufacturing	23
Health Care	21
Office	20
Hotel/Motel	16

Source: The CII ULF Saving Study, 1997, California Urban Water Conservation Council. Survey of 452 California organizations.

Pressurized Tank Toilet

Urinals

It is estimated that about 80 percent of America's 12 million urinals are old and inefficient. The typical water consumption for older urinals is 2 to 3 gpf. Current federal standards require all urinals to use no more than 1 gpf. Urinals can have a flushometer value or water tanks for both washdown and trough urinals.

High-Efficiency Urinals

Newer models that can significantly reduce water consumption are now available. A high-efficiency urinal is now defined as a urinal fixture with a flush volume of 0.5 gpf or less, including waterless units.

Some manufacturers are offering urinals that use as little as one pint (0.125 gallon) per flush. Flush mechanisms for these urinals include standard manual flushometer units, hands-free hardwired sensor-operated units and hands-free battery-powered sensor-operated units.

Waterless Urinals

Waterless urinals can save time and money and conserve significant amounts of water. The waterless urinal involves a vitreous china

FIGURE 4-5

Making a toilet replacement project successful

Below are factors to consider when installing new ULF or HET fixtures:

- Replace highest use toilets first – highest use toilets will provide quickest payback.
- Carefully choose toilet type depending on use level and the potential for misuse.
- Know your sewer infrastructure. Older cast iron types with a larger diameter (4" and 6") may have more problems transporting waste with 1.6 or 1.3 gallons. Substandard wastewater pipe grading should be addressed before installing water efficient toilets. All toilets, regardless of flush volume, will experience problems with sewer drains compromised by root intrusion, sagging or broken lines, or solids build-up. Very long commercial/industrial drain line runs can be more problematic with UFL/HET replacements if no other wastewater sources discharge near the toilet. Make sure the building's water pressure is adequate if switching from a gravity type to flushometer or pressurized tank toilets. Usually, 25 to 35 psi or more at the toilet is required for pressure dependant systems.
- ULF toilets cannot be used as trash cans. If flushing trash is a problem at the facility, employee education with the new toilet installation is necessary.
- Ask for references from building manager, plumbers or other users who have installed the manufactured products.
- Base decisions on the current models. Many design improvements continue to be made.
- Listen to noise levels of the model you are considering.
- A high cost does not automatically mean better performance.
- Ask about guarantees and returns especially for future leak problems.
- Choose a licensed plumber or contractor.
- Plan for the legal disposal of old toilets. Consult your local solid waste authority for recycling options or disposal requirements.

Use Satisfaction

Some owners of early 1.6 ULF toilets reported dissatisfaction. Many improvements have been made in the 1.6 gpf toilet design to address these issues. It is important to remember that 1.6 gpf units are finely-tuned design systems that require proper use. The type of toilet should be chosen carefully for its level of use and application. Educating employees not to flush trash and of the importance of water efficiency will go a long way in improving user satisfaction. Actual customer satisfaction surveys conducted in Santa Rosa, Calif.; Denver, Colo.; and New York City had a high customer satisfaction rate for customers installing ULF toilets. Less than 10 percent reported any dissatisfaction.

or stainless steel fixture and a replaceable oil-filled cartridge that traps odors.

Progressive public facilities, businesses and new high-performance LEED buildings have been demonstrating this technology in North Carolina. Waterless systems are more economical to purchase and install than flush urinals because they have no flushing mechanism. Waterless urinals offer the savings of flush water and sewer charges, but these operational savings are balanced with the cost of cartridges for the drain which typically are replaced every 7,000 uses.

Cleaning crews must have training on proper cleaning and cartridge replacement procedures for units to function as designed. Waterless urinals are not without controversy, and further research is needed to better understand long-range impact and wide application of their use. Retrofit applications which were not installed perfectly vertical have been problematic. Pilot trials are suggested.

Washout and Washdown Urinals

Replacement options

Some models can be retrofitted to use less water per flush by replacing a part in the flush valve or float levels in tanks. Make sure any retrofit will continue to allow adequate removal of liquid waste. Again, bowls and flush valves need to be compatible in design use to function properly. Installing new models that use 1.0 gpf can achieve the maximum water savings for urinals.

Special Note: *Monitoring toilet usage patterns may indicate that replacing a toilet with a less water intensive urinal is possible.*

CASE STUDY

Urinal Timer Adjustment

The Asheville Civic Center has several large banks of urinals to handle restroom traffic during large events. Sensors had been installed to continuously flush all urinals when the restroom doors were open. This system lead to excess water use. After a water audit by the Waste Reduction Partners program, a two-minute delay timer was added to the sensor so the urinals could not flush more frequently than every two minutes. This simple change saved almost 90 percent of urinal water use and reduced water consumption by 600,000 gallons per year.

CASE STUDY

Install Water-Saving Fixtures

The University of North Carolina at Chapel Hill installed 300 water-free urinals in new buildings on campus, and retrofitted 30 older buildings with dual flush toilets. The installation of these 300 units is expected to save the university 12 million gallons of water annually. In high-use areas, water-free urinals will save at least 40,000 gallons per unit per year. Additionally, low flow showerheads and faucets have been installed in all new resident halls for additional water conservation savings.

Showerheads

Showerhead replacement or modification represents another water efficiency area that is cost effective. Most conventional showerheads use three to seven gpm at 60 psi water pressure. Current standards require showerheads to use no more than 2.5 gpm. These new water-efficient showerheads come in many different models and features and typically perform very well. Water efficient showerheads also reduce energy consumption related to hot water generation.

EPA, through its WaterSense program, is currently developing specifications to establish a maximum flow rate between 1.5 and 2 gpm at a pressure of 80 psi . This flow rate represents a 20- to 40-percent reduction over the current 2.5 gpm rate.

Behavioral Modifications

- Encourage users to take shorter showers (10 minute maximum). User awareness is important, especially in institutional settings. Shower timers are available with settings for 5, 8 and 11 minutes.
- Check regularly for leaks, and institute a program to require users or employees to inform maintenance about leaks.

Plumbing Modifications

Avoid retrofitting old showerheads with flow restrictors or flow control values. Such restrictors normally produce user complaints. New, high-performance showerheads are economical, easy to install and designed for water efficiency and performance.

Replacement Options

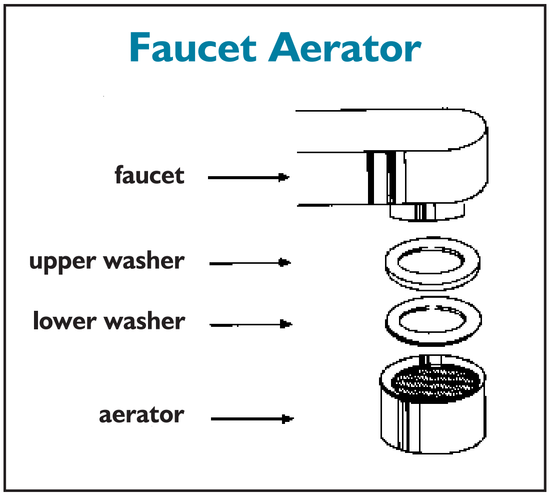
The best water efficiency option is to purchase new 2.5 gpm or less showerheads. Excellent performing showerheads can be purchased with flow rates at 1.5 gpm. The products vary in price, from $3 to $48. Good single-setting showerheads can be purchased for less than $10. The newer code compliant showerheads have a narrower spray area and a greater mix of air and water than conventional showerheads. Wide arrays of spray patterns are available, including adjustable massage action. Fixed and flexible position models also are available.

Showerhead

CASE STUDY

Reduce Consumption

ASMO North Carolina in Statesville substantially reduced city water consumption for potable/domestic use. The facility upgraded all bathrooms with waterless urinals, low flow toilets and motion sensor sinks. The company is now saving 2.7 million gallons of water per year, or an estimated $16,700 in annual water and sewer cost.



Faucets

Older conventional faucet flow rates can range from three to five gpm. A leaking faucet dripping one drip per second can waste 36 gallons of water a day. Federal guidelines mandate that all lavatory and kitchen faucet and replacement aerators manufactured after Jan. 1, 1994, consume no more than 2.2 gpm. For a "public" lavatory faucet, the American Society of Mechanical Engineers sets forth a standard of a maximum of 0.5 gpm.

Modification

- Adjust flow valves to the faucet. Keep in mind this modification can also be easily changed by users.
- Check regularly for leaks.
- Use aerators for faucet flow controllers on existing faucets. Aerators screw onto the faucet head and add air to the water flow while reducing water flow. They are available at common ratings of 0.5, 0.75, and 1.0 gpm. Flow rates as low as 0.5 are adequate for hand wetting purposes in a bathroom setting. Higher flow rate kitchen aerators deliver water at 2 to 2.5 gpm for more general washing purposes. Aerators cost $5 to $10 installed and typically yield a payback within a few months.
- Install flow restrictors. Flow restrictors can be installed in the hot and cold water feed lines to the faucet. Common flow rate designs include 0.5, 0.75, 1 and 1.5 gpm. Flow restrictors can be used where aerators cannot be used or where there is faucet abuse (aerator removal is problematic). Flow restrictors can be installed for less than $25 and also yield a payback within months.

Replacements

Any new faucet purchase must have a flow rate less than 2.2 gpm. ASME specifies 0.5 gpm lavatory faucets for public restrooms. Many types of faucet and water control systems are available for commercial faucets. These include:

- Automatic shutoff – once the handle is released, valve shuts off. This style is not typically recommended since users can wash only one hand at a time.
- Metered shutoff – once the lever is depressed, the faucet delivers a water flow for a pre-set time period (e.g., five to 20 seconds), then automatically shuts off. Federal guidelines require that meter faucets use no more than 0.25 gallon per cycle.

Infrared and Ultrasonic Sensors

"Electric eye" sensors are available for a number of plumbing applications, including lavatory faucets, urinals and toilets. These devices deliver a metered flow only when the fixture is in use. For faucets, both the flow rate and activation time can be adjusted. The "no-touch" activation also is helpful to prevent the spread of disease and useful for users with disabilities. Sensored faucets, too, need to be checked for leaks and clogged flow controllers because of any water impurities. An infrared sensored faucet or urinal/toilet controls can be purchased for about $200.

FIGURE 4-6

Water Efficiency Upgrade Summary: Domestic Applications[1, 2, 3]

Fixture	Existing Style/Flow Rates	Ages	Water Efficiency Options/ Water Saving Estimates	Installed Cost ($)	Typical Payback (years)	Comments
Toilets Flushometer-Type	Flushometer - 1.6 gpf	Post 1994	Install dual fulsh valve. Saves 20% (0.3 gpf average savings).	$50-$80	3-4	User education suggested. Consider HET for new applications.
	Flushometer - 3.5 gpf	1977 to early 1990s	• Install new HET or 1.6 gpf ULF models. Saves 1.9-2.2 gpf.	$200-$300	2.0-4.5	Must change both bowl and valve.
			• Consider valve inserts. Save 0.5 gpf.	$10-$30	0.7-1.9	Usually not rec-ommended by OEM.
	Flushometer - 4.5 gpf	Pre-1980s	Install 3.5 gpf valve retrofit with no change to china bowl. Saves 1.0 gpf. Examine dual flush valves.	$25-$40	0.7-1	Flushometer valves used in commercial high use areas.
Toilets Tanks Type	Tanks-type gravity - 1.6 gpf	Post 1994	• Currently code compliant. • Consider HET for replacements or new applications.	$150-$300	>10	Look for EPA WaterSense labeled HETs.
	Tanks-type gravity - 3.5 gpf	1977 to mid-1990	Install HET or 1.6 gpf gravity/ pressurized flush models. Saves 1.9-2.2 gpf.	$150-$300	1.1-3	Displacement devices/ dams not typically recommended for 3.5 gpf units.
			Consider early closing flapper. Saves 0.5-1.0 gpf.	$20	0.5-1	Adjustable for quality performance.
	Tanks-type gravity - 5-7 gpf	Pre-1980 devices	Install HET or 1.6 gravity flush or pressurized flush models.	$150-$300	0.7-2.1	Consider pressurized tank systems for high use areas.
			Consider dams, displacement devices or early closure flapper. Saves 0.75-2 gpf.	<$20	0.3-0.5	Do not use bricks. Loose granules inhibit flapper performance.
Urinals[4]	Flushometer - 1.0 gpf	Post 1994	Consider HEU at time of replacement. Saves 0.5 gpf.	$200-$450	>7	Urinals available as low as 0.125 gpf.
	Flushometer - 1.6 gpf		Install repair valves to 1.0 or 0.5 gpf for non-pooling styles. Saves 0.6-1.1 gpf.	$20-$40	0.5-1.3	For non-pooling styles.
	Flushometer - 3.0 gpf		Replace urinal fixture and retrofit valves to 1.0 gpf or HEU. Saves 2.0 gpf.	$200-$450	1.8-5.6	
Showerheads[5]	2.5 gpm	Post mid-1990s	• Replace with lower flow showerheads available down to 1.5 gpm. Saves 1.0 gpm.	<$35	0.6-1.3	Energy savings can be two times water savings.
	3-5 gpm	Post 1980	• Install 2.5 gpm or lower showerheads.	$25-$35	0.4-2	
	5-8 gpm	Pre-1980 devices	• Install 2.5 gpm showerheads.	$25-$35	<0.2	
Kitchen Faucets[6]	2.2 gpm	Post 1994	• Code compliant - best avail-able for flow and pot filling needs	N/A	N/A	No less than 2.5 gpm for kitchen applications.
	3-7 gpm	Pre-1980 devices	• Install aerators to reduce flow to 2.5 gpm.	$5-$10	0.2-2	Note energy savings.
Lavatory Faucets[7]	2.2 gpm	Post 1994	Install 0.5 faucet aerators for public restroom applications.	$5-$10	0.05-0.7	Note energy savings. Consider sensor-controlled or metered.
	3-7 gpm	Pre-1980 devices	Install aerators to reduce flow to 1.0 gpm or as little as 0.5 gpm.	$5-$10	<0.3	0.5 gpm aerators are industry standards for public restrooms.

[1]Based on 2006 average N.C. water and sewer rates of $6.76 per 1,000 gallons.
[2]Payback estimated for one shift operation. Divide payback by two and three for two- and three-shift operations, respectively.
[3]Cost estimates are based on approximate installed cost using internal maintenance. Actual cost and payback period may vary. Options based on widely available equipment believed not to reduce service quality or reliability. Faucet costs reflect aerator cost only, not entire fixture.
[4]Urinal savings based on two uses per day per male employee.
[5]Showerhead savings based on two eight-minute showers per work day and include energy savings.
[6]Kitchen faucet saving based on three minutes of use per day.
[7]Lavatory faucet use based on 10 seconds of use per restroom visit.

Water Spigots

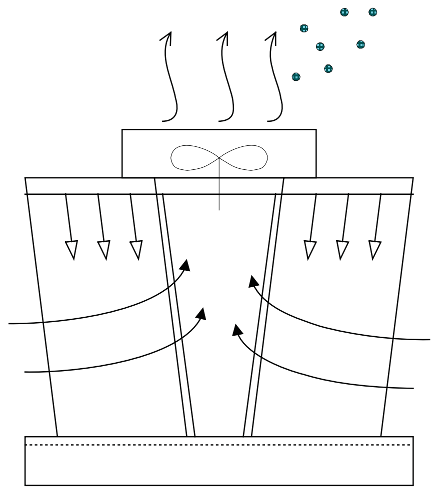
Self-closing commercial valves are available for water spigots, like those installed in public areas. Shut-off cycles from four to 25 seconds typically are available.

Pressure Reducing Valves

Facilities should consider using a pressure-regulating valve when water line pressure is higher than 50 to 60 psi. Lowering excessively high-line pressure helps reduce the formation of leaks and will lower water flows from spigots, hoses, faucets and water feed lines. A pressure reduction of 15 psi from 80 to 65 psi will reduce water flow by about 10 percent without sacrificing water service. A reduction from 80 to 50 psi will correspond to about a 25 percent water use reduction in light commercial settings.

COOLING AND HEATING

Cooling tower



Background

The use of cooling towers represents the largest use of water in industrial and commercial applications. Cooling towers remove heat from air conditioning systems and from a wide variety of industrial processes that generate excess heat. While all cooling towers continually cycle water in a closed loop, they still can consume 20 to 30 percent, or more, of a facility's total water use. Optimizing operation and maintenance of cooling tower systems can offer facility managers significant savings in water consumption.

Cooling Tower Design

Warm water is recirculated continuously from a heat source, such as an air conditioning system or process equipment, to the cooling tower *(see Figure 4-7)*. In most cooling tower systems, warm water (or water to be cooled) is pumped to the top of the tower where it is sprayed or dripped through internal fill. The fill creates a large surface area for a uniform thin film of water to be established throughout the tower. Fans pull or push air through the tower in a counterflow, crossflow or parallel flow to the falling water in the tower. Water is evaporated carrying away the heat. For most efficient cooling, the air and water must mix as completely as possible. Cooling is reduced when dew points are high.

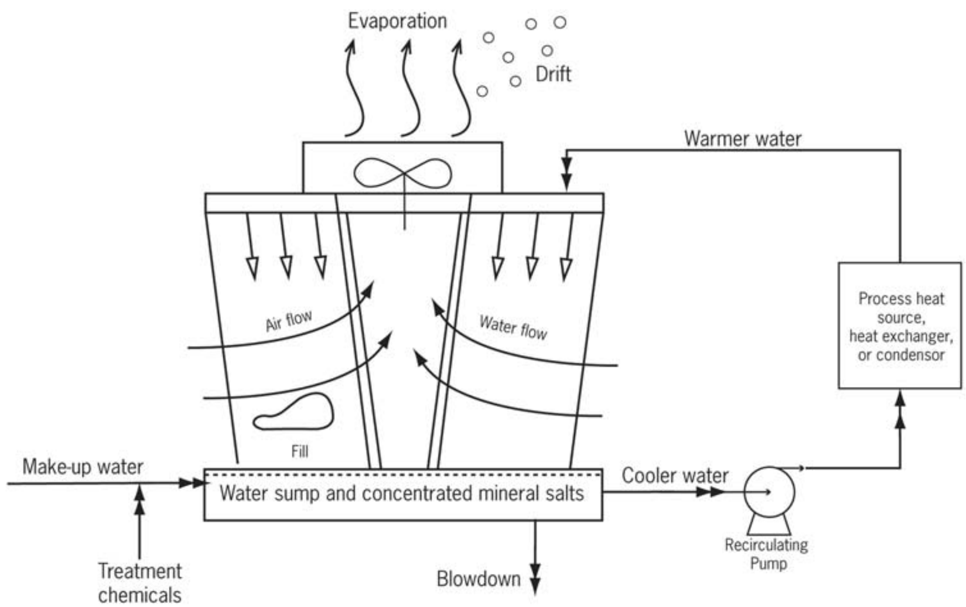
Evaporation

Cooling occurs in a tower by the mechanisms of evaporative cooling and the exchange of sensible heat. The loss of heat by evaporation (approximately 1,000 British thermal units per pound of water) lowers the remaining water temperature. The smaller amount of cooling also occurs when the remaining water transfers heat (sensible heat) to the air.

The rate of evaporation is about one percent of the rate of flow of the recirculating water passing through the tower for every 10° F decrease in water temperature achieved by the tower. The decrease in water temperature will vary with the ambient dew point temperature. The lower the dew point, the greater the temperature difference between water flowing in and out of the tower. Another rule of thumb for estimating the rate of evaporation from a cooling tower is as follows: evaporation equals three gallons per minute per 100 "tons" of cooling load placed in the tower. The term "ton," when used to describe cooling tower capacity, is equal to 12,000 Btu per hour of

FIGURE 4-7

Cooling Tower System Schematic



heat removed by the tower. When the dew point temperature is low, the tower air induction fans can be slowed by using a motor speed control or merely cycled on and off, saving both energy and water evaporation losses.

Blowdown

Blowdown is a term for water that is removed from the recirculating cooling water to reduce contaminant buildup in the tower water. As evaporation occurs, water contaminants, such as dissolved solids, build up in the water. By removing blowdown and adding fresh makeup water, the dissolved solids level in the water can be maintained to reduce mineral scale build-up and other contaminants in the tower, cooling condensers and process heat exchangers. Thermal efficiency, proper operation and life of the cooling tower are directly related to the quality of the recirculating water in the tower.

Water quality in the tower is dependent on make-up water quality, water treatment and blowdown rate. Optimization of blowdown, in conjunction with proper water treatment, represents the greatest opportunity for water efficiency improvement. Blowdown can be controlled manually or automatically by valves actuated by timers or conductivity meters.

Drift Losses

Drift is a loss of water from the cooling tower in the form of mist carried out of the tower by an air draft. A typical rate of drift is 0.05 to 0.2 percent of the total circulation rate. Reduction in drift through baffles or drift eliminators will conserve water, retain water treatment chemicals in the system, reduce "spotting" around the tower area and improve operating efficiency.

Make-up Water

Make-up water is water added to the cooling towers to replace evaporation, blowdown and drift losses. The amount of make-up water added directly affects the quality of water in the systems. The relationship between blowdown water quality and make-up water quality can be expressed as a "concentration ratio" or a "cycle of concentration." This ratio is shown in Figure 4-8.

The most efficient use occurs when the concentration ratio increases and blowdown decreases.

Water Balance

A simple water balance on a cooling tower system can be determined if three of the four following parameters are known: make-up, evaporation, drift and blowdown. *(See Figure 4-9 for a description of the cooling tower water balance.)*

FIGURE 4-8

CONCENTRATION RATIO

$$\frac{\text{TDS of blowdown}}{\text{total dissolved solid (TDS) of make-up water}}$$

OR

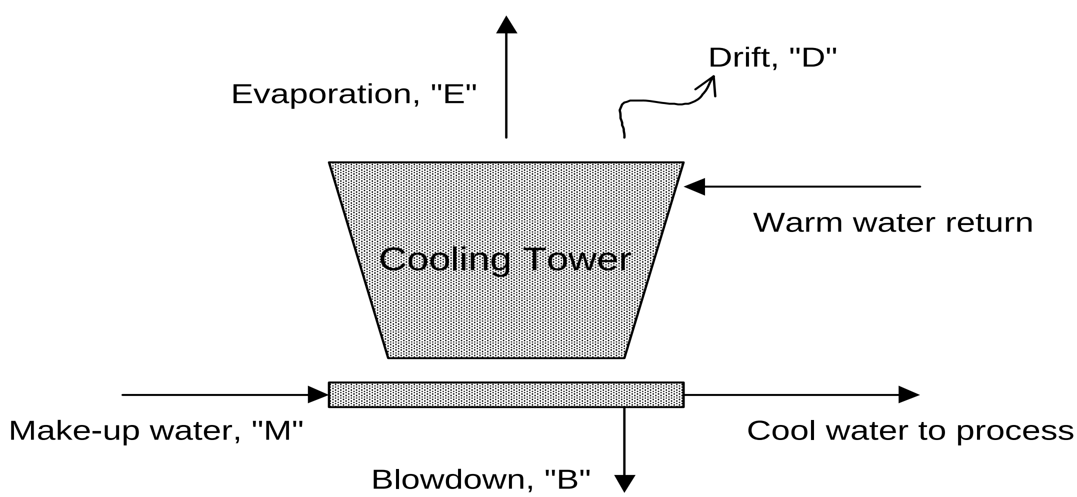
$$\frac{\mu\text{mhos of blowdown}}{\text{specific conductance } (\mu\text{mhos}) \text{ of make-up}}$$

OR

$$\frac{\text{gallons of blowdown + gallons of drift}}{\text{gallons of make-up}}$$

FIGURE 4-9

Cooling Tower Water Balance



Water Balance: M = E + B+ D

Concentration Ratio: CR = M Quality / B Quality

Water Efficiency Options for Cooling Towers

FIGURE 4-10

Percent of Make-Up Water Saved

Initial Concentration Ratio (CR_i)	New Concentration Ratio (CR_f)										
	2	2.5	3	3.5	4	5	6	7	8	9	10
1.5	33%	44%	50%	53%	56%	58%	60%	61%	62%	63%	64%
2	--	17%	25%	30%	33%	38%	40%	42%	43%	44%	45%
2.5	--	--	10%	16%	20%	25%	28%	30%	31%	33%	34%
3	--	--	--	7%	11%	17%	20%	22%	24%	25%	26%
3.5	--	--	--	--	5%	11%	14%	17%	18%	20%	21%
4	--	--	--	--	--	6%	10%	13%	14%	16%	17%
5	--	--	--	--	--	--	4%	7%	9%	10%	11%
6	--	--	--	--	--	--	--	3%	5%	6%	7%

Blowdown Optimization

Water consumption of cooling towers can be reduced significantly by minimizing blowdown in coordination with an integrated operation and maintenance program. *Blowdown is minimized when the concentration ratio increases.* Historical concentration ratios are 2-to-3, and generally can be increased up to six or more with generic treatment options. Automation and 24-7 online monitoring can often allow cycles to be pushed to ten.

Some states have passed laws governing the quality level in a cooling tower as an attempt to promote efficient cooling tower water use.

The volume of water saved by increasing the cycles of concentration can be determined by this equation:

$$V = M_i \quad X \quad \frac{CR_i - CR_f}{(CR_i)(CR_f - 1)}$$

V = volume of water conserved

M_i = initial make-up water volume (before modification)

CR_i = concentration ratio before increasing cycle

CR_f = concentration ratio after increasing cycles

For example, increasing concentration ratio from two to six will save 40 percent of the initial make-up water volume. Figure 4-10 allows users to easily estimate potential water savings.

The maximum concentration ratio at which a cooling tower can still properly operate will depend on the make-up water quality, such as pH, TDS, alkalinity, conductivity, hardness and microorganism levels. The use and sensitivity of a cooling system will also control how much blowdown can be reduced. Scale, corrosion, fouling and microbial growth are four critical parameters that must be controlled in cooling towers. Minimum blowdown rates must be determined in tandem with the optimum water treatment program for the cooling tower.

CASE STUDY

Cooling Tower Reduces Usage

Chem-tex laboratories in Concord installed two new tanks, pumps and a small cooling tower to cool and recycle water that was formerly sent to the city of Concord wastewater treatment plant after one use. The small cooling tower and tank system cost less than $15,000 and reduced water usage by appoximately 60 percent (~20,000 gallons per day), and also reduced the plant's wastewater effluent sent to the city's treatment plant by about 85 percent. Total cost savings are between $35,000 and $40,000 per year.

Practical Guidance for Working With a Service Contractor

- Work closely with your chemical vendor or contracted service provider to reduce blowdown. Because reducing blowdown also reduces chemical purchasing requirements, facility personnel must keenly set up performance-based service contracts.
- Require vendors to commit to a predetermined minimum level of water efficiency. Have them provide an estimate of projected annual water and chemical consumption and costs.
- Tell your vendor that water efficiency is a priority, and ask about alternative treatment programs that will help reduce blowdown.

When purchasing chemicals for treating cooling tower water, have the chemical vendor explain the purpose and action of each chemical. Your vendor should provide a written report of each service call. Be sure the vendor explains the meaning of each analysis performed, as well as the test results.

Controlling Blowdown

To better control the blowdown and concentration ratio, facilities can install submeters on the make-up water feed line and the blowdown line. Submetering allows operators to carefully control water use. In some areas, evaporative water loss, as determined by submetering and water balances, can be subtracted from local sewer charges. Submeters can be installed on most cooling towers for less than $1,000.

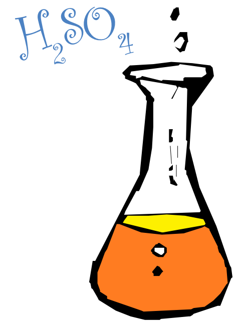
Recirculating water systems are blown down when the conductivity of the water reaches a preset level. Blowdown can be done manually or automatically. Automation generally allows for higher cycles. Typically, towers are blown down in a "batch" process, releasing water to lower the tower volume until the make-up turns on and begins to reduce the concentration in the tower. Once tower levels are replenished the cycle repeats. This produces a saw tooth pattern. If the mechanicals and tower load allow it to be done, proportional or continuous make-up and blowdown systems can reduce the saw tooth and increase overall cycles.

Recovering Sewer Charges

Because all cooling towers lose significant quantities of water through evaporation, some wastewater utilities allow these evaporative losses to be subtracted from utility bills. The utilities that allow this billing adjustment typically will require that a submeter be installed on the make-up water line to the cooling tower(s). Some system of reading this submeter monthly and requesting a reimbursement can be established where allowed. Submeters can be installed on most cooling towers for less than $1,000.

Cooling Tower Water Treatment

Almost all well-managed cooling towers use a water treatment program. The goal of a water treatment program is to maintain a clean heat transfer surface and preserve capital while minimizing water consumption and meeting discharge limits. Critical water chemistry parameters that require review and control include pH, alkalinity, conductivity, hardness, microbial growth, biocide and corrosion inhibitor levels.



Depending on the quality of the make-up water, treatment programs may include corrosion and scaling inhibitors, such as organophosphate types, along with biological fouling inhibitors. Historically, chemicals have been fed into the system by automatic feeders on timers or actuated by conductivity meters. Automatic chemical feeding tends to decrease chemical dosing requirements. Current technology allows chemicals to be monitored and controlled online 24-7 in proportion to demand. This ensures results and can allow cycles to be increased. Where overfeed is prevalent, it can reduce chemical feed, too.

Sulfuric "Acid" Treatment

Sulfuric acid can be used in cooling tower water to help control scale buildup. When properly applied, sulfuric acid will lower the water's pH and help convert the calcium bicarbonate scale to a more soluble calcium sulfate form. In central North Carolina, most plants will be able to operate six to 10 cycles of concentration without acid feed. Along our coasts, acid can be used to increase cycles as water tends to be harder and higher in alkalinity. The same can be said if hard alkaline well water is used as tower make-up.

Important precautions need to be taken when using sulfuric acid treatment. Because sulfuric acid is an aggressive acid that will corrode metal, it must be carefully dosed into the system and must be used in conjunction with an appropriate corrosion inhibitor. Workers handling sulfuric acid must exercise caution to prevent contact with eyes or skin. All personnel should receive training on proper handling, management and accident response for sulfuric acid used at the facility.

Side Stream Filtration

In cooling towers that use make-up water with high suspended solids, or in cases where airborne contaminants such as dust can enter cooling tower water, side stream filtration can be used to reduce solids buildup in the system. Typically, five to 20 per-

CASE STUDY

Reverse Osmosis Water Use

A pharmaceutical company in Clayton substantially reduced city water consumption for cooling towers by reusing the "reject" stream from its reverse osmosis water treatment process. By reusing the RO "reject" water to replace cooling tower evaporative losses, the company is saving 10 million gallons of water per year.

FIGURE 4-11

Summary of Cooling Tower Water Efficiency and Treatment Options

Option	Advantages	Disadvantages
Operation improvements to control blowdown and chemical additions	Low capital costs Low operating costs Low maintenance requirements	None
Sulfuric acid treatment	Low capital cost Low operating cost Increased concentration ratio, when alkalinity limited	Potential safety hazard Potential for corrosion damage if overdosed
Side stream filtration	Low possibility of fouling Improve operation efficiency	Moderately high capital cost No effectiveness on dissolved solids Additional maintenance
Ozonation	Reduced chance for organic fouling Reduced liquid chemical requirements	High capital investment Complex system Possible health issue
Magnet System	Reduced or eliminated chemical usage	Novel technology Controversial performance claims
Reuse of water within the facility	Reduces overall facility water consumption	Potential for increased fouling, scale or corrosion Possible need for additional water treatment

cent of the circulating flow can be filtered using a rapid sand filter or a cartridge filter system.

Rapid sand filters can remove solids as small as 15 microns in diameter while cartridges are effective to remove solids to 10 microns or less. High efficiency filters can remove particles down to 0.5 microns. Neither of these filters are effective at removing dissolved solids, but can remove mobile mineral scale precipitants and other solid contaminants in the water. The advantages of side stream filtration systems are reduced particle loading on the tower. This ensures heat transfer efficiency and may reduce biocide or dispersant demands.

Ozone

Ozone can be a very effective agent to treat nuisance organics in the cooling water. Ozone treatment also is reported to control the scale by forming mineral oxides that will precipitate out to the water in the form of sludge. This sludge collects on the cooling tower basin, in a separation tank or other low-flow areas. Ozone treatment consists of an air compressor, an ozone generator, a diffuser or contactor and a control system. The initial capital costs of such systems are high but have been reported to provide payback in 18 months.

Magnets

Some vendors offer special water-treating magnets that are reported to alter the surface charge of suspended particles in cooling tower water. The particles help disrupt and break loose deposits on surfaces in the cooling tower system. The particles settle in a low-velocity area of the cooling tower -- such as sumps -- where they can be mechanically removed. Suppliers of these magnetic treatment systems claim that magnets will remove scale without conventional chemicals. Also, a similar novel treatment technology, called an electrostatic field generator, is also reported.

Alternative Sources of Make-Up Water

Some facilities may have an opportunity to reuse water from another process for cooling make-up water. Clean internal wastewater streams such as reverse osmosis (hyperfiltration) reject water is suitable for in-process reuse. In some cases treated in-process effluent can be used as cooling tower make-up if the concentration ratio is maintained conservatively low. Similarly, blowdown streams may be suitable for use as in-process water in some applications.

North Carolina's Environmental Management Commission rules allow the use of reclaimed water, or tertiary treated municipal wastewater, for cooling tower make-up water (see p. 67). In reuse and reclaimed water applications for cooling towers, water quality and system dynamics must be fully understood. Factors such as mechanical design, metallurgy, water chemistry and fluid flow dynamics must be considered.

CASE STUDY

Eliminating Once-Through Cooling

A small medical equipment manufacturer in Arden was using a continuous tap water flow of 12 gpm to cool a 20-horsepower vacuum pump. After a water efficiency audit, the company installed a chiller water recirculating system. The company is now saving 6.6 million gallons of water per year, an estimated $30,500 annual savings in water and sewer costs.

Eliminate Once-Through Cooling

Many facilities use "once-through" water to cool small heat-generating equipment. Once-through cooling is a very wasteful practice because water is used only one time before being sent to the sewer system. Typical equipment that may be using once-through cooling includes: vacuum pumps, air compressors, condensers, hydraulic equipment, rectifiers, degreasers, X-ray processors, welders and sometimes even air conditioners. Some areas of the country prohibit the use of once-through cooling practices. Options to eliminate once-through cooling are typically very cost effective. They include:

- Connect equipment to an existing recirculating cooling system. Installation of a chiller or cooling tower is usually an economical alternative. Sometimes excess cooling capacity already exists within the plant that can be utilized.
- Consider replacing water-cooled equipment with air-cooled equipment. One example is switching from a water-cooled to an air-cooled ice making machine. This must be balanced against energy costs.
- Reuse the once-through cooling water for other facility water requirements such as cooling tower make-up, rinsing, washing and landscaping.

CASE STUDY

Tertiary Treated Reclaim Water

A Triangle-area comfort cooling plant has been using tertiary treated reclaim water for cooling tower make-up for more than five years. Careful monitoring of biogrowth, corrosion rates and system efficiency ensure long-term success.

Ideas to Reduce Potable Make-up to a Cooling Tower

- Catch air handler condensation and route it to the tower, be sure to check for bio compatibility
- Catch rinse waters from processess such as softeners, demineralizers, etc. and route as tower make-up
- Catch rain water, filter and test appropriately to feed tower
- Consider advance recycle techniques such as ultrafiltration
- Consider other water reuse sources and quality, such as centrifuge blowdown
- Ensure the tower is set up to minimize or eliminate overflow during intermittent operation when headers may drain to the sump

CASE STUDY

Condensate Water Reuse in Towers

The Fulton County Health Center in Wauseon, Ohio, is capturing HVAC condensate water and reusing this high quality water in its cooling towers. The 280,000 sq. ft. hospital complex is reusing more than 353,000 gallons per year of condensate water. The condensate water has several positive characteristics for reuse that include 1) being cold (around 45°F), 2) not requiring any treatment (i.e., very clean with low solids), 3) has a pH of 8.2, and 4) increases in flow as cooling tower demand increased. The water was able to be gravity fed to towers systems and total project cost was less than $1,500.

CASE STUDY

Condensate Used for Irrigation

The Ford Foundation uses water from steam condensation; condensate off cooling coils and roof drains to supply cooling towers and provide garden irrigation. Rain runoff flows into 3,000 and 13,000 gallon tanks. The 3,000 gallon tank is used for watering plants and trees in the building's atrium, using about 900 gallons a week. This tank is easily replenished from the cooling condensate and/ or rainwater within one day of use. The 13,000 gallon tank is used for the cooling towers. Warmer summers requiring more work of the cooling towers to maintain the building temperature create more condensation, thus more water for the tanks. When the tanks get low, the foundation uses water from the New York water system. The foundation receives a utility credit from the city for this water, because it is evaporated, rather than sent into the sewer system.

CASE STUDY

Instantaneous Hot Water System

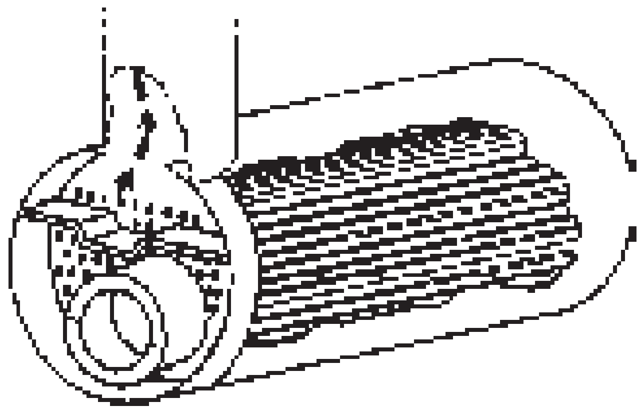
Smithfield Packing Corporation in Wilson significantly reduced water usage while still experiencing an increase in production. The facility installed an instantaneous hot water system which allows the facility to decommission its boilers, saving approximately 11,000 gallons of water per production day; equal to an 8.9 % reduction in usage and a cost avoidance of approximately $8,000 per year. The facility has also decreased natural gas usage by 6,269 MCF, resulting in an approximate cost avoidance of $85,550 per year and reduced annual greenhouse gas emissions by 720 tons. Total cost avoided by this project is approximately $93,550 per year.

Steps to Evaluate Streams to Reduce Potable Make-up to a Tower

- Analyze the sample
- Model the water against the application
- Balance the results vs. the investment to make it work
- If the cost is large, test the results in a pilot application

BOILERS

Boiler



Boiler Water Impurities

All boiler make-up water contains impurities. As clean steam is released from the boiler, impurities build up. The increasing concentration of these impurities, such as dissolved solids, can lead to carryover into the steam, causing damage to piping, steam traps and even process equipment. The increasing concentration of suspended solids impurities in the boiler can form sludge, which impairs boiler efficiency and heat transfer capability.

Blowdown

To maintain solids at an acceptable level, water is removed from the boiler system. This water bleed-off, termed "blowdown," from industrial boilers is an important part of boiler operations. Achieving the right amount of blowdown is critical. As with cooling towers, insufficient blowdown can lead to excessive buildup of impurities. Too much blowdown can lead to wasted water, treatment chemicals and energy.

Blowdown is released from beneath the water surface in the boiler's steam drum, mud drum, bottom header or from the bottom of the boiler. Surface water blowdown is often done continuously to reduce the level of dissolved solids, and bottom blowdown is performed periodically to remove sludge from the bottom of the boiler. Additionally, the blowdown heat can be used to increase the overall efficiency of the system.

The optimum amount of blowdown required is a function of boiler type, steam pressure, chemical treatment program and feedwater quality. Because supply water quality varies from place to place, no hard and fast rules exist as to the exact volume of blowdown required. Blowdown rates can very from one percent (of feedwater flow) to as much as 20 percent, with the typical range of four to eight percent.

Blowdown amount is typically calculated and controlled by measuring the conductivity of the boiler feed and blowdown water. Conductivity is a viable indicator of the overall total dissolved solid concentration. Blowdown for boilers is usually expressed in percentage:

$$\text{Percent Blowdown} = \frac{\text{Quality of Makeup Water}}{\text{Quality of Blowdown}} \times 100$$

$$= \frac{\text{TDS or } (\mu\text{mhos}) \text{ of Makeup}}{\text{TDS or } (\mu\text{mhos}) \text{ of Blowdown}} \times 100$$

Boiler water quality also is commonly expressed as cycles of concentration, which is simply the inverse of percent blowdown.

Optimizing Blowdown

Facility managers should know the optimum operating parameters for their boiler water quality. While optimizing boiler water treatment and control procedures can conserve water, more importantly, they will maintain proper boiler performance, extend life and save energy. The American Boiler Manufacturers Association and American Society of Mechanical Engineers have developed guidelines for water purity controls in boilers. These can be used as a starting point for determining boiler blowdown needs. The maximum recommended concentration limits according to the ABMA is listed in the table below. Operating the boiler below these levels requires more blowdown, wasting water and energy, thus increasing the cost of operation. The total dissolved solids are the sum of all naturally occurring minerals dissolved in supply water and any treatment chemicals added to the system.

Recommended boiler blowdown practices also are described in Sections VI and VII of the ASME *Boiler and Pressure Vessel Code*. Facility managers can identify water- and energy-saving opportunities by comparing the blowdown and makeup water treatment practices with the ASME practices. The ASME *Boiler and Pressure Vessel Code* can be ordered through the ASME Web site at http://www.asme.org/bpvc/.

Automatic Blowdown Controls

There are two types of boiler blowdown: manual and automatic. Plants using manual blowdown must check samples many times a day or according to a set schedule, and adjust blowdown accordingly. With manual boiler blowdown control, operators are delayed in knowing when to conduct blowdown or for how long. They cannot immediately respond to the changes in feedwater conditions or variations in steam demand.

An automatic blowdown control constantly monitors boiler water conductivity and adjusts the blowdown rate accordingly to maintain the

Maximum Recommended Concentration Limits

Boiler Operating Pressure (psig)	Total Dissolved Solids (ppm)	Total Alkalinity (ppm)	Total Suspended Solids (ppm)
0 - 50	2,500	500	--
50 - 300	3,500	700	15
300 - 450	3,000	600	10

desired water chemistry. A probe measures the conductivity and provides feedback to the controller driving a modulating blowdown valve. An automatic blowdown control can keep the blowdown rate uniformly close to the maximum allowable dissolved solids level, while minimizing blowdown and reducing energy losses.

Purchasing and installing an automatic blowdown control system can cost from $2,500 to $6,000 with generally a one- to three-year payback period on the investment. A complete system should consist of a low- or high-pressure conductivity probe, temperature compensation and signal condition equipment, and a blowdown-modulating valve.

Changing from manual blowdown control to automatic control can reduce a boiler's energy use by two to five percent and reduce blowdown water losses by up to 20 percent.

Action Plan for Optimizing Boiler Blowdown

- Monitor blowdown rates, feedwater quality and blowdown water quality.
- Work with experienced vendors and boiler service providers to determine best water treatment program to complement water efficiency goals.
- Establish maximum boiler water contaminant levels.
- Estimate cost and operation savings in water use, heat loss and chemical loss that can be accomplished by modifying concentration ratios.
- Evaluate implementing systems to continuously monitor and blowdown boiler water.

Maximizing Condensate Return

Improving condensate return is another way to minimize blowdown water and maximize cycles of concentration at which a boiler operates. By increasing condensate return, operators will increase the concentration cycles, decrease chemical usage, decrease blowdown and conserve the heat value of the high-temperature condensate. A well-functioning steam trap inspection program is essential to maximizing condensate return. When steam traps exceed condensate temperature, the trap is leaking steam. Use infrared temperature gun/device to check this. Steam lines and traps should be checked for leaks periodically and repairs should be scheduled. Such repairs are typically very cost effective because of the potential for energy savings. Condensate return systems and automatic shut-off controls should be considered for boiler systems not utilizing them. Consultation can be conducted with boiler vendors, service providers and other technical assistance providers.

Improving External and Internal Water Treatment

External or feedwater pre-treatment systems remove impurities form the boiler feedwater. Treatment systems address three areas:

1. Removal of suspended solids
2. Removal of hardness and other soluble impurities
3. Oxygen removal

There are several technologies available to pretreat boiler feed water. These include softeners, reverse osmosis and demineralization. Increasing feedwater quality will increase the cycles of concentration at which a boiler can operate.

Internal water treatment regimes for boilers seek to manage corrosion and deposits. Choices for internal and external water treatment approaches are interdependent. While seeking to optimize boiler water systems, the importance of using knowledgeable people to ensure proper evaluation of water treatment needs cannot be overemphasized. It is best to utilize someone familiar with boiler system operation as well.

Blowdown Heat Recovery Units

The evaluation of reclaiming heat from blowdown is a wise consideration. Systems with continuous blowdown rates exceeding five percent of the steam generation rate are often good candidates for a blowdown waste heat recovery system. The blowdown water has the same temperature and pressure as the boiler water. Before this high-energy waste is discharged, the residual heat in blowdown can be recovered with a flash tank, a heat exchanger or the combination of the two. A boiler blowdown heat recovery project at Augusta Newsprint Mill in Georgia saved the company $31,000 in fuel costs and 14,000 MMBtu in energy annually.

CASE STUDY

Clean Cooling Water Reuse

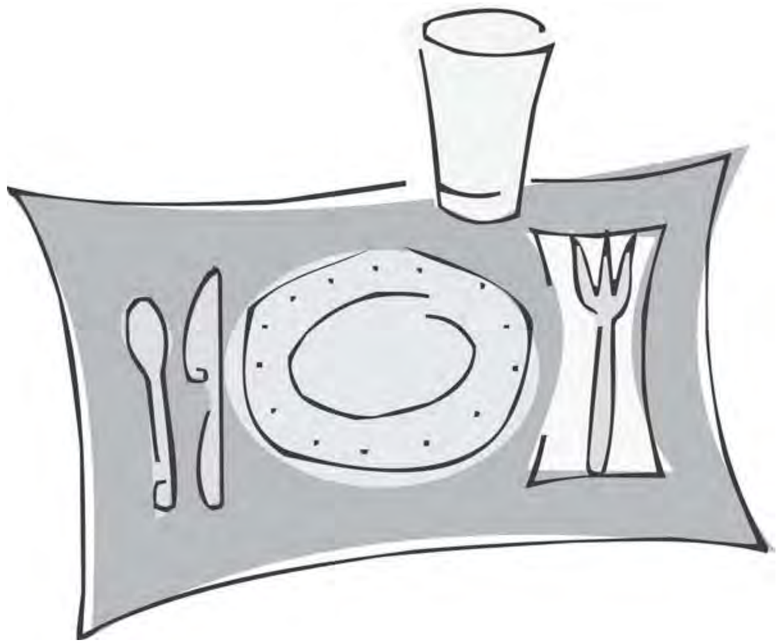
Safelite Glass Company in Enfield, N.C., utilizes water from air compressors and hydraulic fluid cooling water for boiler makeup. Clean once-through cooling water is a good candidate for boiler water make up. The reuse practice saved 8.5 million gallons of city water per year and was implemented for $3,000. Simple payback was two months.

CASE STUDY

Chemical Free Boiler Water Treatment

Vanir Solar Construction in Fletcher operates a 150-hp boiler around the clock during the heating season. The boiler has a high condensate return and very high-quality make-up water. The water treatment system for the boiler utilized a conventional approach of chemical treatment using phosphate, hydroxide alkalinity (caustic) and sulfite. Beginning in the 2007-08 heating season, a non-chemical treatment water system was installed by Fluidyne International. The new treatment system reduced boiler corrosion and deposits while significantly reducing boiler blowdown water. With visual inspection, rusty deposits in the boiler and condensate return lines were disappearing from the walls of the wetted areas. The annual (heating season) savings related just to blowdown, including water, sewer and energy costs, was $4,070. The new system is saving 189,000 gallons of water annually. Significant additional savings were achieved in eliminated chemical costs and chemical servicing.

KITCHEN & FOOD PREPARATION



Although commonly overlooked, there are many ways to reduce water usage in the kitchen. Traditionally, saving water has not been a major consideration of commercial food preparers. Many establishments cite the lack of money or employees as reasons for not using water conservation methods. Case histories have shown that water efficiency programs are cost-effective, and most initial costs are retrieved within a two-year period. Participation in municipal water efficiency programs shows that the food preparation sector is interested in striving for high efficiencies in its water use.

Inefficient uses of water in kitchen operations come mainly from two areas: equipment design and behavioral patterns. The main types of water-using equipment found in kitchens are dishwashers, faucets, ice-making machines and garbage disposals. Improved technology has eliminated many of the water issues associated with equipment, as more rigid standards have been created to curtail excessive water

CASE STUDY

Geothermal Energy Use

The Proximity Hotel, located in Greensboro, has an innovative refrigerator system in its kitchen that uses geothermal energy instead of the conventional water-cooled systems, providing significant water savings.

FIGURE 4-12

Commercial Kitchen/Cafeteria Operations

Equipment	Type	Water Use: Traditional	Water Use: Existing Standard	Water Use: High Efficiency	Savings Potential	Comments
Commercial Dishwashers	Undercounter	1-1.8 gal/rack	No standard	1 gal/rack	Up to 0.8 gal/rack	Machines with an overall height of less than 36"; rack of dishes remains stationary within machine during sequential wash and rinse sprays. High temp machines are most water efficient.
	Stationary Single Tank Door	1.1-2.2 gal/rack	No standard	0.95 gal/rack	Up to 1.2 gal/rack	Includes machines commonly referred to as pot, pan and utensil washer. Also applies to machines in which the rack revolves on an axis during the wash and rinse cycles. High temp machines are most water efficient.
	Single Tank Conveyor	0.7-1.4 gal/rack	No standard	0.7 gal/rack	Up to.7 gal/rack	A single tank conveyor machine has a tank for wash water followed by a final sanitizing rinse and does not have a pumped rinse tank.
	Multi Tank Conveyor	0.54-1.2 gal/rack	No standard	0.54 gal/rack	Up to 0.58 gal/rack	Machines with one or more tanks for wash water and one or more tanks for pumped rinse water. Followed by a final sanitizing rinse.
Pre-rinse Spray Valves	Handheld hose-mounted dish sprayers	2-5 gpm	1.6 gpm at 60 psi		0.4-3.4 gpm	
Commercial Steam Cookers	Compartment Steamers	25-35 gal/hr	No standard	ENERGY STAR Qualified cookers average 2 gal/hr	Up to 33 gal/hr	

use. Water audits of commercial facilities have shown that 60 percent of identified water savings comes from simply installing 2.2 gpm faucet aerators in all kitchen sink outlets. An effective part of water savings in kitchens is attributed to behavioral patterns in facilities. Awareness programs, education, training and job performance measures can influence proper behavioral patterns of staff.

Dishwashers*

Commercial dishwashers, considered to be one of the largest water and energy consumers in a food service area, often use more than two-thirds of the overall kitchen water use. There are four main classes of commercial dishwashers: undercounter, stationary rack door type, rack conveyor and flight type. Each class of dishwasher may employ single or multiple wash tanks, and use hot water (high-temp machines) or chemicals (low-temp machines) to achieve final rinse dish sanitization. Requirements for machine class and size can be calculated by estimating the amount of traffic that will be served in the food service area.

Water usage across commercial dishwasher classes does not appear to be directly related to the size of the machine and varies from .33 gallons per rack to 20+ gpr. A typical commercial dishwasher uses approximately four gpr. Using an appropriately sized, water efficient model will save a significant amount of water.

**Taken from the Alliance for Water Efficiency - Commercial Dishwashing Web site.*

Types of Dishwashing Machines

- Undercounter
- Stationary rack door
- Rack Conveyor
- Flight

Undercounter

The smallest of commercial dishwashers, undercounter dishwashers, are best suited for small establishments of about 60 people. They commonly are used in nursing homes, churches, small food service areas and office buildings. The undercounter machines are similar to residential dishwashers in that the door opens downward with rack(s) rolling out onto the lowered door for access.

A revolving wash arm handles the wash and rinse cycles, with a small holding tank being automatically drained after each cycle. An automatic timer controls cycle length. Undercounter machines come in both hot water and chemical sanitizing models, with optional booster heaters for the latter. Hot water machines are the most water efficient.

Stationary Rack Door

Designed to service 50-200 people, stationary rack door machines are the most widely used for commercial dishwashing machines. Door machines are used in schools, hospitals, churches, restaurants, catering businesses, fast-food establishments and as glass and utensil units in larger operations.

These box-shaped machines have one or multiple doors that slide vertically for loading and unloading. Stationary rack door type machines are available in both hot water and chemical sanitizing models. Hot water machines are the most water efficient. These "dump and rinse" machines have a single tank for water and detergent, which are circulated in measured volumes and temperatures. Two revolving spray arms distribute wash solutions evenly over the dishes. Some stationary rack door machines have the ability to recycle rinse water to be used again in a wash cycle.

Rack Conveyor

Rack conveyor, or c-line, machines use a motor-driven conveyor belt to move the rack-loaded dishes through a large tank with separate wash and rinse compartments. Most widely-used in hotels, large restaurants, hospitals, schools and universities, these machines are well suited for service of 200 or more people, accommodating most heavy food service operations.

Rack conveyors come in varying sizes, with available additions such as pre-wash units, side-loading trays, condensers and blower-dryers. A single tank holds the water and detergent at a regulated temperature. The wash solution is pumped through multiple spray arms (revolving or stationary) that run constantly once the machine is operational, regardless of the presence of a dish rack. The rack is then sent through the rinse compartment, where it is sprayed with 180°F water by spray nozzles above and below the rack. Rack conveyor machines with multiple tanks differ in that some use stationary vs. rotating spray arms. The racks are then sent into a pump-driven rinse tank that rinses the dishes heavily. This process usually uses recycled water from the final rinse. All rack conveyor machines have a timer control for the speed of the conveyor to assure proper wash and rinse times.

Water efficient measures, such as the installation of an electric eye sensor (that keeps the conveyor from running when there are no dishes on the racks) make conveyors more water-, energy- and cost-effective.

Flight

Similar in that they use a conveyor belt to move dishware, flight-type machines do not have racks. Rather, dishes are loaded directly onto the belt. Flight-type dishwashers provide high volume washing capability needed only in the largest institutional, commercial and industrial facilities. Variations in possible machine additions include power scrapers, power wash, power rinse, final rinse and blower-dryer.

Water efficient strategies for these machines include the recirculation of final rinse water, electric eye sensors, extra-wide conveyors and low-energy built-in booster heaters. These additions can translate to water savings as much as 47 percent, while maintaining loads of more than 14,000 dishes per hour.

Water Efficient Practices for Dishwashers

The volume of consumption in dishwashers can be reduced by a variety of practices, all of which target awareness of equipment and operational needs.

Behavioral Modifications

- Educate staff about the benefits of water efficiency and the importance of hand scraping before loading a dishwasher.
- Instruct staff to quickly report leaks and troubleshoot.
- Run rack machines only if they are full.
- Try to fill each rack to maximum capacity.

Mechanical Modifications

- Reuse rinse water to pre-rinse or wash dishes.
- Keep flow rates as close as possible to manufacturer's specifications.
- Install advanced rinse nozzles.
- Install "electric eye sensors" to allow water flow only when dishes are present.
- Install door switches for convenient on/off access.
- Check voltage of booster heater to make sure it fits the machine.
- Use "steam doors" to prevent loss of water due to evaporation.
- Check volumes of service and estimate facility needs. A better option may be a larger machine that has a lower water flow per rack rate.

CASE STUDY

Adopting Water Efficiency Practices

The Angus Barn restaurant in Raleigh reduced daily water usage by more than 10,000 gallons by installing new water efficient equipment and adopting water efficiency practices. New dishwashers, with a significantly shorter wash cycle that still meets performance and sanitation standards, were installed. An older water-cooled ice machine was replaced with an air-cooled ice machine. A variety of low-flow restroom fixtures including faucets, automatic flush urinals and toilets that meet performance expectations were installed. Changing from hosing kitchen floors every night to mopping floors on alternate nights and hosing the floor in between decreased water usage. Sanitation was not compromised with any of these water-efficient techniques.

Quick Tip

Pre-rinsing dishes by hand before loading the dishwasher can use up to 20 gallons of water. Simply scrape food off dishes and load. ENERGY STAR qualified dishwashers and today's detergents are designed to do the cleaning so pre-rinsing can be eliminated. If dirty dishes are going to sit overnight, use the dishwasher's rinse feature that uses a fraction of the water and time used to hand rinse.

Kitchen Faucets and Pre-rinse Sprayers

Faucets can waste large amounts of water, as they are the most heavily used water source in kitchens. Conventional faucets, with typical flow rates of 2.5 to 4.0 gpm, can waste as much as 40 gallons of water a day when not fully closed. Since 1994, water efficiency standards have been federally mandated, requiring that all post-1994 manufactured faucets consume a maximum of 2.5 gpm @ 80 psi. But many facilities have older fixtures with rubber gaskets that wear and deform because of high amounts of hot water use. By simply installing a brass gasket and an automatic shut-off nozzle, a facility could save as much as 21,000 gallons of water per year. There have been many adjustments and technology advancements in faucet design as a variety of low-flow faucet types are being manufactured. Foot-activated kitchen faucets will reduce water use while providing additional convenience. Faucets used in kitchens will be primarily the conventional type or pre-rinse pressure sprayers. There are a variety of modifications that can be employed for all types.

Water Efficiency Options for Kitchen Faucets

- Adjust flow valve to reduce water flow.
- Check for leaks and worn gaskets.
- Install a flow restrictor to limit maximum flow rate to 2.5 gpm or less.
- Install a 2.5 gpm faucet aerator, maximizing flow efficiency by increasing airflow to the stream.
- Consider infrared or ultrasonic sensors that activate water flow only in the presence of hands or some other object.
- Install pedal operated faucet controllers to ensure valves are closed when not in use.
- Educate staff to look for leaks and broken faucets in their area.
- Do not leave faucets on to thaw vegetables and other frozen foods.
- Post water conservation literature and reminders to staff around work areas.

Pre-Rinse Sprayers

Known as high-efficiency sprayers, these inexpensive nozzles use less water and can save a commercial kitchen hundreds of dollars a year in energy costs alone. The sprayers can also cut the water bill.

Pre-rinse sprayers are an essential component of kitchen operations. They are used to remove leftover grease and food off dishes, pots and pans before they go into a dishwasher. While conventional sprayers use between 2.5 and 4 gallons of water per minute, the high-efficiency sprayers use from 1.6 to 2.65 gpm.

The new generation of sprayers also comes with an automatic shut-off valve at the hose head, so water is supplied only when needed.

Ice Machines

Ice machines have many commercial uses, from restaurants to lodges, and can use significant amounts of water, depending on the type of machine and the desired type of ice.

Ice machines are composed of the following components: a condensing unit used for cooling, an evaporator surface for ice formation, an ice harvester, an ice storage container, and, in some models, a dispenser. The type of condenser an ice machine uses will have the largest effect on water use. Two types of condensers are available: air-cooled and water-cooled.

CASE STUDY

Foot-actuated Faucet

By installing a foot-actuated faucet, one food service facility reduced its monthly water usage by 3,700 gallons. This translated to annual savings of nearly $700.

Water-cooled machines use 10 times as much water as air-cooled machines and water rarely is recirculated. In comparing water- and air-cooled compressors, the compressor horsepower at design conditions is invariably higher with air-cooled machines. However, operating costs frequently compare favorably during a full year.

The desired quality and visual clarity of ice also will influence water consumption. Ice quality, machine cleaning and water efficiency all need to be balanced for optimum operation.

Garbage Disposals

Studies show that garbage disposals can waste a significant amount of water. It is recommended that their use be minimized or eliminated from kitchen operations. Many facilities use strainers or traps that employ a mesh screen to collect food waste for proper waste treatment. Another option is to install strainers in sinks, leaving the food matter in the sink for disposal in trash receptacles or composting units.

Ice Machine Water Use

Equipment	Type	Building Type	Water Use: Traditional	Water Use: Existing Standard	Water Use: High Efficiency	Savings Potential	Comments
Commercial	Ice-making head and remote condensing units	Operations requiring large volumes of ice	Water cooled units can use 150 gal/100 lbs. of ice	None	Air cooled units can use 25 gal/100 lbs. of ice	125 gal/100 lbs. of ice	Typically larger volume applications where ice-making head and storage bin are separate or ice-making head and condenser units are separated
	Self-contained	Most common configuration for low volume applications	Water cooled units can use 150 gal/100 lbs. of ice	None	Air cooled units can use 30 gal/100 lbs. of ice	120 gal/100 lbs. of ice	Free-standing units where ice-making unit and storage compartment are housed together in a single cabinet

COMMERCIAL LAUNDRIES

Commercial, industrial and institutional facilities include those that wash linens, uniforms and other items for hotels and motels, hospitals, nursing homes, prisons, universities and restaurants. Large amounts of water are regularly used in laundering facilities for operations that include the wash and rinse cycles of washing machines, steam-heated dryers, steam-pressing equipment and reclamation of dry solvent.

Traditional washer-extractor machines used by most laundry facilities operate with a rotating drum that agitates the laundry during wash and rinse cycles, then spins it at high speeds to extract water. Washer-extractors and most other traditional large-scale washing machines use fresh water for each wash and rinse cycle. The capacity for washer-extractors ranges from 25 to 400 dry pounds per load and use 2.5 to 3.5 gallons of water per pound of laundry. Water efficient laundering equipment, such as continuous-batch washers and water reclamation systems, can reduce water use by as much as 70 percent at commercial, industrial and institutional facilities equipped with traditional washer-extractors.

Water Efficiency Measures

Water and wastewater costs represent more than 50 percent of the total operating costs in a typical commercial, industrial and institutional laundry operation. In general, two gallons of water used per pound of clothes is considered a "good" water efficiency standard for commercial, industrial and institutional laundries; though this is not always achievable for heavily soiled fabrics. Water efficiency measures should not impair the cleaning or sanitation goals of the laundry operation. Water efficiency measures that may be applicable to commercial, industrial and institutional laundry operations include:

- Operate laundry equipment with full loads only.
- Reduce water levels, if possible, for partial loads.
- Replace or modify existing conventional laundry equipment to reduce water use.
- Replace traditional commercial clothes washers (vertical axis) with high efficiency washers (horizontal axis), which can save as much as two-thirds of the energy and water used by traditional models.
- Install a computer-controlled rinse water reclamation system. These systems can save as much as 25 percent of wash load's water demand by diverting rinse water to a storage tank for later reuse as wash water.
- Install a wash and rinse water treatment and reclamation system, except in very rare situations where health codes prohibit such use in specialized situations. By recycling both wash and rinse water, these systems can reduce a laundry's water demand by about 50 percent.
- Install a continuous-batch (or tunnel) washer, which can reduce water demand by about 60 percent compared with that of washer-extractors.
- Install an electrically generated ozone laundry system, which can reduce water use by about 10 percent compared with that of traditional laundering systems. The ozone acts as a cleaning agent and also reduces detergent use by 30 to 90 percent.
- Consult service personnel and the laundry's supplier of chemicals for the washer-extractors to ensure that equipment is operating at optimal efficiency.
- Avoid excessive backflushing of filters or softeners; backflush only when necessary.
- Place "save water" notices in hotel and motel guest rooms, urging guests to save water by minimizing the amount of linen that needs to be laundered.

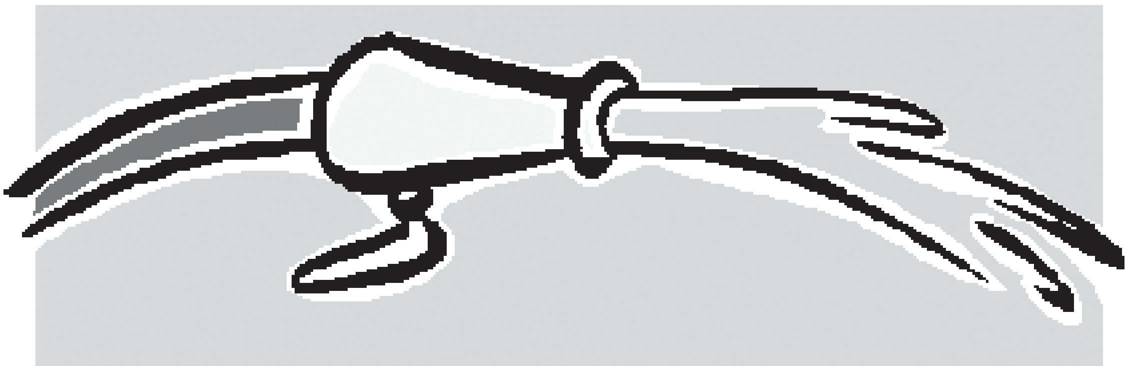
The Commercial Laundries section was taken from the "Handbook of Water Use and Conservation," by Amy Vickers.

CASE STUDY

Rinse Water Reuse

A laundry facility in Manchester, N.H., saves approximately 675,000 gallons of water per month by using a horizontal flow "tunnel-type" washing machine that reuses rinse water for bleaching and washing. This washing system is capable of using approximately 40 percent less water than a conventional type machine, based on equivalent cleaning requirements.

CLEANING AND RINSING APPLICATIONS



Most industrial and commercial businesses have a variety of cleaning and rinsing applications that can consume large volumes of water. Water efficiency techniques presented here address general water uses for process change-overs, equipment clean-out, parts rinsing, tank rinsing, line flushing, floor cleaning and other applications. Because this section is generic in nature, the water efficiency concepts presented will need to be individualized for specific business needs and any regulatory cleanliness standards. *(Also see sections on metal finishing, textiles and food processing in Chapter 5 for more specific water efficiency applications.)*

Education: First and Foremost

Employees must be aware of the need for water efficiency. Many cleaning processes can be made significantly more efficient by simple measures. If employees are actively solicited and involved in water reduction efforts, behavior and equipment modifications will successfully reduce water consumption.

Dry Clean-up

Dry clean-up means using brooms, brushes, vacuums, squeegees, scrapers and other utensils to clean material before water is used. By collecting the majority of wastes, residues or contaminants in a dry form, large volumes of water and wastewater can be eliminated. The bulk of solid materials can be more efficiently removed in dry form before water is introduced for secondary washing.

Examples of Dry Clean-up Practices

- Sweeping floors instead of hosing with water.
- Vacuuming or sweeping dry material spills such as salt or dyes instead of using water.

CASE STUDY

Dry Clean-up

The Equity Group in Reidsville instituted a comprehensive program to reduce water use and wastewater pollutant loading in its food processing operation. Employees were trained to remove all dry waste from floors and equipment for cleaning. Because of dry clean-up practices, much of the waste food residuals can have a secondary use, such as for animal food. Dry clean-up, improved employee awareness and other operational modifications saved 1.25 million gallons per month and reduced organic pollutant loading to wastewater by 50 percent.

- Use squeegees and scrapers first to remove residuals from machines, such as ink sludge from machine troughs between color change-overs.
- Vacuuming or sweeping particulate emissions (dust) instead of hosing with water.
- Use rubber squeegees to collect food processing residuals from the floor before hosing with water.
- Use "pigs" to purge residuals from pipes before flushing with water.

Benefits of Dry Clean-up

- Saves water and reduces wastewater.
- Reduces water, wastewater and surcharge costs.
- Reduces pollutant loading entering wastewater system.
- Saves energy for processes that use hot water.
- Reduces hydraulic capacity demands on any wastewater treatment systems.

CASE STUDY

Dry Clean-up

Tyson Foods in Sanford reduced wastewater discharge volumes and limited the amount of production material lost to the sewer; totaling approximately $29,000 annually in water and sewer cost avoidance. Employees frequently used water hoses to wash the material down the drain. To reduce water usage, Tyson shut off and locked all water-cooled compressors during the first and second shifts and educated employees on the need to reduce water usage. Tyson also modified production equipment to reduce material losses to the floor and covered production lines not in use to reduce unnecessary cleaning. As a result of implementing these measures, Tyson reduced its average daily discharge from 35,000 to 15,000 gallons and substantially reduced the amount of production material lost to the sewer. Sanitation was not compromised with any of these water-efficient techniques.

- Better enables the recovery of process material. Also enables the recycling or composting of "dry" collected materials.

Eliminate/Reduce Floor Washing Where Feasible

- Many floor surfaces (i.e., warehouses, offices, automotive garages, non-critical processing areas, facility support operations, etc.) do not need to be washed with water.
- If necessary, use dry absorbents and sweep or vacuum these areas.
- Find and eliminate the source of spills and

leaks that may be the sole reason why water washdowns are needed.

- Spot mop if necessary.
- Use floor mats, "clean-zones" and other means to reduce the tracking of waste and dirt residuals throughout a facility.

Use Efficient Spray Washing/Rinse

Many improvements can be made to the water delivery system for washing and rinsing. Proper selection, control, use and maintenance are essential. Consider these suggestions:

- Do not use a hose as a broom. This practice is a waste of valuable labor, water and energy.
- Use efficient spray nozzles with automatic shutoffs on the end of hoses. Garden hose nozzles are not very efficient.
- Consider high-pressure washers to clean more quickly and efficiently.
- Consider pressurized air-assisted spray nozzles to provide more cleaning force with less water.
- Use low-flow "fogging" nozzles to rinse parts efficiently.
- Use flow restrictors in water lines that supply hoses and pressure washers.
- Use timers to shut off process water rinses when process is shut down.
- Turn off running water when not in use.
- Ensure stationary spray nozzles are aimed properly.
- Review nozzle spray patterns for optimum application. Fan, cone, hollow cone, air atomizing, fine spray and fogging are a few examples of nozzle spray patterns.
- Replace worn spray nozzle heads. They can result in poor spray patterns and excessive water consumption.
- Use countercurrent washing techniques. *(See Chapter 5.)*
- Use conductivity controllers to regulate rinse water flow rates. *(See Chapter 5.)*

CASE STUDY

High-Pressure Washers

A food processing facility in St. Paul, Minn., replaced garden hoses with high-pressure washers to clean equipment that processes flour products. The new high-pressure washers cost $200 each. Equipment now is cleaned quicker and more efficiently using half the water. The washers save 217,000 gallons of water per year, and the payback was less than three months. Sanitation was not compromised with this application.

- Use spray washing/rinsing techniques for tank cleaning vs. refilling/dropping tank washwater.

Other Improvements to the Cleaning Process

Teflon™ Surface Coatings

Tanks, vats, pipeline and other equipment surfaces can be coated with a Teflon™ non-stick surface. This allows for easier cleaning during process line changeovers and clean-up.

Cleaning Chemical Changes

Changes in the type, temperature and concentration of cleaning solutions can save water.

Operational Controls and Maintenance

Overflow controls should be in place for filling tanks and vessels.

Sub-Metering Water Use

Some businesses restrict water flow to an entire processing area and force water operators to find the optimum ratio level for individual activities. Sub-metering and monitoring allows excessive water consumption and leaks to be quickly detected and corrected.

Vehicle Washwater Recycling

Many commercial water recycle systems are available for fleet maintenance and vehicle cleaning. With a recycle water permit from the proper authority, facilities can install a washwater recycle system for vehicle cleaning.

Washwater recycling systems provide several advantages over typical wastewater disposal:

1. These systems allow for simple cleanup of contaminants from spills or system failures by preventing entry to the sanitary sewer or septic system.
2. These systems reduce costs for water use and disposal.
3. Many of the systems are pre-engineered, have a proven track record, and can be submitted for permit issuance from previously approved plans and specifications.

Typical washwater recycling systems consist of a sedimentation basin for grit/sand removal, an oil/water separator, filtration and a disinfection unit to prevent biological growth. Basin/sump compartments are used to settle grit, sand and other solids, and also used to skim any floating oils. Water then is filtered, typically using a multimedia filter that removes solids in the water larger than five to 20 microns in diameter. The filtered water is oxidized/sanitized to reduce organics and meet any health/safety standards for non-potable

CASE STUDY

Cleaning Solution Reuse

Campbell Soup Company in Maxton instituted a corporate wide integrated pollution prevention program. For water efficiency measures, Campbell soup used dry-clean-up procedures for floors and equipment, installed process water flow meters, and eliminated water transport (fluming) of scrap. A continuous maintenance/housekeeping schedule was implemented instead of the previous once-a-day practice. These water efficiency techniques have saved $125,000 annually in operating costs. The program also improved solids collection and recycling.

CASE STUDY

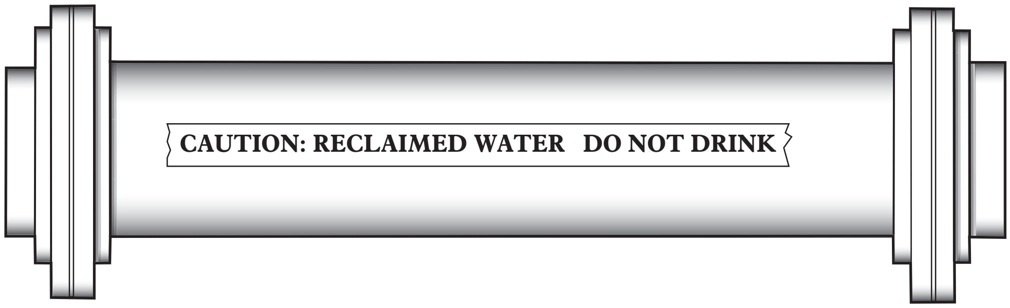
Cleaning Solution Reuse

T.S. Designs, a screen printer in Burlington cleaned printing screens using strong oxidizing solution in manual wiping application. To reduce chemical consumption and save water, T.S. Designs installed a 43-gallon reclamation tank to continuously filter and circulate the aqueous cleaning solution past the printing screen suspended in a tank. A similar reuse system was used for a stain and haze removing wash step. The reuse process allows cleaning solution to be used continuously for one month. With the reuse system, less concentrated and safer solutions could be employed. The reuse system saves $5,200 per year in chemical, water and sewer costs.

water reuse. Water then is stored and pumped back to the washing bay for reuse.

Although such systems can be nearly closed-loop, except for occasional solids removal and filter backwash wastewater, occasionally water must be changed due to buildup of dissolved solids (salts). Washing practices and discharges to the recycling system must be closely controlled, as they will not handle shock loads. Maintenance to the treatment/recycle equipment also is very important. Pre-engineered units for single wash bays cost approximately $20,000. The regional staff for the N.C. Division of Water Quality can provide additional details about permits for a recycling system.

REUSE AND RECLAMATION



Making Water Do More Work

Maximizing utility of in-process water is accomplished by using it more than one time to do work. Water quality characteristics will determine if multi-functional use of in-process water is acceptable for achieving necessary product quality control/assurance. Fortunately, many water treatment technologies can provide cost-effective opportunities to reduce water supply demand and the resultant savings can be used to justify capital costs. Depending on water quality requirements for the stage of use, water may simply be recirculated or require only basic treatment such as solid settling, oil skimming and/or filtration using cartridge, bag, disk, indexing fabric or sand filtration. (*See Figure 4-13.*)

Water quality standards need to be carefully established for each point of multiple-use. For high water quality demands, technologically advanced water treatment techniques exist such as ultrafiltration, nanofiltration, hyperfiltration (reverse osmosis), carbon filtration and ion exchange.

Additional uses of in-process water effluents can also allow the user to salvage a valuable product that presently is being discharged as a wastewater constituent, such as cleaning chemicals in washing solutions or valuable metals in rinsing solutions. This may also reduce wastewater treatment surcharges.

Consider staged cleaning techniques where the first- and second-pass cleaning water is saved for further use or reclamation of chemicals.

In-Process Water Reuse Rules

Areas in North Carolina are approaching limits on seasonal availability of high-quality raw source water. One way to reduce withdrawal of source water is to reduce demand by implementing reuse of industrial in-process wastewater to increase water efficiency. North Carolina's Environmental Management Commission rules support the reuse of industrial in-process wastewater to increase water efficiency.

Title 15A NCAC Subchapter 2T, Section .1000 applies to closed-loop recycle systems where non-domestic wastewater is repeatedly recycled back through the process in which the water was generated. This section permits by regulation (i.e., no permit needed) the return of wastewater contained and under roof within an industrial or commercial process. Spill control plans are required for these systems that do not have secondary containment. An operations and maintenance plan shall be maintained for all closed-loop systems. A residuals management plan shall be maintained for all systems that generate residuals.

N.C. Division of Water Quality issued non-discharge permitting is required for closed–loop recycle systems that are not under roof (i.e., exposed to precipitation inputs) and/or utilizing an earthen basin for storage. Special conditions apply as defined in the Subchapter 2T rules.

Industrial in-process effluents can be directly reused without a DWQ non-discharge permit in these specific situations:

- Industrial in-process water reused within the facility that originated the effluent.
- Cooling tower make-up water.
- Fire-fighting or extinguishing water.

Reuse of industrial in-process effluents are allowed as specified in the Subchapter 2T rules. Before constructing a water reuse system, it is important to verify if a permit will be needed. Modifications to an existing water reuse system may require permitting and/or modification to an existing permit (e.g., pretreatment industrial user permit).

All types of industrial/commercial water reuse require the facility to assure protection of employee health and safety, and to notify employees that non-potable water is being reused. All valves, piping and storage facilities of in-process reuse water must be tagged or labeled to inform employees that the water is not intended for drinking.

Reclaimed Water Systems Rules

Reclaimed water must meet two criteria. First, whether treated or untreated, it must meet specific qualitative standards. Second, it must also be reused in a beneficial manner for the purpose of conservation of the state's water resources. The most common reclaimed water is effluent from a tertiary wastewater treatment process. Reclaimed water utilization serves to offset the use of potable water, surface water and/or groundwater. The water resources benefit derived from the use of reclaimed water is to offset withdrawal of raw water for supply from another location in the hydrological system.

The rules in Title 15A NCAC Subchapter 2T, Section .0900 apply to reclaimed water systems. Reclaimed water effluent standards are very stringent in order to provide for protection from pathogens. Reclaimed water systems are classified in the rules as conjunctive only if the wastewater treatment plant that produces the effluent has the capability to dispose of this water by another method (e.g., NPDES permit). Facilities producing reclaimed water are permitted by the N.C. Division of Water Quality Aquifer Protection Section, Land Application Unit.

CASE STUDY

In-Plant Water Reuse

Previously, the open-loop cooling system on the emergency generator at the Michelin Aircraft Tire Corporation in Norwood pumped 150 gallons of water per minute into the storm water outflow drains. The facility replaced the open-loop generator cooling system with a closed-loop generator cooling system that recycles water from an onsite cooling pond. The facility also replaced bathroom faucets and toilets with more efficient reduced flow, motion sensor models. As a result of the closed-loop cooling system and bathroom fixture replacements, the facility reduced water consumption by 4.8 million gallons per year.

In some localities, it is now possible for customers to receive reclaimed water that is distributed directly from a publicly owned wastewater treatment plant. Reclaimed water distribution piping is distinguishable from potable lines by being colored purple or wrapped and continuously embossed or integrally stamped or marked "CAUTION: RECLAIMED WATER - DO NOT DRINK." No cross-connections are allowed to occur between the reclaimed water system and potable water systems. Where potable water is used to supplement the equipment using reclaimed water, an air gap must separate the potable and reclaimed water. The supplemental system is then subject to approval by the potable water supplier.

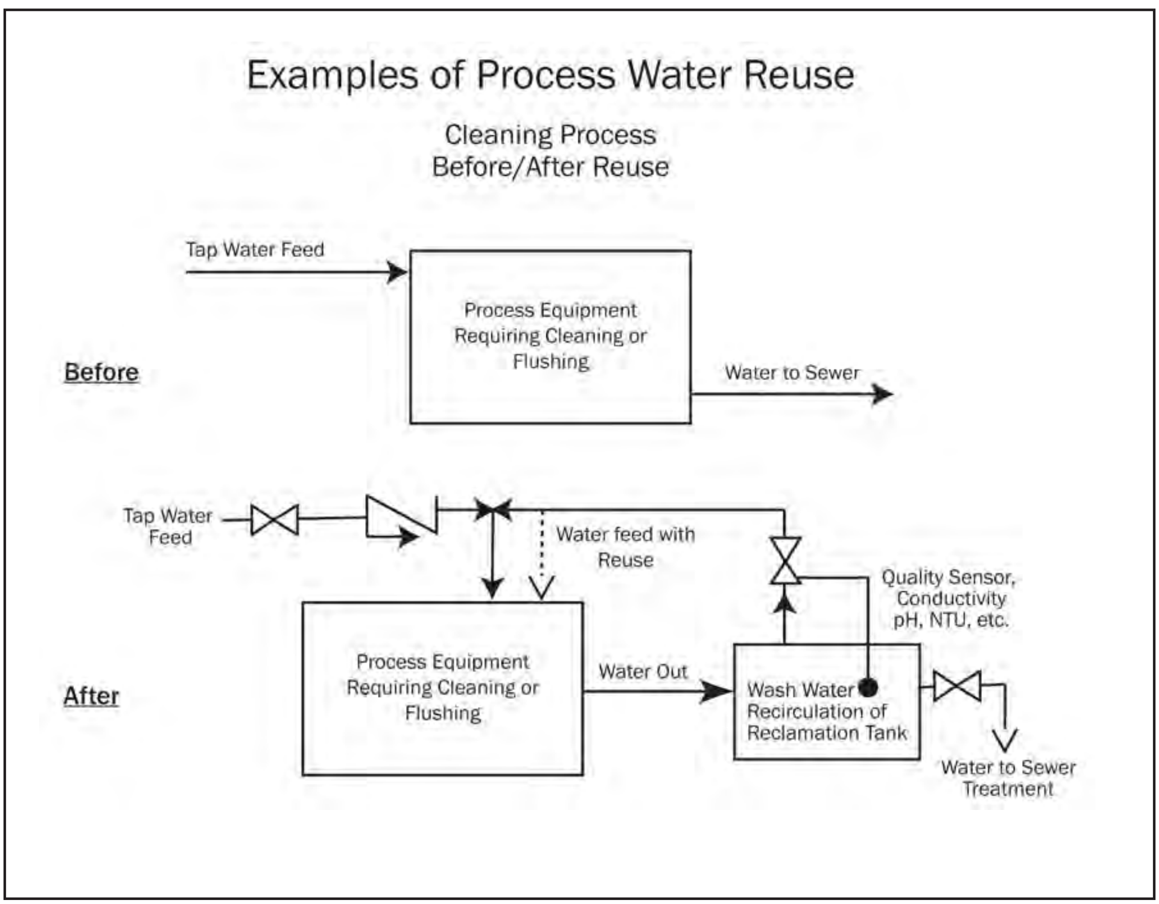
Once reclaimed water is distributed to customers it is not allowed to be directly discharged to the surface waters of the state by the customer. If the reclaimed water is used to supply a landscape irrigation system, runoff into stormwater catchments and conveyances is not allowed.

After reclaimed water is used, it can be disposed of only in a manner in which it is either assimilated into a product (e.g., concrete batch), transpired (e.g., plant uptake), evaporated (e.g., cooling tower) or discharged into a wastewater treatment collection system.

Examples of acceptable uses for reclaimed water are:

- Golf course and landscape irrigation
- Dust control

FIGURE 4-13



- Soil compaction
- Non-potable industrial processes such as cooling water concrete production
- Industrial and commercial toilet flush and fire prevention systems where there are separate, non-potable plumbing lines
- Decorative ponds and fountains
- Street cleaning
- Vehicle washing
- Cooling tower and boiler make-up

N.C. Environmental Management Commission rules specify criteria that apply to certain uses of reclaimed water as an added control measure to protect public health and the environment. The rules prohibit the use of reclaimed water for irrigation of direct food chain crops; make-up for swimming pools, spas and hot tubs; and raw water supply.

Bulk distribution of reclaimed water is made available to customers by permitted wastewater treatment facilities. Contact the local public works department to see if your public utility service provider has been approved to distribute reclaimed water.

Industrial effluents meeting reclaimed water effluent standards can be permitted by the N.C. Division of Water Quality Aquifer Protection Section, Land Application Unit, in order to beneficially use the effluent outside of the industry's process. The rules also have provisions to allow for the distribution of such a reclaimed water effluent to other entities.

For additional information about water reuse, reclaimed water and rule language in the "Waste Not Discharged to Surface Waters" subchapter, see the N.C. Division of Water Quality Aquifer Protection Section, Land Application Unit's Web page at: http://h2o.enr.state.nc.us/lau/main.html.

CASE STUDY

In-Plant Water Reuse

BSH Home Appliances in New Bern installed a system in its enameling facility that filtered rinse water from the parts washer and reused the water in the first stages of the washer. This water conservation project saved the facility approximately 2,500 gallons of water per day of operation. Several additional filters were added to the washer system to keep the water in the tanks cleaner for longer use, thus reducing the frequency needed to dump and clean the tanks.

CASE STUDY

In-Plant Process Water Reuse

Jackson Paper in Sylva manufactures corrugated cardboard medium from 100 percent recycled feedstock. An on-site wastewater facility allows 100,000 gallons of wastewater per day to be reused on-site. Treated mill water is reused for papermaking, boiler scrubber make-up water and sludge press showers in the wastewater treatment area. No wastewater is discharged from the facility. The intensive water reuse modifications save an estimated $92,000 per year.

LANDSCAPING

Landscape Water Use

In North Carolina, outdoor water use annually averages 20-30 percent of the total water used in a facility. This amount can peak during the summer growing season up to 70 percent. North Carolina's rainfall is generally consistent throughout the year with no pronounced wet or dry seasons. Thirty years of records show that everywhere in the state gets between 40 and 60 inches of rain a year. Landscape irrigation is used to supplement this rainfall. Based on historical averages, supplemental watering of the landscape would be required about 20 percent of the time. Averages are notoriously fickle so this section will review ways to plan, plant and maintain a water-efficient landscape.

Starting From Scratch

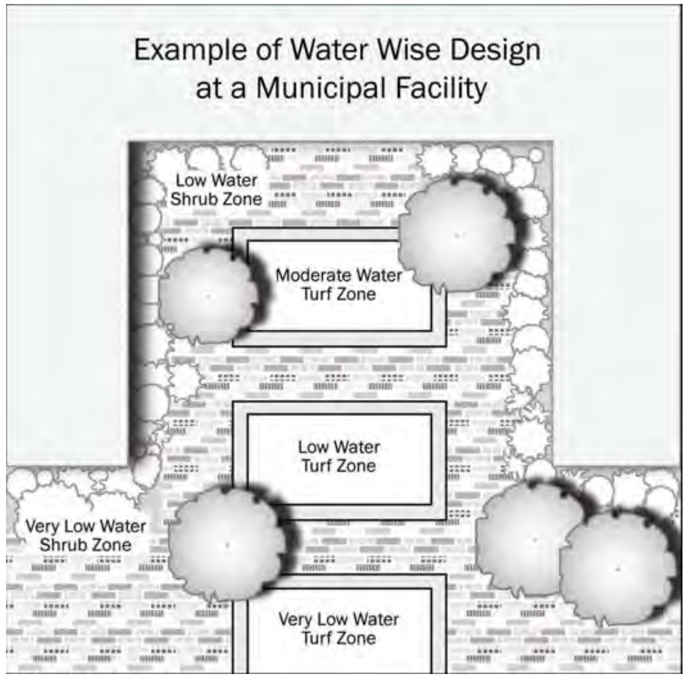
When considering a new or revised project, keep in mind these practical steps to get an attractive and low water use landscape:

(A) Planning and Design

A comprehensive design plan is the initial step to a water-efficient landscape. A well-thought out and researched design will minimize cost and attain a proper strategy for plant and sprinker placement. These factors should be considered:

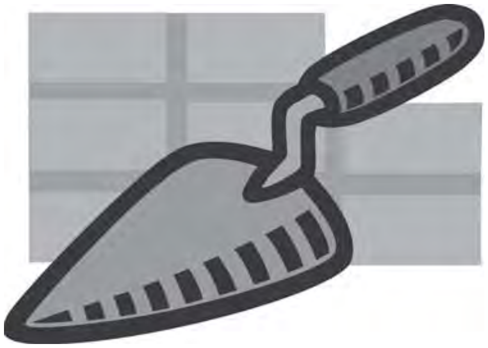
- Site conditions such as drainage, soil type, sun exposure/shade, aesthetic preferences, existing plantings, slope/grade and water availability are all crucial elements of an efficient plan.
- Intended use of the site must be carefully considered, including recreation, habitat and traffic.
- Trees, shrubs and grass all require different amounts of water. Plants should be placed in groups according to their respective water needs, called hydrozones. This way, an irrigation system can be designed to properly match the needs of the plants, soils and weather conditions.
- A proper irrigation design should have a base calculated schedule that includes projected sprinkler run times and weekly frequency for each month of the growing season. This base schedule is used as a starting point for an irrigation manager.
- Incorporate high water demanding plants at the bottom of slopes.
- Incorporate the use of existing trees, plants and wildlife areas to help add value to the site.
- Consider creating shade areas, which can be 20 degrees cooler than non-shaded areas.
- Minimize the use of impervious surfaces to reduce runoff and subsequent stormwater pollution.
- Consider using porous materials such as porous concrete or permeable paving methods.
- Consider grading and directing surface run-off and rainfall gutters to landscaped areas as opposed to drainageways that exit the property.

FIGURE 4-14



(B) Soil Analysis and Improvement

- Soil testing will help determine soil quality, nutrients present and absorptive capacity. Choose plants based on these findings. Most soils require some adjustment of the pH (acidity or alkalinity). Your county cooperative extension offices can provide more information about how to conduct soil testing. The N.C. Department of Agriculture and Consumer Services provides free soil testing and improvement recommendations.
- Organic matter such as compost, mulch or manure increases the water holding capacity of soil and can help improve water distribution.
- When improving the soil of a given area, it is important to treat a large area around the planting to allow ample space for root systems.
- Do not allow heavy construction equipment to compact soil around existing trees or other sensitive natural areas.



(C) Proper Plant Selection

- The selection of native species can greatly reduce maintenance costs.
- Consider plants' water demand, pest tolerance, soil nutrient and drainage requirements.
- Native species are adapted to work together in similar soils and benefit each other's growth by forming symbiotic relationships.

(D) Practical Turf Areas

- Turfgrass has the highest water consumption of any plant group. Typically, turf in North Carolina requires one inch of water per week.
- Plant grass only where it will provide optimal functional and aesthetic benefits.
- Avoid very small turf areas under 10 feet wide.
- Proper watering of turf (less frequent and deeper vs. frequent and light watering) will promote deep root development, which will make the turf more drought resistant.
- Turfgrass should be cut to the maximum recommended height for its type, generally a minimum of two inches to a maximum of four inches for optimum water use.
- Whenever possible, plant alternative groundcovers that require less water, or consider the use of patios and decks, further reducing water demand.

(E) Efficient Irrigation

- The proper design, installation and maintenance of both the irrigation system and the landscape will lead to efficient irrigation. No amount of good maintenance can overcome the inefficiencies of poor design.
- Additional irrigation will be needed on newer transplanted landscapes.
- Automatic controllers are a cost-effective time-based method to save labor and consistently deliver water. It is important to adjust controllers regularly for weather changes and plant growth.
- Drip irrigation and microsprays place water at the base of the plant. This reduces evaporation and saves water by not wetting the entire ground surface. This technique is good for trees, shrubs and ground covers.
- Uniformity of the water being applied by the irrigation system is the key ingredient in irrigation efficiency. Sprinkler uniformity is affected by the operating pressure, the nozzle used and the sprinkler spacing, as well as external forces such as wind.
- Plants transpire moisture through their leaves and the soil allows water to evaporate into the air. This condition is called evapotranspiration. Replacing the plant's ET will allow the plant to thrive. Rain will replace some of the moisture, irrigation will do the rest. Tenisometers measure soil moisture in a plant's root system. The measurement is very close to ET and a practice tool to use when needing to know how much irrigation is necessary.
- Rain shut-off devices on automatic systems cut off the power to the controller during rain events and won't allow the system to operate until the unit has dried out and irrigation may be needed again.
- Overspray that covers concrete or other impervious areas can waste water by running off the property.

- Over-watering landscapes is a more common problem than under-watering. People tend to think that if a little is good, a lot is even better.

(F) Use Mulches

Mulches are various organic materials, such as pine/oak bark, pine straw, aged wood chips and compost mixtures that are placed around the root zone of a plant.

- The use of mulches around planting is highly effective in retaining soil moisture and reducing the need for watering and maintenance.
- Three to five inches of mulch reduces the level of evaporation from the soil, insulates root systems from heat and limits the germination of weeds around beds and flora.
- Fine textured mulches help retain more moisture than coarse mulches.

(G) Proper Maintenance

The most crucial element in sustaining water efficiency in any landscape site is ensuring that a regular maintenance schedule is met. Attention to the landscape and irrigation system at regular time intervals will lower the cost of maintenance, and increase the effectiveness of water for landscaping.

- Mow grass at a proper height. No more than one-third of the leaf blade should be removed during mowing.
- Regular aeration of clay soils will improve water holding capabilities and prevent runoff.
- Monitor irrigation schedules to replace evapotranspiration.
- Analyze the soil several times during the season to be sure nutrient levels are maintained.
- Inspect, adjust and replace sprinkers, filters, valves and emission devices for proper operation once a month.

Xeriscape, Water-Wise, Water-Smart or Low-Water Landscapes

All of these words are used to describe a plan for landscapes that seek to use native plants or low-water use plants to reduce water demand, lower maintenance requirements with little or no reliance on lawn and garden chemicals. Xeriscape, from the Greek word Xeros, which means to dry, originated in Denver in the early 80s. The concept is valid in the humid east, but the word Xeriscape has a more western connotation; therefore, water-wise, water-smart or low-water are synonymous words used in North Carolina. The planning principles mentioned in this chapter are the foundation of a water-wise landscape.

CASE STUDY

Planning Receives Recognition

The town of Cary has received national recognition for its water conservation activities. The town has done comprehensive water planning to map its future requirements. It has set up public education programs, school lessons aimed at teaching children about water conservation and a local block leader program that gets the whole community involved. Cary has instituted a permanent alternative day watering ordinance, a water waste ordinance and passed a rain sensor ordinance. This central North Carolina town was one of the first to offer reclaimed water for outdoor irrigation uses and now has 10.4 miles of dedicated distribution lines providing 176,000 gallons per day for this purpose. Conservation pricing in its water rates and irrigation system audits are also some of the tools the town used to reduce water consumption. Cary's active leadership is viewed as a model for North Carolina local governments.

Benefits

Benefits of ecologically-based, water-conserving landscapes include:

- Reduced off-site water consumption.
- Lower HVAC requirements.
- Provision for pedestrian movement and habitat needs.
- Maintained nutrients on site.
- Lower energy use and pollution.
- Reduced water pumping and water treatment.
- Lessened runoff of stormwater and irrigation water.
- Lower maintenance and labor costs.
- Increased quality of landscape and surrounding habitat.

Tips For Existing Landscapes

Practical steps can be taken to reduce water use and improve plant conditions in mature landscapes with a little effort and attention to detail. Managing an irrigation system is much like the management of other mechanical devices. Proper settings, operation and maintenance equate to proper results. Understanding the system is the first step. Locate the original design of the system and check it against the system that is actually on the property. Significant changes may have been made over the years to the facilities that make what was originally installed much less efficient. Outside professional assistance may be warranted in this review stage. The Irrigation Association tests and certifies individuals in various specialties such as design, contracting, water management and system auditing. North Carolina individuals with these certifications can be located on the association's Web site at http://www.irrigation.org.

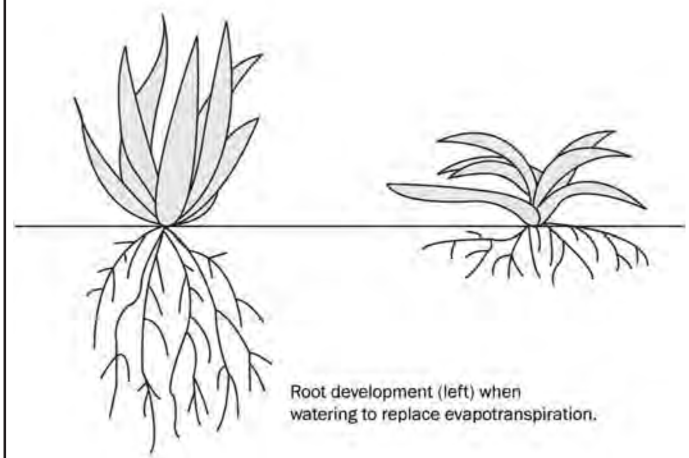
How to Water

- Water in the early morning or late evening to maximize absorption and minimize evaporation
- Water only when wind is less than 10 miles an hour.
- Peak water demand occurs with summer temperatures and plant demand is much lower in the spring and fall seasons.
- Be sure irrigation system is balanced, especially in turf areas. A balanced or matched system provides the same precipitation rate whether using a quarter

inch circle pop-up spray head or a full circle rotor type sprinkler. There is an old adage that everyone waters to take care of the dry spot. If the system is in balance no dry spots appear and the balance, of the turf is not over-watered.

- Use evapotranspiration data to help determine the plant's water needs. N.C. State University's Web site "Turfgrass Irrigation Management System," provides information about ET demand and the irrigation requirements of N.C. turfgrasses (http://www.TurfFiles.ncsu.edu/TIMS).
- Measure the amount of rainfall at various locations throughout the facility. Maintain a record of this rainfall and adjust the operating time of the irrigation system to replace the ET minus the weekly rainfall. This is sometimes called the "checkbook" method.
- Alternatively, use tensiometers which measure soil moisture; set the controller to replace the water needed to bring the tensiometer gauge to "moist."
- Water once or twice a week using an automatic sprinkler system. Drip irrigation requires more frequent longer duration runs.
- Note any areas where the sprinklers are over-spraying buildings, sidewalks or pavement and adjust the spray pattern to avoid these areas. A system that was poorly designed initially will immediately give itself away by watering hardscape areas.

FIGURE 4-15



Root development (left) when watering to replace evapotranspiration.

Amount of Water Plants Require

- Use evapotranspiration data to help determine a plant's water needs.
- Water deeply once or twice a week instead of lightly every day. *(See Figure 4-15.)*
- To prevent runoff or deep percolation below the roots, never apply water faster than the soil can take it in or more than the soil can hold. *(See Figure 4-16, next page.)*
- Assess the characteristics of a site through a water audit. Audits evaluate the specific water needs and conditions of an existing site.
- Consider that every square foot of watershed hardscape can shed more than 25 gallons of irrigation water every year.

Check Out These N.C.-based Landscaping Links

Going Native: Urban Landscaping for Wildlife with Native Plants - http://www.ncsu.edu/goingnative/index.html

TurfFiles - http://www.turffiles.ncsu.edu/Default.aspx

Industrial/Commercial Horticultural Information Leaflets - http://www.ces.ncsu.edu/depts/hort/hil/landscape-index.html

FIGURE 4-16

Maximum Sprinkler Run Time
Minutes Per Application

Soil Type	Sprinkler Type Spray	Rotor
Sand	15 to 20	45 to 60
Loam	10 to 15	30 to 45
Clay	7 to 10	20 to 30

System Maintenance Considerations

- Use the same size nozzle when replacement is needed.
- Replace sprinklers with the same brand of sprinklers. Spray heads should not operate on the same valve with rotors.
- Ensure spray heads are aligned with grade.
- Replace worn spray nozzles.
- Regulate pressure properly for system demands.
- Many times a rotor or spray head will be mounted incorrectly in an attempt to cover a greater area. Replace with proper unit for the job.
- Post the current controller schedule inside the door of the controller.
- Check for leaking valves.
- Inspect low-volume emitters for any stoppage.
- Inspect sprinklers for clogged nozzles which distort the spray pattern.
- Adjust sprinklers to water plant material and not sidewalks or roads.
- Adjust the operating time (runtimes) of the sprinklers to match the seasonal or monthly requirements.
- Monitor plant leaves and take soil samples to confirm proper system operation.

Irrigation System Operations

- Consider adding a rain shutoff device to your automatic irrigation control system.
- Consider alternative sources for irrigation water, including the use of wells as opposed to city water, water reuse options from air conditioning condensate, storm water retention ponds, cisterns or non-contact cooling water.
- Reclaimed water from the local water treatment facility may be available for use at a lower cost.
- Use electronic controllers with precise timing, multiple irrigation zones, multiple cycles and attached rain shut-off devices.
- Incorporate separate irrigation zones for all irrigated plant hydrozones, and use separate irrigation zones for turf areas.
- Use dedicated water meters for landscaping water use.
- Use drip or other low volume irrigation wherever possible.
- Have a catchment, or distribution uniformity, test performed on-site to determine how evenly water is applied when sprinklers are in use.

Water Supply Expectations

Most landscape irrigation systems use potable water supplied by the local water purveyor. These firms are in the conflicting business of selling water and sheparding local water resources at the same time. When dry periods occur and demand accelerates, the water purveyors must limit access to their finite resource. Most have policies in effect as to what steps will take place in water-short periods. These policies may include limiting outdoor watering to certain days a week, increasing rates on high water users or barring outdoor water use altogether. It is important to know what to

Untreated Gray Water

The North Carolina Plumbing Code defines gray water as "waste discharged from lavatories, bathtubs, showers, clothes washers, and laundry sinks." The disposal of sewage/wastewater is regulated by North Carolina law, which can be found online at http://www.deh.enr.state.nc.us/osww_new/new1//images/Rules/1900RulesJune2006.pdf.

15NCAC 18A.1935 Definitions: "Sewage" means the liquid and solid human waste and liquid waste generated by water-using fixtures and appliances, including those associated with food handling. The term does not include industrial process wastewater or sewage that is combined with industrial wastewater.

expect in a drought emergency, so check with your local water purveyor to see what plans it has in place.

Many jurisdictions can provide reclaimed water (treated effluent water suitable for plants) that can be obtained through a contract with the purveyor. Separate pipelines are needed to get this water to your facility and this infrastructure problem may be the prime obstacle. If reclaimed water is available, it is generally lower cost and available in periods of water stress.

Water Efficient Technologies

Automatic Irrigation Timer

A simple-to-operate automatic timer or controller can be installed on an existing manual irrigation system. The controller automatically will operate the sprinklers on the proper day of the week for the correct amount of run time. This will meet the plant's water needs as well as apply the water in off-peak night or early morning hours. More elaborate controllers offer extra flexibility to manage larger sites with many different hydrozones and site conditions. Any controller can use a rain or soil moisture sensor to prevent the sprinklers from operating when natural precipitation has met the plants' water needs.

"Smart" Controllers

A new class of "smart" controllers is now available on the market. Unlike traditional controllers, which are really just timers, "smart" controllers work by monitoring and using information about site conditions (such as soil moisture, rain, wind, slope, soil, plant type and more), and applying the right amount of water based on those factors. These climate based "smart" controllers are avialable from many manufacturers and the irrigation industry has created an evaluation program to set standards of performance for this class of product.

CASE STUDY

Rainwater Cisterns

UNC-Chapel Hill installed a 70,000-gallon underground cistern and gravel storage field at a sports field on campus. The cistern system captures rainwater from the roofs of nearby buildings, and stores the water until it is used to irrigate the field. Various other cistern systems on UNC-CH's campus, can be used for both irrigation and flushing toilets.

Centralized Irrigation Controllers

To manage many irrigation controllers spread out among many sites, a centralized control system will save labor costs as well as increase water efficiencies. A typical central irrigation control system utilizes a computer to create, adjust and save irrigation schedules for multiple controllers at various locations. The computer then communicates to the controllers by radio, hardwire, telephone or a combination of two or more methods. A computer-central system can also monitor and react to different alarm situations like broken heads or pipes, valve malfunctions or many other water-saving sensors.

A central control system does not relieve the water manager from monitoring and adjusting the equipment. It allows them to quickly adjust multiple controllers to the monthly or daily changes in conditions that affect the water needs of the plants. These units can be economically justified for larger and multiple site operations.

PC Software

Software programs have been developed to assist the designer and water manager in the analysis of the efficiency of an existing or newly-designed irrigation system. Two of the primary programs were developed by the Center for Irrigation Technology at California State University, Fresno. The program used to generate graphic representations of sprinkler efficiencies is called *Hyper-SPACE*™. The software that analyzes the costs versus the benefits of improving irrigation efficiencies is called *SPACE Irrigation Survey*™. Many certified water auditors and certified irrigation designers use these software programs extensively.

New Sprinkler Type

Install a multi-trajectory rotating stream sprinkler with high application uniformity. This friction resistance head operates at lower pressures and fills the product range between spray heads and rotors.

CASE STUDY

Wastewater Reuse

Aurora, Colo., eliminated more than one billion gallons of water needs by the construction of a wastewater reclaimed system that uses industrial wastewater for irrigation.

Flow Control Nozzles

Sprinklers with a uniform application rate that use the lowest possible water pressure are the goal. One method that helps achieve this goal is the use of flow-control nozzles. Each sprinkler nozzle is equipped with a flow-control device that compensates for flow changes and maintains a uniform pressure. This can be a desirable feature on slopes. The flow control also acts to reduce flow should a sprinkler head be broken.

Sensors

Several types of sensors are available that take the human factor out of irrigation system operation.

- Rain shut-offs
- Freeze sensors
- Wind sensors
- Flow sensors
- Soil moisture measurement
- Weather stations

Rain shut-offs have the single largest impact on water savings in automatic irrigation. North Carolina has regular and balanced rains, making this sensor a valuable tool as it cuts off the controller when a pre-set rain level is reached. When the weather conditions dry out, the rain shut-off allows the controller to resume normal operation without affecting the programming of the controller.

Freeze sensors are specialized sensors that stop all irrigation when a pre-set temperature is reached.

Wind sensors cut off irrigation as wind velocities reach certain levels. This sensor would be most commonly used in coastal areas or where wind velocities vary throughout the growing season.

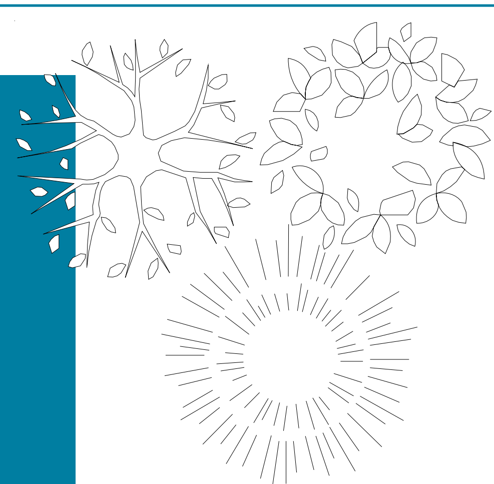
Flow sensors respond to high flow situations caused by broken sprinkler heads or a pipeline break. The sensor shuts off the irrigation until repairs can be made. This is especially important on hillsides that could wash away.

Soil moisture measurement sensors are devices that measure soil/water tension and function as an artificial root. These devices can use various methods to report soil moisture, including tensiometers, gypsum blocks and electrical resistance devices. All are designed to signal when there is not enough moisture in the root zone of a plant. The sensors can activate a control device such as a valve or controller to turn on.

Weather stations that are situated at a facility include all of the sensors mentioned plus data logging of weather conditions at the site. On-site weather stations can record and advise "smart" controllers about real time local conditions.

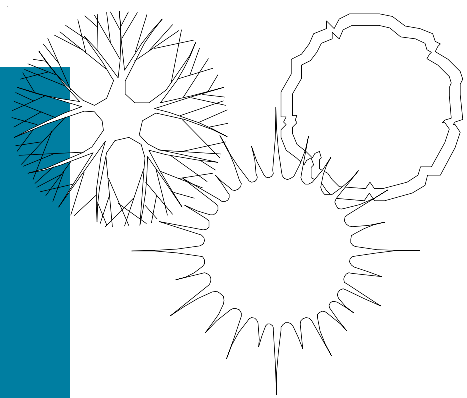
Water-Efficient Plants

A major factor of water-efficient landscapes is the selection of plants. Plants' watering needs are divided by hydrozones. The use of drought-tolerant and native plants not only minimizes runoff concerns, but also can strategically make the most use of rainfall patterns. In addition to the lists of drought-tolerant plants (*see next two pages*), the N.C. Cooperative Extension Service can provide further information and assistance for selecting water-efficient plants.



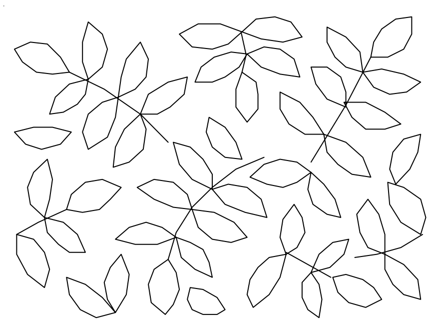
TREES

Common Name	*Botanical Name*
Lacebark elm	*Ulmus parvifolia*
Japanese zelkova	*Zelkova serrata*
Tulip poplar	*Liriodendron tulipfera*
Sycamore	*Platanus occidentalis*
Laurel oak	*Quercus lauifolia*
Live oak	*Quercus virginiana*
Pin oak	*Quercus palustris*
White oak	*Quercus alba*
Crepe myrtle	*Lagerstroemia indica*
Hollies	*Ilex spp.*
Chaste tree	*Vitex agnus-castus*
Sweet gum	*Liquidambar styraciflua*



SHRUBS

Common Name	Botanical Name
Chinese photinia	Photinia serrulata
Elaeagnus	Elaeagnus
Firethorn (pyracantha)	Pyracantha coccinea
Japanese privet	Ligustrum japonicum
Junipers	Juniperus spp.
Yaupon holly	Ilex vomitoria
Mahonia	Mahonia spp.
Nandina	Nandina domestica
Chinese holly	Ilex cornuta
Strawberry bush	Euonymus americana
Forsythia	Forsythia intermedia
Barberry	Berberis spp.
Quince	Chaenomeles japonica
Viburnum	Viburnum spp.
Euonymus	Euonymus spp.
Spirea	Spirea spp.
Glossy abelia	Abelia grandiflora
Jasmine	Jasminum spp.

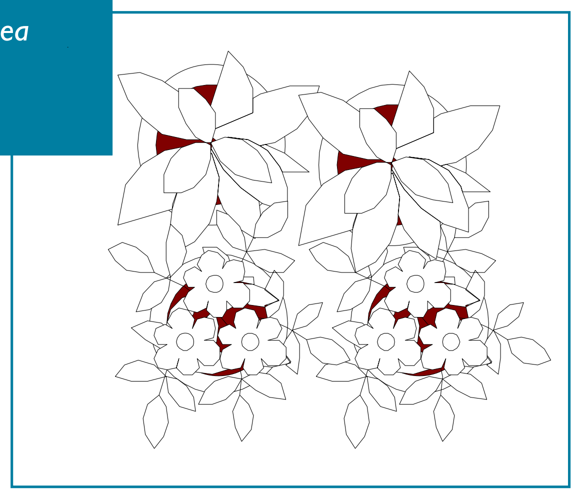


GROUND COVERS/VINES

Common Name	Botanical Name
Mondograss	Ohpiopogon japonicus
Liriope	Liriope spp.
Junipers	Juniperus spp.
Thrift	Phlox subulata
English ivy	Hedera helix
Clematis	Clematis spp.
Trumpet honey suckle	Lonicera sempervirens
Wisteria	Wisteria spp.
Wintercreeper	Euonymus fortunei
Periwinkle	Vinca spp.

ANNUALS & PERENNIALS

Common Name	Botanical Name
Gazania	Gazania rigens
Annual vinca	Catharathus roseus
Annual phlox	Phlox drummondii
Baby's breath	Gypsophila spp.
Black-eyed Susan	Rudbeckia spp.
Coreopsis	Coreopsis spp.
Cape marigold	Dimorphotheca sinuata
Cornflower	Centaurea cyanus
Cosmos	Cosmos spp.
Globe amaranth	Gomphrena globosa
Moss rose	Portulaca grandiflora
Straw flower	Helichrysum bacteatum
Verbena	Verbena spp.
Butterfly weed	Asclepias tuberosa
Gaillardia	Gaillardia x grandiflora
Goldenrod	Solidago hybrids
Liatris	Liatris spp.
Purple coneflower	Echineacea purpurea
Sedum	Sedum spp.
Stokes' aster	Stokesia cyanea



5 Industry Specific Processes

Textiles

Food & Beverage

Metal Finishing

TEXTILES*

FIGURE 5-1

Water Use in Textile Procesing

Processing Subcategory	Water Use Minimum, gal/lb of production	Water Use Median, gal/lb of production	Water Use Maximum, gal/lb of production
Wool	13.3	34.1	78.9
Woven	0.6	13.6	60.9
Knit	2.4	10.0	45.2
Carpet	1.0	5.6	19.5
Stock/Yarn	0.4	12.0	66.9
Nonwoven	0.3	4.8	9.9
Felted Fabrics	4.0	25.5	111.8

*Excerpts from "Best Management Practices for Pollution Prevention in the Textile Industry," EPA, 1996.

Water Consumption in Textiles

Water is used extensively throughout textile processing operations. Almost all dyes, specialty chemicals and finishing chemicals are applied to textile substrates from water baths. Most fabric preparation steps, including desizing, scouring, bleaching and mercerizing, use aqueous systems. In addition, there are many washing steps in textile manufacturing.

The amount of water used varies widely in the industry, depending on the specific processes operated at the mill, the equipment used and the prevailing management philosophy concerning water use. Reducing water consumption in textile processing is important for furthering pollution prevention efforts, in part because excess water use dilutes pollutants and adds to the effluent load.

Mills that currently use excessive quantities of water can achieve large gains from pollution prevention. A reduction in water use of 10 to 30 percent can usually be accomplished by taking fairly simple measures. A walk-through audit can uncover water waste in the form of:

- Hoses left running.
- Broken or missing valves.
- Excessive water use in washing operations.
- Leaks from pipes, joints, valves and pumps.
- Cooling water or wash boxes left running when machinery is shut down.
- Defective toilets and water coolers.

In addition, many less obvious causes of water waste exist. These causes are presented below by subcategory, unit process and machine type.

Subcategory

Textile operations vary greatly in water consumption. Figure 5-1 summarizes the water consumption ranges observed in an extensive study of various types of operations. Wool and felted fabrics processes are more water intensive than other processing subcategories such as wovens, knits, stock and carpet.

Water use can vary widely between similar operations as well. For example, knit mills average 10 gallons of water per pound of production, yet water use ranges from a low of 2.5 gallons to a high of 45.2 gallons. These data serve as a good benchmark for determining whether water use in a particular mill is excessive.

Unit Process

Water consumption varies greatly among unit processes, as indicated in Figure 5-2. Certain dyeing processes and print after-washing are among the more intensive unit processes. Within the dye category, certain unit processes are particularly low in water consumption (e.g., pad-batch).

Machine Type

Different types of processing machinery use different amounts of water, particularly in relation to the bath ratio in dyeing processes (the ratio of the mass of water in an exhaust dyebath to the mass of fabric). Washing fabric consumes greater quantities of water than dyeing. Water consumption of a batch processing machine depends on its bath ratio and also on mechanical factors such as agitation, mixing, bath and fabric turnover rate (called contact), turbulence and other mechanical considerations, as well as physical flow characteristics involved in washing operations. These factors all affect washing efficiency.

In general, the major energy uses in dyeing are (1) preparation of fabric for dyeing (wash-

FIGURE 5-2

Water Consumption by Unit Process

Processing Subcategory	Water Consumption, gal/lb of Production
Yarn & fabric forming	Nil
Slashing	0.06 to 0.94
Preparation	
Singeing	Nil
Desizing	0.3 to 2.4
Scouring	2.3 to 5.1
Continuous bleaching	0.3 to 14.9
Mercerizing	0.12
Dyeing	
Beam	20
Beck	28
Jet	24
Jig	12
Paddle	35
Skein	30
Stock	20
Pad-batch	2
Package	22
Continuous bleaching	20
Indigo dyeing	1 to 6
Printing	3
Print afterwashing	13.2
Finishing	
Chemical	0.6
Mechanical	Nil

ing, bleaching, etc.), (2) heating dyebaths and wash water, and (3) drying goods after dyeing. Therefore, low bath-ratio dyeing equipment not only conserves water but also saves energy, in addition to reducing steam use and air pollution from boilers. Low-bath-ratio dyeing machines conserve chemicals as well as water and also achieve higher fixation efficiency. But the washing efficiency of some types of low-bath-ratio dyeing machines, such as jigs, is inherently poor; therefore, a correlation between bath ratio and total water use is not always exact.

FIGURE 5-3

Water Consumption for a Typical Bleach Range

Stage	Water, gph	Percent
Saturators	550	5
Steamer and J Boxes	150	1.4
Washers		
Desize	3,700	33.5
Scour	3,100	28.1
Bleach	3,100	28.1
Dry Cans	450	4.1
TOTAL	11,050	100

Reusing Non-process Cooling Water

Perhaps the easiest of all water recycle activities is to plumb the once-through non-contact cooling water back to the clean well (or water influent). This water requires little or no treatment as it's not contaminated from process chemicals. Also, be sure to stop the cooling water when the machine is stopped and to limit the amount of cooling water when the machine is on. It is very common to find water-cooled bearings, heat exchangers, etc.with very excessive flow rates.

Process Water Conservation

Washing

Washing and rinsing operations are two of the most common operations in textile manufacturing that have significant potential for pollution prevention. Many processes involve washing and rinsing stages, and optimizing wash processes can conserve significant amounts of water. In some cases, careful auditing and implementation of controls can achieve wastewater reductions of up to 70 percent. The washing and rinsing stages of preparation typically require more water than the other stages (e.g., bleaching, dyeing). Several typical washing and rinsing processes include:

- Drop and fill batch washing.
- Overflow batch washing.
- Continuous washing (countercurrent, horizontal or inclined washers).

A report on water consumption for a typical continuous bleach range found that consumption was more than 11,000 gallons per hour, or 270,000 gallons per day *(see Figure 5-3)*. Washing stages accounted for 9,900 gallons per hour, or 90 percent of the total. The application of the following simple, low-technology methods of water conservation reduced water use:

- Properly regulating flows: 300 gallons per hour savings.
- Counterflowing bleach to scour: 3,000 gallons per hour savings.
- Counterflowing scour to desize: 3,000 gallons per hour savings.
- Shut off water flow when machine is stopped.

The total water savings without process modification was 150,000 gallons per day, or 55 percent of water use. A process modification such as a combined one-stage bleach and scour also would save 6,200 gallons of water per hour, or an additional 150,000 gallons per day, along with energy savings.

One of the critical points in water conservation for washing processes is stopping the process at the appropriate time. Factories often have very specific procedures for dyeing processes but vague specifications for washing. In addition, washing processes are often excessively long to ensure completeness. This ensures that the darkest shades are adequately washed, but may result in excessive water and energy use for lighter shades that do not require extended washing.

Drop-Fill Vs. Overflow Washing

In the drop/fill method of batch washing, spent wash water is drained and the machine is refilled with a fresh wash bath. The fabric or other substrate in the machine retains much of the previous bath, perhaps as much as 350 percent onweight of goods. This percentage can be reduced by mechanical means (e.g., extraction, blowdown). Comparison of several methods of washing after bleaching shows the benefits of countercurrent wash methods (*see Figure 5-4*). Methods five and six, which implement countercurrent washing, produce savings of 26 and 53 percent compared with the standard drop/fill method. These results are based on comparisons of washing processes that would produce the same degree of reduction of fabric impurities using computer models.

FIGURE 5-4

Water Use in Batch Washing

Process Description	Bath Ratio	Water Use, gal/lb	Percent Change from Standard
1. Standard - 3 step drop/fill	1:8	1.62	--
2. Reduced bath - 7 step drip/fill	1:5	1.26	-22.2
3. Continuous overflow	1:8	2.38	46.9
4. Continuous overflow - reduced bath	1:5	1.49	-8
5. 3 step drop/fill, reuse bath 2	1:8	1.19	-26.5
6. 3 step, reuse baths 2 and 3	1:8	0.75	-53.7

Countercurrent washing processes require the addition of holding tanks and pumps. The capital cost of setting up such a reuse system typically is less than $50,000 and generates estimated savings of $95,000 annually. In many cases, reducing wastewater also reduces the need for expensive waste treatment systems.

Reusing Wash Water

Many strategies can be applied for reusing wash water. Three of the most common strategies are countercurrent washing, reducing carryover and reusing wash water for cleaning purposes.

Countercurrent Washing

The countercurrent washing method is relatively straightforward and inexpensive to use in multistage washing processes. Basically, the least contaminated water from the final wash is reused for the next-to-last wash and so on until the water reaches the first wash stage, after which it is discharged. This technique is useful for washing after continuous dyeing, printing, desizing, scouring or bleaching.

An important variant of the countercurrent principle is "horizontal" or "inclined" washers. Horizontal or inclined washing is more efficient because of the inherent countercurrent nature of water flow within the process. The mechanical construction of an inclined or horizontal countercurrent washer has to be much better than a traditional vertical washer, however.

Sloppy roll settings, weak or undersized rolls, unevenness, bends, bows, biases, bearing play or other misalignments within the machine are much more important in a horizontal or inclined washer because the weight of water pressing down on the fabric can cause it to sag, balloon or stretch. If properly constructed and maintained, horizontal or inclined washers can produce high quality fabrics while saving money and water.

Reducing Carryover

Because the purpose of washing is to reduce the amount of impurities in the substrate, as much water as possible must be removed between sequential washing steps in multistage washing operations. Water containing contaminants that are not removed is "carried over" into the next step, contributing to washing inefficiency.

Proper draining in batch drop/fill washing and proper extraction between steps in the continuous washing process are important. Often, 350 percent on weight of goods is carried over in typical drop/fill procedures. This amount can be reduced in some batch machines (e.g., yarn package dyeing, stock dyeing) by using compressed air or vacuum blowdown between washing steps.

In continuous washing operations, squeeze rolls or vacuum extractors typically extract water between steps. Equipment employing vacuum technology to reduce dragout and carryover of chemical solutions with cloth, stock or yarn is used to increase washing efficiency in multistage washing operations.

In one case history, a processor installed vacuum slots after each wash box in an existing multistage continuous washing line and was able to reduce the number of boxes from eight to three. Wash boxes with built-in vacuum extractors are available for purchase, as well as washers for prints that combine successive spray and vacuum slots without any bath for the fabric to pass through. Because the fabric is never submerged, bleeding, marking off and staining of grounds is minimized, and water use decreases.

Another washer configuration with internal recycling capabilities is the vertical counterflow washer, which sprays recirculated water onto the fabric and uses rollers to squeeze waste through the fabric into a sump, where it is filtered and recirculated. The filter is unique, consisting of continuous loops of polyester fabric that rotate continuously and are cleaned of filtrate at one end with a spray of clean water. This construction allows for maximum removal of suspended solids from water before discharge or reuse in another process. High-efficiency washing with low water-use results. Energy use decreases greatly because less water must be heated.

Reuse for Cleaning Purposes

In many types of operations, washwater can be reused for cleaning purposes. In printing, cleanup activities can be performed with used washwater, including:

- Backgray blanket washing.
- Screen and squeegee cleaning.
- Color shop cleanup.
- Equipment and facility cleaning.

A typical preparation department may also reuse wash water as follows:

- Reuse scour rinses for desizing.
- Reuse mercerizer washwater for scouring.
- Reuse bleach washwater for scouring.
- Reuse water-jet loom washwater for desizing.
- Recycle kier drains to saturator.

Work Practices

Workers can greatly influence water use. Sloppy chemical handling and poor housekeeping can result in excessive cleanup. Poor scheduling and mix planning also can require excessive cleanup and lead to unnecessary cleaning of equipment like machines and mix tanks. Leaks and spills should be reported and repaired promptly. Equipment maintenance, especially maintenance of washing equipment, is essential. Inappropriate work practices waste significant amounts of water; and good procedures and training are important. When operations are controlled manually, an operations audit checklist is helpful for operator reference, training and retraining.

In one case history, a knitting mill experienced excessive water use on beck dyeing machines. A study of operating practices revealed that each operator was filling the machines to a different level. Some operators filled the becks to a depth of 16 inches, others as much as 24 inches. Also, the amount of water used for washing varied. Some operators used an overflow procedure, and others used drop/fill or “half baths” (repeatedly draining half of the bath, then refilling it).

Inspection of the written procedures showed that the fill step simply said “fill.” The wash step simply said “wash.” Without training and without a specific operating procedure, operators were left to determine water use on their own. This case may seem extreme, but even the best mills, which have well-documented production procedures, often do not have documented cleaning procedures. Cleaning operations that contribute large amounts of pollution to the total waste stream include machine cleaning, screen and squeegee cleaning and drum washing.

Engineering Controls

Every mill should have moveable water meters that can be installed on individual machines to document water use and evaluate improvements. In practice, mills rarely measure water use but rely on manufacturers’ claims concerning equipment and water use. The manufacturers’ estimates are useful starting points for evaluating water consumption, but the actual performance of equipment depends on the chemical system used and the substrate. Therefore, water use is situation-specific and should be measured on-site for accurate results. The water meters should be regularly maintained and calibrated.

Other important engineering controls, some of which have been discussed in other sections of this chapter, include:

- Flow control on washers.

- Flow control on cooling water (use minimum necessary).
- Countercurrent washing.
- High extraction to reduce dragout.
- Recycle and reuse.
- Detection and repair of leaks.
- Detection and repair of defective toilets and water coolers.

Machinery should be inspected and improved where possible to facilitate cleaning and to reduce susceptibility to fouling. Bath ratios sometimes can be reduced by using displacers that result in lower chemical requirements for pH control as well as lower water use.

Process Changes

Pad-Batch Dyeing

In pad-batch dyeing, prepared fabric is padded with a solution of fiber reactive dyestuff and alkali, then stored (or batched) on rolls or in boxes and covered with plastic film to prevent evaporation of water or absorption of carbon dioxide from the air. The fabric then is batched for two to 12 hours. Washing can be done on whatever equipment is available in the mill.

Pad-batch dyeing offers several significant advantages, primarily cost and waste reduction, simplicity and speed. Production of between 75 and 150 yards per minute, depending on the construction and weight of the goods involved, is common. Also, pad-batch dyeing is flexible compared with a continuous range. Either wovens or knits can be dyed in many constructions. Frequent changes of shade present no problems because reactives remain water soluble, making cleanup easy. This method of dyeing is useful when versatility is required. Water use typically decreases from 17 gallons per pound to 1.5 gallons per pound, a reduction of more than 90 percent.

Processing Bath Reuse

Water from many processes can be renovated for reuse by a variety of methods. Several research efforts are underway. In a few operations, up to 50 percent of the treated wastewater is recycled directly back from the effluent to the raw-water intake system with no adverse effects on production. In some cases, specific types of wastewater can be recycled within a process or department. Examples are dyebath reuse, bleach bath reuse, final rinse reuse as a loading bath for the next lot, washwater reuse, countercurrent washing and reuse for other purposes.

Bleach Bath Reuse

Cotton and cotton blend preparation (e.g., desizing, scouring, bleaching) are performed using continuous or batch processes and usually are the largest water consumers in a mill. Continuous processes are much easier to adapt to wastewater recycling/reuse because the wastestream is continuous, shows fairly constant characteristics and usually is easy to segregate from other waste streams.

Waste-stream reuse in a typical bleach unit for polyester/cotton and 100 percent cotton fabrics would include:

- Recycling J-box and kier drain wastewater to saturators.
- Using countercurrent washing.
- Recycling continuous scour washwater to batch scouring.
- Recycling washwater to backgray blanket washing.
- Recycling washwater to screen and squeegee cleaning.
- Recycling washwater to color shop cleanup.
- Recycling washwater to equipment and facility cleaning.
- Reusing scour rinses for desizing.
- Reusing mercerizer washwater for scouring.

Preparation chemicals (including optical brighteners and tints), however, must be selected in such a way that reuse does not create quality problems such as spotting. Batch scouring and bleaching are less easy to adapt to recycling of waste streams because streams occur intermittently, drains generally go into pits and are not easily segregated and batch preparation steps frequently are combined. With appropriate holding tanks, however, bleach bath reuse can be practiced in a similar manner to dyebath reuse, and several pieces of equipment are now available that have the necessary holding tanks. The spent bleach bath contains all of the alkali and heat necessary for the next bleaching operation. Peroxide and chelates must be added to reconstitute the bath. Like dyebath reuse, the number of reuse cycles in bleach bath reuse is limited by impurity buildup. The main impurities are metals, such as iron, that can interfere with the bleaching reaction.

New types of rope bleaching units for knits featuring six to 12-stage jet transport systems have made continuous bleaching of most knit styles possible. These units were introduced in the late 1970s and typically produce 40 pounds per minute of knit fabric or more than one million pounds per month based on a three-shift, six-day operation. These machines have become very popular with large knit processors because of their flexibility and ability to conserve energy, water and chemicals. They also have complete built-in countercurrent capabilities. These units are being promoted for use in afterwashing fiber reactive and other types of dyes (e.g., after pad-batch dyeing) in addition to use as continuous knit preparation ranges.

Final Rinse Reuse as Loading Bath for Next Lot

One simple technique that saves water and, in some cases, biological oxygen demand loading is to reuse the final bath from one dyeing cycle to load the next lot. This technique works well in situations where the same shade is being repeated or where the dyeing machine is fairly clean.

A good example of this technique is acid dyeing of nylon hosiery. The final bath usually contains an emulsified softener that exhausts onto the substrate, leaving the emulsifier in the bath. This technique can serve as the wetting agent for loading the next batch, thus saving the water, heat, wetting agent and associated BOD.

FOOD & BEVERAGE

Water Conservation Techniques

In the food and beverage industry, water plays a significant role in transporting, cleaning, processing and formulating products, as well as in meeting many federal sanitary standards. Facilities implementing water conservation programs sometimes struggle to balance these needs with the many benefits of reducing water usage. The following section discusses the methods and techniques that many facilities have used to implement successful water conservation programs while maintaining production requirements.

For general rinsing and cleaning operations, refer to Chapter 4 on cleaning, rinsing and in-process water reuse. Several opportunities in the beverage industry include:

- Adjust pumped cooling and flushing water to the minimum required.
- Investigate potentially reusable discharges, including final rinses from tank cleaning, keg washes and fermenters; bottle and can soak and rinse water; cooler flushwater; filter backwash; and pasteurizer and sterilizer water, as well as cooler water. Measure these uses to get a baseline inventory for monitoring.
- Potential areas for reuse include first rinses in wash cycles; can shredder; bottle crusher; filter backflush; caustic dilution; boiler make-up; refrigeration equipment defrost; and floor and gutter wash. Cooler water can be retreated and reused in many instances.

Several opportunities in the food industry include:

- Rechlorinate and recycle transport water where feasible.
- Use conveyor belts for product transport. Preference should be given to "rabbit-ear" or V-shaped roller supports because these are much easier to clean.
- Use pneumatic conveying systems where practical.
- Use flumes with parabolic cross-sections rather than flat bottom troughs.
- Consider these alternatives to water-intensive units: 1) rubber-disc scrubbing units vs. raw product cleaning and peeling; 2) steam rather than water blanchers, or 3) evaporative coolers rather than water-cooled systems.
- Establish optimum depth of product on conveyors to maximize wash water efficiency.
- Optimize nozzle size and pressure.
- Change eroded and non-functional nozzles.
- Divide spray wash units into two or more sections, and establish a counterflow reuse system.
- Control belt sprays with a timer to allow for intermittent application of chlorinated water.
- Consider soaking units where indicated.

Figure 5-5 provides a listing of potential reuse areas for specified canning operations.

CASE STUDY

Recycling Transport Water

A food processing facility in St. Paul, Minn., hired an intern to evaluate water usage in corn processing. For the transport water use (5,200 gallons per day) the intern investigated alternative dry methods: 1) screw conveyors were unacceptable because of the degradation of corn, 2) belt conveyors on the vertical cook tanks were a potential solution but only reduced water by 10 percent, making the initial investment unjustifiable. The intern found that 20 percent of the transport water could be recycled without affecting product quality (concerns included pH and cleanliness). Recycling 20 percent would reduce total plant water usage by 3.5 percent and save $1,570 annually.

Figure 5-5

Potential Water Reuse for Selected Food Processing Operations

Operation	Can reserved water be used?	Can effluent be used?	Source of make-up water
Acid dip for fruit	yes	no	can coolers
Washing of product			
First wash, followed by second wash	yes	yes[1]	can coolers
Final wash of product	no	yes[1]	can coolers
Flumes			
Fluming unwashed or unprepared product	yes	yes[1]	can coolers
Fluming partially prepared product	yes	yes[1]	
Fluming fully prepared product	no	yes	any wastewater
Fluming waste	yes	no	can coolers
Lye peeling	yes	no	
Product holding vats (covered with water or brine)	no	no	
Blanchers, all types			
Original filling water	no	no	
Replacement of make-up water	no	no	
Salt brine quality graders with fresh water final wash	yes	this operation	
Washing pans and trays			
Tank washers, original water	no	no	
Spray or make-up water	no	no	
Lubrication of product inside machines	no	yes[1]	can coolers
Washing cans after closing	no	no	
Brine and syrup	yes	yes[1]	can coolers
Processing jars and underwater	no		
Can coolers	yes	this operation	can coolers
Cooling canals			
Original make-up	no	yes[2]	
Make-up water	yes	yes[2]	
Continuous cookers (cans partially immersed)			
Original make-up	no	yes[2]	
Make-up water	yes	yes[2]	
Spray coolers with cans not immersed	yes	yes	
Batch cooling in retorts	yes	yes[2]	
Clean-up purposes			
Preliminary wash	yes	yes[1]	can coolers
Final wash	no	no	
Box Washers	yes	no	can coolers

[1]Use in preceeding operation under precautions.

[2]Use in can coolers if quality is maintained.

Water and Wastewater Use in the Food Processing Industry*

The following sections discuss major water-using and waste-generating processes in fruit, vegetable, dairy, meat, poultry and oil processing. The information is provided to help food processing managers evaluate water use performance and consider additional water efficiency measures. In the absence of water use data, wastewater (hydraulic) loadings information is presented as a reference for water use.

Fruit and Vegetable Processing

The fruit and vegetable processing industries may be described as consisting of two segments: fresh pack and processing. The former collects crops and field packs them into lug boxes or bulk bins for shipment to a produce finishing plant. Products are cooled to preserve integrity and fumigated or treated to control insect infestation or microbial disease development. Products may be culled, graded or trimmed. Product is sold as fresh produce. The processing segment, or packers, includes all unit operations, extending the shelf life of food being processed and adding value through produce modification to satisfy market niches.

The fresh pack segment of the industry shares unit operations with the processing segment. These operations are the sorting/trimming, washing, grading and packing lines. But after the packing lines, additional unit operations may add to the waste-generating scheme for the processing segment alone. Additional operations may include combinations of peeling, stemming, snipping, pitting, trimming, chopping and blanching. In some instances, the final product is dehydrated (e.g., chopped onions). In others, it is packaged and processed. Processing can include one treatment or a combination of several treatments (e.g., acidifying, brining, freezing, cooking or cooling).

**Excerpts from "Waste Management and Utilization In Food Production and Process," CAST, October 1995.*

Major water use and waste-generation points associated with the fruit and vegetable industry include the washing steps for raw and processed produce, peeling and pitting practices, blanching, fluming the produce after blanching, sorting and conveying the product within the plant and cooling after processing. Reducing size, coring, slicing, dicing, pureeing and juicing process steps, as well as filling and sanitizing activities after processing, also contribute to the waste stream.

Wastewater Characterization

Major wastewater characteristics to be considered for the vegetable and fruit processing industry are the wide ranges of wastewater volume and the concentrations of organic

Figure 5-6

Representative Wastewater Loadings Per Ton of Product Associated with Typical Vegetable and Fruit Raw Products

Crop	Flow (1,000 gal/ton) minimum	Flow (1,000 gal/ton) mean	Flow (1,000 gal/ton) maximim
Vegetable products			
Asparagus	1.9	8.5	29.0
Bean, snap	1.3	4.2	11.2
Broccoli	4.1	9.2	21.0
Carrot	1.2	3.3	7.1
Cauliflower	12.0	17.0	24.0
Pea	1.9	5.4	14.0
Pickle	1.4	3.5	11.0
Potato, sweet	0.4	2.2	9.7
Potato, white	1.9	3.6	6.6
Spinach	3.2	8.8	23.0
Squash	1.1	6.0	22.0
Tomato, peeled	1.3	2.2	3.7
Tomato, product	1.1	1.6	2.4
Fruit Products			
Apple	0.2	2.4	13.0
Apricot	2.5	5.6	14.0
Berry	1.8	3.5	9.1
Cherry	1.2	3.9	14.0
Citrus	0.3	3.0	9.3
Peach	1.4	3.0	6.3
Pear	1.6	3.6	7.7
Pineapple	2.6	2.7	3.8
Pumpkin	0.4	2.9	11.0

materials. Wastewater characteristics can be influenced by a number of factors such as the commodity processed, the process unit operations used, the daily-production performance level and the seasonal variation, e.g., growing condition and crop age at harvest. Figure 5-6 presents historical data collected from raw wastewater discharged from the vegetable- and fruit-processing industry.

Water Use and Wastewater Sources

In the processing environment for vegetable and fruit material handling, heating, cooling and packaging, there are six major contributing point sources for waste. These sources are the following operations: (1) raw produce washing, grading and trimming, (2) washing after steam/lye peeling and/or size reducing, (3) blanching and fluming, (4) filling, (5) sanitation/plant cleanup, and (6) processed product cooling. Plant management practices greatly influence process operation efficiency relative to final product yield and waste quantity generated. *(Refer to Figure 5-6 for industrial variability.)*

Water Use and Waste Minimization

Ideally, considerable waste reduction can be achieved if harvesting equipment permits additional stems, leaves and culled materials to remain in the field during harvest. If crop washing, grading and trimming can occur in the field, then additional soil and food residues will remain at the farm. Realistically, most such wastes are being handled at vegetable and fruit processing plant sites. Primary waste-management strategies used by this industry are water conservation and waste-solids separation.

Water use by the vegetable and fruit processing industry is essential to the washing, heating and cooling of food products. But the industry has adopted a number of practices, showing increased sensitivity to the need for water conservation:

1. Use of air flotation units to remove suspended debris from raw crop materials.
2. Recovery and reuse of process water throughout the processing plant.
3. Decrease of water volume use in peeling and pitting operations, as well as decrease of raw product losses.
4. Separation of waste process streams at their sources, for potential byproduct use.
5. Countercurrent reuse of wash and flume/cooling waters.
6. Separation of low- and high-strength wastestreams.
7. Installation of low-volume, high-pressure cleanup systems.
8. Conversion from water to steam blanching.
9. Use of air cooling after blanching.

Fruit Processing (Canning, Freezing, Fermenting, etc.)

The initial preparation processes for canned, frozen and fermented fruits are washing, sorting, trimming, peeling, pitting, cutting or slicing, inspecting and grading. Unwanted and undesirable materials must be removed before the fruits undergo additional processing, but not all fruits are subject to each step. For example, cherries and plums may be canned whole and unpeeled, whereas apples, peaches and pears must be peeled and either cored or pitted before being canned. Peeling can be by hand or with machines, chemicals or steam. After inspection and grading, the peeled fruits are conveyed mechanically or flumed to product handling equipment for processing.

The converted fruit handling processes are can filling, syrup adding, exhausting and sealing, thermoprocessing, can cooling and storing. Processing equipment and plant floors usually are cleaned at the end of each shift and so constitute a final source of waste materials (*see Figure 5-7*).

Figure 5-7

Wastewater Loadings Per Ton of Product from Canned Fruits

Fruit	Flow (gallon/ton)
Apple	500,000
Apricot	500,000
Cherry	200,000
Citrus	300,000
Peach	400,000
Pear	400,000
Pineapple	50,000
Other fruit	800,000

Water and Wastewater Management

Several water conservation and waste prevention techniques are available by which to decrease water volume. These techniques include:

- The use of high-pressure sprays for cleanup.
- The elimination of excessive overflow from washing and soaking tanks.
- The substitution of mechanical conveyors for flumes, the use of automatic shut-off valves on water hoses.
- The separation of can cooling water from composite waste flow.
- The recirculation of can cooling water. When can cooling water is not recirculated, it may be reused in caustic soda (NaOH) or in water peeling baths, in removal of NaOH after peeling, in primary wash of the raw material, in canning belt lubrication, and in plant cleanup operations.

Dairy Processing

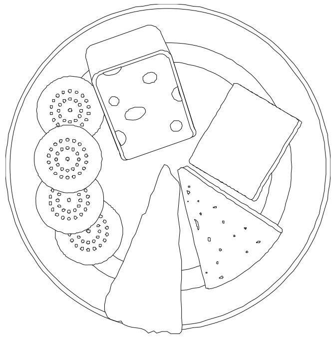
The processing of dairy products often entails various unit operations. These generally include the receiving and the storing of raw materials, the processing of raw materials into finished products, the packing and the storing of finished goods and a number of ancillary processes (e.g., heat transferring and cleaning), associated indirectly with processing and distributing.

Equipment and facilities for receiving, transporting and storing raw materials are much the same industrywide. Bulk carriers unload products in receiving areas by means of flexible lines or dump material into hoppers connected to fixed lines and subsequently transferred by pump to storage. Storage facilities can be of the refrigerator, vertical or silo type, with storage tanks containing either liquid or dry products and ranging in volume from a few thousand gallons to one million gallons or more.

Milk, a perishable product made up of fat, protein, carbohydrates, salts and vitamins, is an ideal food for microorganisms as well as for humans. Thus, it needs to be protected from contamination, and much of the efforts of the dairy industry are directed to this end. Milk and its byproducts are processed according to approved procedures, on machinery normally run no longer than about 20 hours per day. Much equipment is dismantled daily. Systems may be cleaned in place or after they are taken apart. Automated cleaning systems, now predominant in the industry, require less labor but more water and cleaning chemicals than hand washing of dismantled equipment.

Wastewater and Management

Dairy processing wastewaters are generated during the pasteurization and the homogenization of fluid milk and the production of dairy products such as butter, ice cream and cheese. The principal constituents of these wastewaters are whole and processed milk, whey from cheese production and cleaning compounds.



Water use in the dairy products industry depends on plant complexity and water-management practices. Process wasteloads also differ considerably and are influenced greatly by the extent to which the plant controls raw material and product losses. Raw wastewater loading for the American dairy industry is summarized by commodity segment in Figure 5-8.

Milk product losses typically range from 0.5 percent in large, technologically advanced plants to greater than 2.5 percent in small, older plants. Given redoubled effort by management, water usage in most plants could be decreased to approximately 0.50 L/kg milk equivalent processed. Considerable improvements in water and waste management remain important and realistic industry goals.

Innovations

In recent years, technological innovations with membrane systems have provided many new opportunities. For example, ultrafiltration now can be used instead of the biological separation of organic material from liquid substrate. And instead of using reverse-osmosis systems for tertiary waste treatment, some food plants use them to recycle internal liquid waste streams. The outflow from reverse-osmosis treatment can be of better quality than the native water.

Meat and Poultry Processing

The meat and poultry processing industries in the United States together make up a $117 billion per year industry. The U.S. Department of Agriculture reported that the value of red meat production for 2007 totaled $36.1 billion. Most red meat processing plants are

Figure 5-8

Summary of American Dairy and Milk Processing Plant Effluent Loadings

Products	Wastewater (kg ww/kg milk) range	Wastewater (kg ww/kg milk) average
Milk	0.10-5.40	3.25
Cheese	1.63-5.70	3.14
Ice cream	0.80-5.60	2.80
Condensed milk	1.00-3.30	2.10
Butter		0.80
Powder	1.50-5.90	3.70
Cottage cheese	0.80-12.40	6.00
Cottage cheese and milk	0.05-7.20	1.84
Cottage cheese, ice cream and milk	1.40-3.90	2.52
Mixed products	0.80-4.60	2.34

located in the Midwest; most poultry processing plants are in the Southeast and the Mid-Atlantic. Processing of prepared meats, including canned cooked products, luncheon meats, hot dogs, bacons, stews and other ready-to-eat meat products, has expanded rapidly in recent years.

Waste and Byproducts

Most waste products are recovered somehow by the industry. Blood, feathers and bone usually are processed into a meal product for animal feed. Similarly, meat scraps unsuitable for processing into food products are sold or given to rendering facilities for processing into animal and pet foods. The ultimate characteristics of solid materials and wastewaters generated by these source areas in a plant and unrecovered for another use differ greatly and are affected by:

1. Animal size and type
2. Processing level
3. Conveyance means
4. Processing water use
5. Cleanup and housekeeping procedures.

Water Usage

Water use for broiler processing typically ranges from 3.5 to 10.0 gal/bird; for turkeys, 11 to 23 gal/bird. Flow rates of 350 gal/animal have been reported for beef slaughtering plants. In one beef slaughtering operation, water use dropped from 458 to 187 gal/head after water conservation measures were adopted. Similar water use numbers appear in the examples in Figure 5-9.

Figure 5-9

Typical Water Consumption for Beef, Turkey and Broiler Processing

Animal type	Water (gallon/animal)
Beef	150 - 450
Turkey	11 - 23
Broiler	3.5 - 10

Water is used for chilling, scalding, can retorting, washing, cleaning and waste conveying. For example, poultry processing uses approximately 3.5 to 7.0 gallons of water per bird of four-pound average weight. All broiler processing plants are required to have a scalder overflow rate of 0.25 gal/bird and a chiller overflow rate of 0.50 gal/bird. In many instances, this water is used in the plant for the transport of feathers and offal from the processing area. One researcher, studying a broiler processing plant, reported that processing accounted for 76 percent of the water use, with 13 percent used in cleanup and 12 percent used in downtime.

Beef processing water usage, primarily from carcass washing and process clean-up, has been reported in the range of 150 to 450 gallons per animal processed. As a general rule, meat processors use about one gallon of water per pound of processed hamburger meat.

Use and Minimization of Wastes

The amount of wastewater generated by the industries can be decreased largely through changes in cleanup practices. Water use can be minimized by means of commercially available high-pressure, restricted flow hoses, which can be fit with automatic shutoffs to prevent water loss during inactivity. Many materials can be handled mechanically. For example, flour and other dry material can be vacuumed from the floor, and augers and conveyors can be used to transport scrap meat and viscera.

Chiller and scalder water is reused in most poultry processing plants for flushing water to remove offal and feathers. Reconditioning of chiller overflow through the use of filtration and ultraviolet irradiation has been recommended. Limits to use include the potential of bacterial contamination by coliforms or by Escherichia coli. Recycling is limited by the characteristics of the wastestream and by the potential for contamination of food products.

Grain Processing for Oils

The extracting, refining and processing of edible oils produces a variety of waste products. This chapter, which focuses on conventional caustic refinements and on related downstream processes, briefly reviews major processes and facilities, especially as they relate to waste generation and control.

Process Components and Major Wastewater Sources

Figure 5-10 lists primary processes and associated wastewater loadings from a well-run fat and oil processing facility. Separate totals are presented with and without salad dressing and mayonnaise because these processes often are absent in a facility. Certain oil processing and refining operations have no oil seed processing facilities, but instead bring in crude vegetable oil. To account for this practice, adjustments can be made to the figures in the table. Data presented in Figure 5-10 are based on these operating parameters:

1. Milling and extracting: 80,000 bushels per day.
2. Caustic refining with single-stage water wash: 60,000 lb/hr, nondegummed soybean oil.
3. Semicontinual deodorizing with scrub cooler, barometric condenser with atmospheric cooling tower.
4. Acidulating of soapstock and washwater with 90 to 95 percent recovery efficiency.
5. Bottling line and/or other extensive liquid-oil packaging.
6. Margarine, mayonnaise and salad dressing production and packaging.
7. Washing of tank cars for finished oil only (cars carrying crude oil excluded).

Obviously, operations of an atypical size or those omitting certain processes will have different waste loads. This applies especially to operations involved in acidulation or in mayonnaise and salad dressing processing. The effects of process control and its impacts on wastewater loading are very important. As noted, these loadings are representative for an operation running reasonably well from a process loss control standpoint. But actual loadings depend on how well plants are run.

A final source of wastewater is contaminated runoff from truck and rail loadout areas and from tank farm drainage. During rainy periods, runoff from these sources can contribute the equivalent of five to 10 gal/minute to total daily average flow and, in fact, may affect peak flows to a much greater extent.

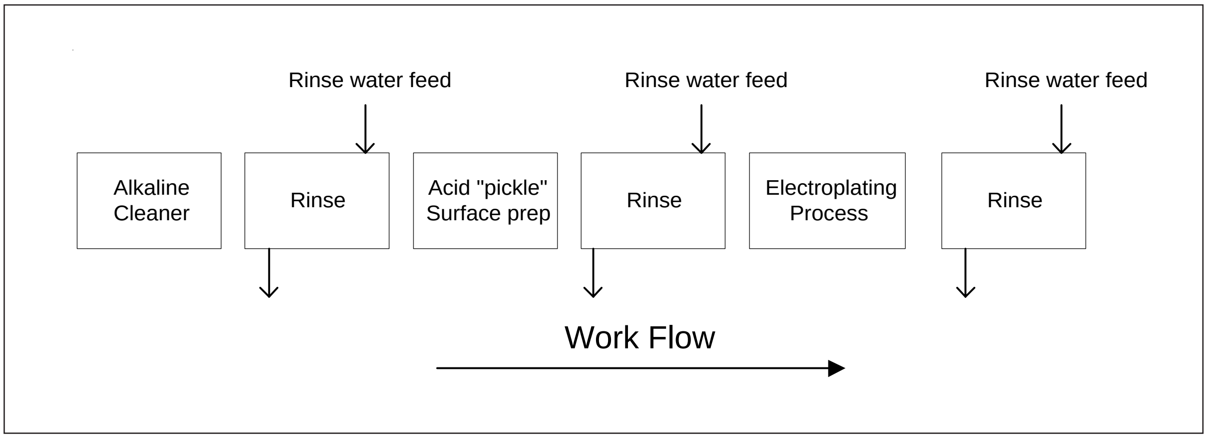
Figure 5-10

Fats and Oils Processes and Wastewater Loads from a Well-run Facility

Process	Flow (gallons/day[1], avg.)
Milling and extraction	75,000
Caustic refining	11,000
Further processing	5,000
Deodorizing	5,000
Acidulating	19,000
Tank car washing	5,000
Packaging	10,000
Subtotal	130,000
Margarine	70,000
Salad dressing/mayonnaise	50,000
TOTAL	250,000

[1]gallons/day = gallons per day

METAL FINISHING



During the past 15 years, the metal finishing industry has made great strides in reducing water use. In a 1994 survey by the National Association of Metal Finishers, 68 percent of respondents had made substantial reductions in water use through pollution prevention techniques. On average, these shops had reduced water flow by 30 percent or about 20,000 gpd. Even with these achievements, metal finishing businesses still continue to have significant opportunities to further reduce water use. Water efficiency within an integrated pollution prevention program can provide these advantages for metal finishers:

- Lower operation cost by reducing water bill.
- Reducing wastewater treatment costs.
- Potentially improving pollutant removal efficiency in wastewater treatment.
- Reducing or delaying need for treatment capacity expansion.

Improving rinsing efficiency represents the greatest water reduction option for metal finishers. A rinsing efficiency program also is the first step to enable metal finishers to implement progressive pollution prevention techniques, such as chemical recovery from the more concentrated waste stream and the potential of closed-looping the electroplating process.

Improving Rinse Water Efficiency

In the metal finishing industry, rinsing quality has a dramatic effect on product quality. Improvements in rinsing efficiency must be carefully integrated into quality control and assurance programs. Rinsing efficiency improvement techniques for metal finishers include improved rinse tank design, flow control techniques and alternate rinse tank configurations *(see Figure 5-11)*.

Rinse Tank Design

Proper design of rinse tanks will improve rinsing efficiency and reduce water use. Optimum rinse tank designs provide fast removal of chemical solutions or "drag-out" from the parts. These techniques can enhance rinse tank design:

- Provide agitation to the tank by air blowers (not compressed air), mechanical mixing or pumping/filtration systems.
- Prevent feed water short-circuiting by properly placing inlets and outlets on opposite ends of the tank.
- Use inlet flow baffle, diffusers, distributors or spray heads.
- Select the minimum sized tank appropriate for all parts/products.
- Consider spray rinsing instead of immersion for flat-surfaced parts.
- Consider ultrasonic rinsing applications where applicable.

Flow Control Techniques

Flow Restrictors

The use of flow restrictors is a very effective means to ensure excessive water is not fed to the process line. Flow restrictors are installed in the feed line of a tank. They are commonly elastomer washers with an orifice that is squeezed smaller with increasing line pressure. They are available in rates ranging from 0.1 gpm to greater than 10 gpm. The flow rate of a restrictor should be chosen to provide sufficient water for quality rinsing. Restrictors work best in consistent production applications.

Flow Cut-off Valves (Manual and Automatic)

Water flow to rinse tanks should be shut off when the process lines are not in use. This can be done manually or automatically. A foot-actuated feed valve can be used in job shops that have discontinuous processing demands. The rinse water valves can be activated only when components are being rinsed. For larger continuous operations, solenoid valves can turn off rinse water lines when power to the electroplating line is turned off. For automatic

Figure 5-11

Survey Rinse Water Efficiency Applications

Technique	Percent of business using technique[1]	Success rating[2]
Flow restrictors	70	4.1
Countercurrent rinse	68	4.2
Manually turn off rinse water when not in use	66	3.6
Air agitated rinse tanks	58	3.7
Spray rinses	39	3.8
Reactive or cascade rinsing	24	3.8
Conductivity controllers	16	3.3
Flow meter or accumulator	12	3.7
Timer rinse controls	11	3.25

[1]Based on NCMS/NAMF study in 1994--318 metal finishers responding.
[2]Success rating based on scale of one to five, with five bing the highest

conveyorized lines, photosensors also can be used to turn on water valves or spray heads only when parts are passing that rinse stage.

Conductivity Meters and Controllers

The most accurate way to control rinse water flows and purity can be achieved using conductivity controls. The use of conductivity meters and control valves will substantially reduce rinse water flow and ensure a set water purity standard is always being met in the tank. Electrical conductivity increases as the concentration of contaminant ions increases.

Conductivity meters indicate the concentration of contaminant ions in the rinse water in units of micromhos (µmhos), also referred to as microsiemens. Specific conductance can be roughly correlated to total dissolved solids in mg/L using empirical data.

Many metal finishing facilities have installed conductivity controllers on the rinse tanks that trigger the introduction of fresh water only when the conductivity reaches a certain set point. This practice significantly reduces water consumption, typically by 40 percent.

Conductivity rinse water flow controllers are most useful on discontinuous electroplating operations. The cost of installing each rinse water conductivity controller will be between $1,000 and $2,000 and typically will have an economic payback of about one year. In the past, conductivity controllers required high maintenance to prevent fouling of electrodes. Newer inductive loop or electrodeless sensors are less susceptible to fouling than conventional electrode types. Determining the optimum set point for these controllers also is imperative to conserve water and maintain quality. Figure 5-12 can be used as a starting point for determining acceptable rinse water purity standards.

CASE STUDY

Conductivity Controller

Artistic Planting and Metal Finishing in Anaheim, Calif., installed electrodeless conductivity controllers on nine rinsing tank systems. Artistic Plating is saving 55,000 gallons per week, which equates to a 43 percent rinse water savings. The conductivity system resulted in decreased rinse water use, wastewater generation, wastewater treatment chemical use and sludge generation. Artistic Plating experienced no adverse quality effects using the controller. Total system payback was one year.

Figure 5-12

Acceptable Rinse Water Contaminant Limits

Rinse bath for	Conductivity in micromhos (µmho)
Alkaline cleaner	1,700
Hydrochloric acid	5,000
Sulfuric acid	4,000
Tin acid	500
Tin alkaline	70-340
Gold cyanide	260-1,300
Nickel acid	640
Zinc acid	630
Zinc cyanide	280-1,390
Chromic acid	450-2,250

CASE STUDY

Rinsing Efficiency

C & R Hard Chrome & Electrolysis Nickel Service Inc. in Gastonia reconstructed its electrolysis nickel line to incorporate several pollution prevention techniques and improve processing efficiency. Single-rinse tanks were switched to a system of multiple counterflow rinse tanks to reduce water consumption. Restrictive flow nozzles on water inlets were added to better control and reduce water consumption. The process line upgrades reduced water consumption by 87 percent, from 7,500 gallons to less than 1,000 gallons per day.

Portable conductivity meters also can be used to establish a fixed flow rate to maintain an appropriate rinse water quality. Once rinse water purity levels are established, permanent flow restrictor valves can be installed in the water supply line to the individual rinse tanks. This technique is suggested only where electroplating production is consistent. Again, use Figure 5-12 as a starting point.

Flow Meters

Relatively inexpensive meters or accumulators can be installed on the main water feed line, process line or on individual rinse tanks. While meters and accumulators do not actually save water, they do allow for careful monitoring of usage and can identify optimum water utilization (or excessive waste), leaks and system failures.

Alternative Rinsing Configurations

Countercurrent Rinsing

Countercurrent rinsing is the practice of overflowing rinse water between a series of rinse tanks so that the water flow is in the opposite direction to work flow. This results in the final rinse being the cleanest. Countercurrent rinsing significantly reduces water usage without sacrificing rinsing efficiency. A common configuration for a countercurrent rinse is two to three rinse tanks in series. Water consumption can be reduced more than 90 percent just by adding a second counterflowing rinse to a single rinse tank. *(See Figure 5-13.)*

If floor space is a problem, a partition could be installed in the existing rinse tank with a metal divider acting as a weir. This modification can be made only if there is sufficient room for the parts rack or barrel in the tank.

Reactive Rinses and Reuse

A reactive rinsing system involves diverting the overflow from an acid rinse to an alkaline rinse tank. *(See Figure 5-14.)* The acid ions neutralize the alkaline ions without causing contamination of the rinse water or compromising plating quality. By reusing acid rinse baths for alkaline cleaner rinses, the effectiveness of the alkaline cleaner rinses can be improved while reducing water consumption by 50 percent. Furthermore, the rinse water from single rinse stages following plating baths has been shown to effectively clean products in rinses following acid or alkaline cleaning without affecting the rinse effectiveness. Rinse water sometimes can be reused from a critical rinse to a less critical rinse in the same processing line or between processing lines. Care should always be taken to ensure cross contamination is not problematic.

Spray Rinsing

Spray rinsing can be incorporated into existing metal finishing process lines to further reduce water use. Typically, spray rinses can be used directly over heated process tanks or over a dead rinse to reduce drag-out. By spraying drag-out back into its process tank or into a concentrated holding tank, less water will be needed for final rinsing.

Spray nozzles for these applications typically have flow rates ranging from .04 to 1.0 gpm. Nozzles can be hydraulic nozzles, which spray water only, or air-atomized nozzles, which use compressed air. Nozzle spray patterns are available in full cone, hollow cone, flat fan and finer misting and fogging types. Spray angle and length of spray pattern is important when specifying the number and spacing of nozzles. Components of spray systems include a water supply, filter, switch, check valve and nozzle(s). The approximate installed cost for a spray system over an existing tank is less than $2,000. Case studies have shown these systems are paid for in less than one year in water and chemical savings.

Reducing Drag-Out to Improve Rinsing

The term "drag-out" refers the residual solution that still is adhering to a part when it leaves a process bath. The drag-out is the solution that must be rinsed off the part. By employing techniques that reduce the volume of

Figure 5-13

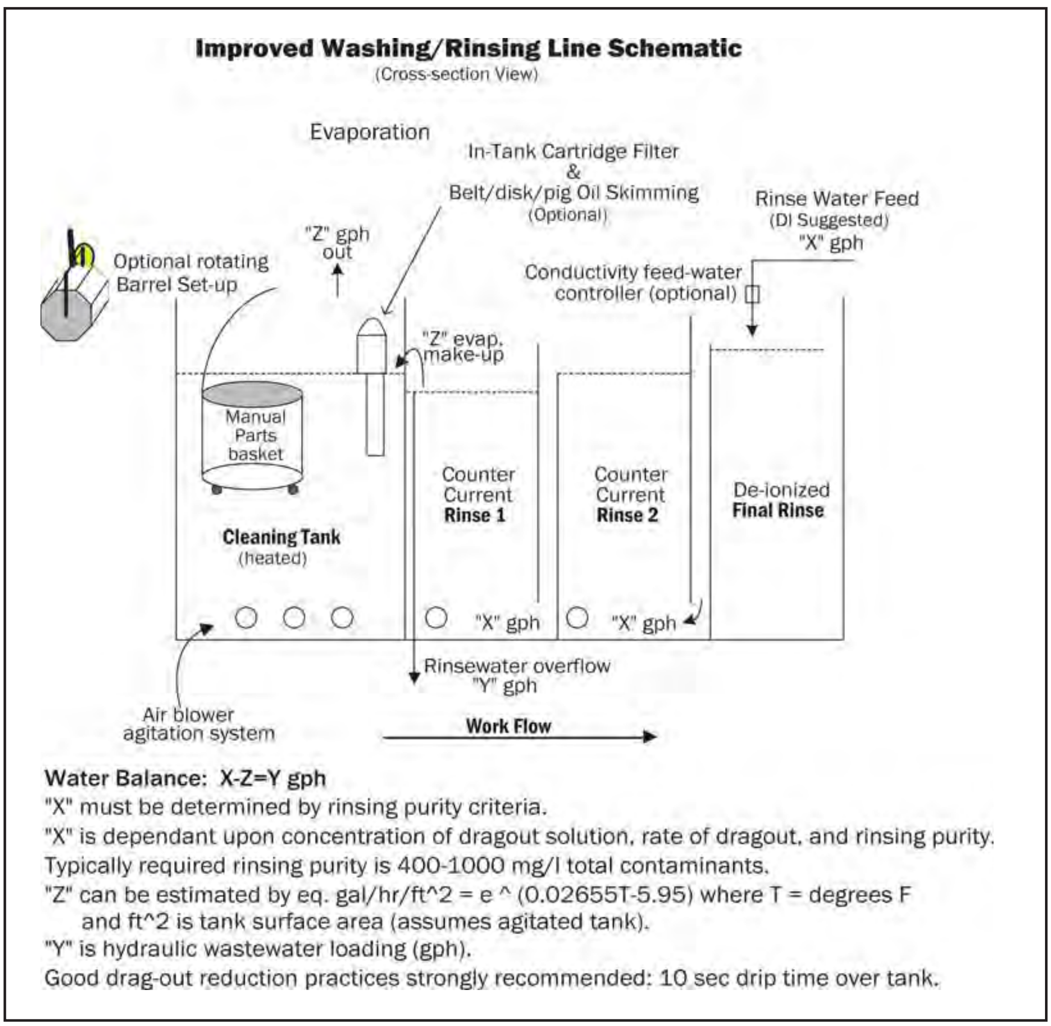
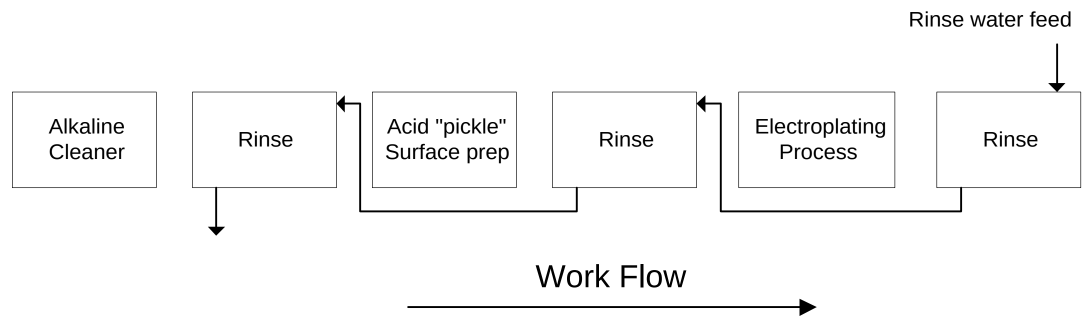


Figure 5-14

Rinse Water Reuse and Reactive Rinsing



drag-out, metal finishers can rinse parts using less water. Potential drag-out reduction techniques for metal finishers include:

- Operating bath formulations at minimum chemical concentrations.
- Maximizing bath operating temperature to lower bath viscosity.
- Using wetting agents to reduce surface tension. Up to a 50 percent drag-out reduction can be achieved.
- Racking parts to maximize drainage. Drag-out rates for very poorly drained parts are three to 12 times the rates for well-drained parts with vertical, horizontal and cup-shaped surfaces.
- Extending drainage time over process tank or dead rinse tank.
- Increasing drip time from three to 10 seconds reduces the drag-out remaining on a part by an average of 40 percent.
- Using spray or fog rinsing over the process tank or dead rinse tank
- Positioning drainage boards between the process tank and next rinse tank.

By reducing the volume of process solutions carried out of the plating tank, metal finishers can reduce rinse water, conserve expensive bath formulations and directly reduce the pollutant mass loading to wastewater.

Wastewater Reuse Techniques

Some electroplating shops are reusing treated wastewater for non-critical rinsing steps such as after alkaline cleaners and acid pickling steps. The reuse of conventionally treated wastewater (via hydroxide precipitation) should be cautioned due to the introduction of high dissolved solids into the plating line. Drag-out and drag-in from conventionally treated water can contaminate other process baths with contaminants such as sodium. In conjunction with advanced membrane separation techniques such as reverse osmosis, wastewater reuse becomes more feasible from an operations standpoint. Some companies have successfully closed-looped electroplating rinse tanks by employing continual cationic and anionic exchange reclamation of metals.

An electro-coagulation/ultraviolet process patented by Pasco Inc., has been successfully applied to treat and reuse alkaline and acid rinse waters and bath dumps. The process offers cost effective high quality water reuse and low sludge generation due to no needed chemical additions for solids coagulation and flocculation treatment stages.

Other novel applications of wastewater treatment techniques such as electro-coagulation and absorptive/adsorptive media hold promise to enable electroplaters to close loop their operations.

6 Auditing Methodology and Tools

A facility water audit or survey is the key starting point of any water efficiency program. This chapter provides supplemental information and tools for the water audit team conducting the plant survey *(see Chapter 3).*

Water Audit Preparation

Thorough preparation for the water audit will ensure maximum results and efficiency. Top management should be completely supportive of this effort. Collect the following information regarding the facility's water use, identify all personnel familiar with the operation and record information collected on the water survey data sheets *(see Data Sheet at end of this chapter)*:

1. The exact location of the facility included in the audit.
2. The age and physical size of the facilities, including the number of buildings and floor space (in square feet) for each.
3. Plumbing drawings, riser diagrams and irrigation plans.
4. Names, phone numbers and e-mails of facility contacts.
5. Specific services or products produced at the site:
   - Record the number of meals served, number of guest rooms and occupancy data for service establishments, such as restaurants, hotels, hospitals, military bases and schools.
   - For manufacturing sites, identify the amount of water used per quantity of product produced (that is, gallons per ton of product or gallons per gross of widgets).
   - For schools and other such institutions, calculate and record the amount of water used per person per day.

6. The operating schedule of the facility, number of employees per shift, maintenance shifts and other operating information.
7. A water use profile (graph) showing the total water use and water used per unit of product per month for the last three years (one year minimum).
8. Copies of the proposed billing rates for energy, water and wastewater for the next two years (if known).
9. List of all water-using equipment, including the manufacturer's recommended flow requirements.
10. Inventories of sanitary fixtures and any water-saving features.

11. Outdoor water use and irrigation controls.
12. Previous water and energy surveys.
13. All water delivery records from water meters, tank trucks or the facilities' own wells. Accurate water meters are essential for a valid water audit. Source water meters indicate the amount of water supplied to the site. Sub-meters indicate water used for specific processes and individual buildings on the site. Obtain the following meter information before starting the audit:
    - Location of all water supply meters that record deliveries from utilities, wells and other water sources.
    - Location of all on-site process and building meters.
    - Sizes of all meters.
14. Any calibration test results for meters to adjust past meter readings to reflect actual water use.

If the firm has never performed a significant water efficiency study, experienced help may be needed. Experienced assistants may be available from the following:

- Other units within the organization.
- Local, state or university technical assistance services.
- Consultants who understand the processes.
- Water, gas, energy and electric utilities.

15. Gather necessary tools needed for the audit: camera, bucket, stopwatch, etc.

Measuring In-Plant Water Usage

Submetering is an excellent way to accurately account for large water uses in specific processing equipment for departments within the plant. Submetering helps personnel become familiar with water use for all operations and indicates whether equipment is using water when it is not needed. (In some rinses, water is left running continuously, even when the need is only occasional.)

To obtain the appropriate size for a submeter, use the actual flow rate rather than just pipe size. Use temporary strap-on meters to determine the approximate flow. Then, the correct size of the positive displacement meter can be determined before installation. Temporary meters also will indicate whether it will be cost-effective to install permanent meters.

Bucket and stopwatch is a simple and accurate measurement tool. To use this method, collect a specified amount of process water for a specific time period (e.g., one quart per minute, which is equivalent to 0.25 gpm).

Micro-weirs are small hand-held weirs that are used to measure low flows of water (0.5 to six gpm) in tight spaces, such as under lavatory faucets.

Conducting the Water Audit

The next step is to conduct a walk-through survey with facility personnel who are knowledgeable of how water is used in each area of the facility. Use direct observation and measurements. Identify and record all pieces of equipment that use water. Check with equipment operators who may have important first-hand information. Record information on water survey data sheets (*see pp.* 112-116) Use the following procedure to conduct the step-by-step survey:

1. During the walk-through, record hours of operation for each piece of equipment, including domestic and kitchen operations. Identify water piping layouts, particularly in areas of older equipment, to aid with identifying water uses. Note those pieces of equipment that have multiple uses of water (e.g., water-cooled ice machines).
2. Identify water flow and quality as needed for each use. This information may be needed to determine if discharges from one use can be re-used as a potential supply for a different application. Include these parameters:
   - Temperature.
   - Water quality indicator parameters, such as pH, total dissolved solids and conductivity.
   - Other key water quality parameters such as biochemical oxygen demand, chemical oxygen demand, metals, or oil and grease.
3. Where possible, measure the actual amount of water being used. The most direct way to measure flow rates is with a bucket and a stopwatch (*see Figure 6-1, p. 110)*. Consider installing meters on major water-using processes or plant departments to record the quantity of water used.
4. Check water quantity and quality of water specified within the equipment operating manuals. Equipment is sometimes operated at higher flows than required by the manufacturer's specifications. Ask qualified engineers to review the specifications and adjust flows accordingly. Further, investigate whether the processes can still operate properly with further reductions in water flow. Be sure to record flow rates before and after changes are made to evaluate the effects of reduced flow.
5. Read water meters regularly and compare actual water use to the facility's water reduction goal. After determining daily use rates, the frequency of the readings should be adjusted to be consistent with the volume of water used, the cost of reading the meters, and potential excessive use fees. For example, large water users (more than 50,000 gpd) should continue to read meters daily. Commercial businesses using water for sanitary purposes only might read meters biweekly or monthly.
6. Identify flow and quality of wastewater resulting from each use.
7. Include any internally generated fluids in the water audit. Water may be generated as a byproduct of processing raw materials, such as fruits or from oil/water separation equipment. Determine the quantity and quality of these fluids and whether there are potential on-site uses for these fluids, such as housekeeping or cooling.

Use survey results to prepare a water balance diagram *(see Figure 3-1, Chapter 3)* to depict all water uses from source through on-site processes, machines and buildings, and finally, to evaporation and discharge as wastewater. If unaccounted for water is greater than 10 percent, revisit the major areas of water use, talk further with plant operators, or take additional measurements.

Additional Water Auditing Tips

- Measuring tools should be used after the walk-through with facilities staff or the audit team. There is no time to start measuring flows while the assessors are being shown the facility.
- The quality of the audit depends on accurate information for the facilities manager or staff guiding the walk-through. Always try to speak directly to line operators or staff working in the water-consuming operations to confirm information.
- For external auditors, follow-up trips are almost a necessity when water balance calculations to estimating water use by category do not align with meter consumption records.
- Spikes on yearly water consumption graphs are a reminder to the auditor to find out the whole story of the water use history.
- While accounting for water use at large commercial and industrial facilities, it may be difficult to keep "unaccounted for" less than 10 percent. A range of six to 12 percent unaccounted for water is certainly acceptable.

Water Audit Report

Proper and efficient presentation of the water audit findings and recommendations is imperative for facility decision-makers. The water audit report should contain the following elements:

1. Executive summary of the recommendations, quantifying of savings, investment costs and payback periods.
2. Introduction.
3. Facility description.
4. Water use history for one or more years.
5. Water use balance.
6. Which efficiency option, technical discussions and savings calculations.
7. Energy savings if applicable.
8. Data normalization for follow-up with suggested time frame.

Leak Detection

All facilities will experience some leaks. Leaks may range from a fraction of a percent up to several percent of total water use. Telltale signs of a leak include low water pressure or dirty water, or both, as well as an unusually high volume of unaccounted for water. Common locations for leaks are in piping joints, restroom fixtures, pump seals, loose nozzles/shut-off valves, drinking fountains, processing equipment and other locations. Eliminating such leaks typically includes tightening or replacing fittings.

Leaks can be identified by visual or audio observations. Water fixtures and process equipment should be observed both during use and during down time. All employees should be responsible for notifying maintenance personnel of leaks, and maintenance personnel should make leak repair a priority.

Water Leak Equations

Rates of water loss for a roughly circular hole can be estimated using the Greely equation *(see Figure 6-2)*:

Q = (30.394)(A)(square root of P)
Where Q is leak rate in gpm, A is the cross-sectional area of the leak in square inches, and P is the line pressure in pounds per square inch.

Leaks in joints or cracks can be estimated by this equation:

Q = (22.796)(A)(square root of P)
Where Q is leak rate in gpm, A is the area of the leak in square inches, and P is the line pressure in psi. For example, a 1/32" wide crack, 1" long will use 4.5 gpm at 40 psi.

Underground or under-the-floor leaks can be detected through a leak-detection survey using the facility's water meter. To do so, all water-consuming items inside and outside the building must be turned off. Alternatively, perform the survey after the last shift has left and no water is being used in the facility; then observe the water meter for a minute or more. If the meter dial moves continually during this time, a leak is indicated. Another method is to record the numbers on the meter and come back an hour later to check the reading, making sure that no water is used during this time. If the meter reading has increased, there is a leak.

If an underground leak is suspected or detected using the water meter, but the leak's location is not readily identified, it may be necessary to have a leak detection survey performed by a service firm. Such firms use state-of the-art audio sound systems to pinpoint the leak's location. To identify a leak or problem area, a portable listening device allows the user to verify that a leak is present in a general area. The equipment consists of (1) a base unit that contains batteries and electronic components that amplify leak noise and filter extraneous noise, and, (2) an acoustic sensor that attaches to the road surface or pipe itself, as well as a pair of headphones. The cost of this equipment can range from $1,000 to $5,000.

Determining Water Loss by Leaks

Determining the volume of water loss by leaks is important to calculate both water and cost savings by repairing the leak. One of the simplest methods to determine leak loss is the bucket and stopwatch method. A small drip also can be measured by the bucket and stopwatch method. Mathematical estimates of leaks can also be used.

FIGURE 6-1

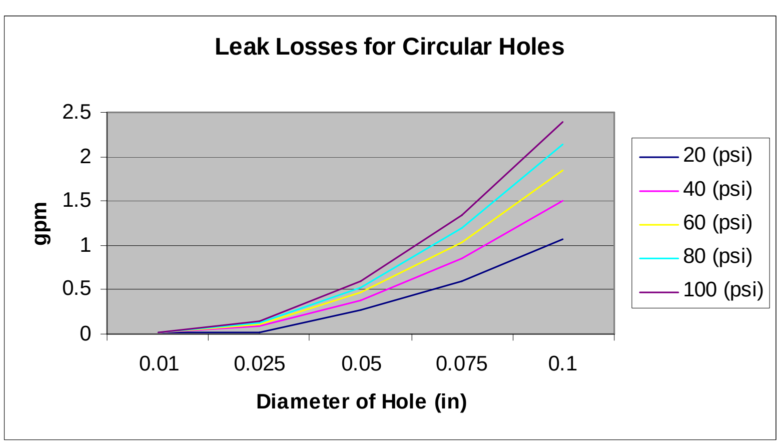
Drips/Second to GPM Conversion

No. drips per second	Gallons per day
1	8.64
2	17.3
3	25.9
4	34.6
5	43.2

Five drips per second is a steady stream.

AWWA: Waterwiser 2008

FIGURE 6-2



Water Meter Issues

The size and accuracy of a facility's water meter is important when accurately accounting for water use. Typical types of meters used for commercial and industrial settings include positive displacement, turbine and compound meters. Figure 6-3 shows typical applications for meter types and sizes. Water meters can become less accurate when the intended water use of a facility has changed or when substantial water conservation activities have been implemented. Water meters should be of adequate size but not oversized. If a meter is oversized for the facility's needs, the facility could be paying unwarranted service charges for the oversized meter. Properly selected and sized water meters can become inaccurate due to wear, which is affected by age and water quality. In-place field testing using a pitotmeter for large meters and a portable meter test unit for smaller water meters can be conducted. In most cases, water used for landscaping, cooling towers, etc., that is not discharged to the sewer can qualify for a rebate from the sewer district. However, the volume of water not going to the sewer must be accurately measured by a separate meter or other device to qualify for the rebate.

FIGURE 6-3

Types of Meters and Applications

Type	Common sizes	Typical applications
Positive displacement	5/8 - 2 inches	Commercial, medium hotels, apartment complexes and industrial plants
Class II turbine	2 - 6 inches	Medium/large hotels, large apartment complexes to large manufacturing and processing plants
Class I turbine	8 - 12 inches	Industrial, manufacturing, processing, pump discharges
Compound, high velocity styles	2 - 4 inches	Special high and low demand applications for schools, public buildings and hospitals

Water Survey Data Sheet

This data collection sheet is designed to assist auditors during assessments. Some items may not be applicable for all assessment situations or conditions.

Assessment Information

Company name ______________________ Date of assessment __________

Address ____

Phone/FAX ____________________ Lead assessor ________________

Company contact person/title ___________________________________

E-mail address ____

Assessment team members ______________________________________

____

Assessment objectives (special concerns) ____________________________

____

Background Information About Water Use

Average water use/bill (for previous year) ___________________________

Average water use/bill (for year before last) __________________________

Size and location of meter(s) ___________________________________

Primary water source ____

Secondary water source ______________________________________

Potential to reduce meter size? __________ Savings ___________________

Should credit be obtained for water that does not go to the sewer? (cooling towers, landscaping) _________________

Is an additional meter required to monitor water not being sewered? __________

Water Balance and Costs

Source of water use	Gallons per Year (est.)	Percent of Total	Water Cost ($/yr)	Sewer Cost ($/yr)	Energy/Other Costs ($yr)
Domestic					
Heating/cooling					
Rinsing/cleaning					
Landscaping					
Unaccounted for					
Total					

Company Background Data

Number of employees ________ Shifts per day ______ Operating days/week __________

Size of and type of plant (sq. ft.) ________________ Year built/renovated __________

Business type (manufacturing, college, office, etc.) ____________________

If manufacturing, list products and annual production rate ____________________

____

If service or institutional sector, list clients, occupancy rates, meals served per year, etc.

____

____

Other pertinent facility data ____________________

Current and past water efficiency program measures (policies, training, awareness and goals)

____

System Parameters

Number, types and sizes of buildings at complex ____________________

Grounds (approximate size in acres)______________ Garages/motor pool/support buildings (approx. sq. ft.) ____________________

On-site water treatment description, rate and costs

____

Wastewater treatment description, rates and operating costs

____

Notes

____

____

Water Used in Manufacturing Processes

Volume used directly in product, per year ______________________________

Description of water used in processing ______________________________

Volume used in production (i.e., plating) ______________________________

Notes ______________________________

____

Washing, Rinsing and Sanitation

Volume used in cleaning, rinsing and sanitation ______________________________

Description of washing and sanitation processes ______________________________

Number of mop sinks, etc. ______________________________

Have improved rinsing techniques (such as counter-current systems, conductivity flow controls, improved spray nozzle/pressure rinsing, etc.) been considered? ______________

Are "dry clean-up" practices used instead of hosing down and first-pass pre-cleaning conducted with squeegees, brushes or brooms? ______________________________

Is water cut off when not in use by flow timers, limit switches or manually? ____________

Notes ______________________________

____

Cooling and Heating

Description of cooling tower evaporative coolers (rated tonnage, types and uses) ______

____

Water rate used in cooling towers and equipment ______________________________

Is condensate being reused? ______________________________

Description of once-through cooling requirements ______________________________

Volume used in once-through cooling (air conditioners, air compressors, vacuum pumps, rectifiers, hydraulic equipment, degreasers, etc.) ______________________________

Or has once-through cooling water for these uses been eliminated through use of chillers, cooling towers or air-cooled equipment? ______________________________

Has blow-down bleed-off control on boilers and cooling towers been optimized?

Notes ______________________________

____

Domestic Use

Toilets (number, type and tank volume) ______________________

Urinals (number and volume) ______________________

Lavatory sinks (number and estimated flow) ______________________

Showers (number and estimated flow) ______________________

Are code-conforming commodes (1.6 gpf), faucet aerators (0.5-1.0 gpm) and low-flow showerheads (2.5 gpm) in use? ______________________

Notes ______________________

____

Landscaping/Outdoor Use

Landscape irrigation (estimated gallons per unit of time) ______________________

Acreage/square footage landscaped and description ______________________

Watering/irrigation system techniques and schedule ______________________

Are low-flow sprinklers, trickle-drip irrigation, optimized watering schedules and water placement, preventive maintenance and xeriscaping techniques in place? ______________________

Notes ______________________

____

Kitchen/Canteen

Dishwasher(s) description, use and volume ______________________

____

Kitchen faucet/pre-rinse sprayers [number and flow rate (gpm)] ______________________

Icemakers, air-or water-cooled and water usage ______________________

Garbage disposals in use? ______________________

Are "electric eye" sensors for conveyor dishwashers installed? ______________________

Have new and water- and energy-efficient dishwashers been considered for future purchse? ______________________

Notes ______________________

____

Other Uses, Leaks and Unaccounted-for Water

List any quantifiable leaks and estimated rates ______________________________

____

Any other miscellaneous uses of water (car washes, wet scrubbers, ornamental ponds, dust control, etc.) ____

____

Notes ____

____

Additional Needs

Factors that couuld affect, increase or decrease water use ____________________

____

Any other major opportunities and assessment opportunities revealed, including

- Energy efficiency
- Lighting
- Heat recovery
- Solid waste reduction
- Pollution prevention

____

____

7 Drought Contingency Planning for Facilities Managers

Large commercial, institutional and industrial facility managers should consider the need to develop a drought contingency plan. A facility's drought contingency plan will include many of the water efficiency strategies covered in this manual, but should also make preparation for the mandatory water use restrictions and the possibility of emergency actions during a severe water shortage.

Facility Plan Approach

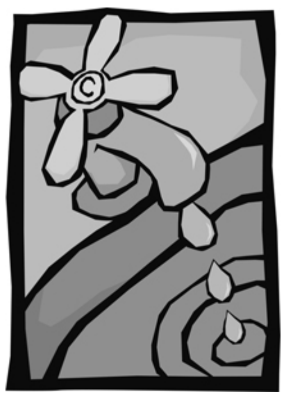
The approach to develop a drought contingency plan can be similar to, or piggy-back on, the "Steps of a Successful Water Efficiency Program" covered in Chapter 3, but with a more succinct focus on responding to a water shortage through a number of short-term measures. With top-down support, key management personnel should outline a plan with the participation of key staff in affected departments. Responsibilities for the plan's action items should be clearly delineated, with special emphasis on emergency response measures. The plan action steps should be integrated with the level of water shortage severity defined by the local water supplier. Predictive timing and internal triggers should be established.

Knowing the local water supply drought requirements is an essential early step *(see "Understand Your Water Supplier's Water Shortage Plan," p. 120)*. A facility should inventory and understand its own water uses and categorize these as "non-essential," "important" and "essential." Other regulatory rules and requirements that may apply to a facility's direct water withdrawal from rivers, reservoirs or diminishing capacity of groundwater wells should be reviewed. Daily water use tracking and supply tracking becomes necessary under mandatory restrictions and essential under emergency levels. As with any contingency plan, proper communications and employee involvement are essential to managing severe drought impacts.

Facility Plan Key Elements

Communications

The most successful facility efforts to address drought come through timely and continual communications with all employees. Whether this is communicated through drought updates posted on a manufacturer's break-room tables or special awareness signs hanging around the showerheads at a YMCA, the importance of these communications cannot be overemphasized. All employees want to feel like part of the team and that their organization is doing its part to minimize water uses during times of drought.



As larger water users come under high scrutiny by community members during a drought, a facility spokesperson should be able to effectively communicate what measures and strategies the organization is taking either in response or proactively. Communicating water conservation successes is an important and positive news release item.

Demand Reductions

Addressing an action plan of key demand response measures will likely be the most important and engaging activity of the plan. Tracking water use and related reduction measures is the first step. For many commercial and institutional facilities, the tracking of water use may not have been conducted in the past. Since water supplier bills may be monthly, bi-monthly or even quarterly, facility staff will need to read the facility's water meters on a more periodic basis.

Developing a list of viable drought response water conservation measures will require creative input from several representatives in the organization. Creating an inventory of all water-consuming equipment and practices should be done by a water conservation team. This can be accomplished with a quick water audit conducted by team members. *(See the "Self-Assessment Checklist" in Chapter 2 for more resources.)* As a list of water conservation action items is generated, the speed and priority of implementation should be carefully considered. Short-term vs. permanent measures need to be noted and managed accordingly. This is also the time to maximize the effect of behavioral water conservation measures throughout the facility.

Water Supply Extensions

Larger water-using facilities may have their own water supplies to deliver process, cooling or irrigation water. Some facilities have considered increasing storage capacity of existing reservoirs and cisterns, some of which are used for stormwater collection. Other facilities have drilled wells for new capacity or expanded capacity. The potential exists for greater water reuse and recycling from on-site processes or from treated public or private wastewater systems. Advance planning is essential for all supply extension efforts. Some projects have had related environmental permits expedited during periods of water use restrictions.

Emergency Measures

Facility management staff should plan for scenarios of severely restricted water supply - down to having no potable water for domestic use at the facility. Could the organization still function with other sources of water for production needs? Can portable restrooms be employed and bottled water be distributed to employees? What minimum sanitation and hand-washing requirements need to be addressed? Identifying appropriate vendors, service providers and governmental officials in advance is sound planning.

Businesses and manufacturing facilities in North Carolina have employed the following actions during emergency response to drought conditions:

- Shutting down of all restrooms, food preparation areas and water fountains.
- Putting portable restroom facilities in use.
- Making bottled water available to employees.
- Drilling wells to supply water for manufacturing processes.
- Bringing in water by tanker truck from geographical areas with more abundant water supplies.
- Treating and recycling wastewater generated by the manufacturing process and recycling it back into the manufacturing process and/or cooling towers where possible.

Drought Response vs. Ongoing Water Efficiency Measures

Drought response planning includes many strategies to meet voluntary, mandatory and even emergency drought mandates that would not normally be employed on a permanent, year-round basis. Selected examples collected from North Carolina communities have included:

- A food processing plant changed its operating shift schedule in order to reduce the number of end-of-shift clean-ups.
- A business took its water fountains out of service and used bottled water.
- Facility managers increased the number of concentration cycles on cooling towers and boilers during drought periods.
- A canteen service is using paper plates to avoid use of the dishwasher.
- Reusable water from various sources is being accumulated in buckets to flush toilets.
- Water used for checking hot water heaters is being reused for cleaning jobs.
- Condensate from dehumidifiers and air handlers is being used to irrigate plants.
- Solenoid valves and flow restrictors installed to shut off/reduce water flows during less critical steps of a continuous dyeing operations.
- Sanitizing hand gel used as a substitute to clean hands to enable turning off water at bathroom sinks.
- Eliminated once-through cooling of pumps, compressors, autoclaves and other equipment by placing equipment on chilled water/cooling tower loops.
- Individuals expected to cut down on time in showers and to turn off water when not required for soaping or rinsing.
- Members of the hospitality industry are posting drought notices from the mayor throughout their facilities to encourage guests to be more efficient in the use of water.
- Porta-toilets used in recreational parks to cut down on the use of water-consuming facilities.
- Manufacturers captured water from chiller units and used it for cleaning purposes and make-up in a closed loop machine coolant system.

CASE STUDY

Change in Flushing Schedule

The city of Gastonia's Water Supply and Treatment Division conserved 6,534,167 gallons of water during the 2007 drought. It increased the time between backwashing the filters in the water plant from 72 hours to 84 hours and decreasing the time spent flushing water lines in the distribution system.

Understand Your Water Supplier's Water Shortage Plan

In North Carolina, local government water systems and other large community water systems are required to develop a water shortage response plan. Facility managers should be aware of these plans, participate in their development and understand how they will affect their operation during a water shortage. The specifics of each plan are unique for each community. The chart on the following page lists key terms in a local water shortage plan.

CASE STUDY

Drought Measures

The N.C. Zoological Park's Horticulture section saved water during the 2007 drought by installing a new irrigation control system, utilizing an evapotranspiration management system, which saved 1,541,568 gallons of water in just one growing season. The zoo also repaired water leaks at two major pools, resulting in savings of between 4,000 and 5,000 gallons per day during the drought. Furthermore, the zoo switched to an ozone water treatment system for two of its larger pools. This change has resulted in a reduction in the number of times a year that these two pools need to be drained and refilled from six times per year to twice a year, saving a total of 250,000 gallons per drain and fill.

CASE STUDY

Campus-wide Changes

The National Institute of Environmental Health Sciences implemented several water conservation activities throughout its campus to reduce its water usage during the 2007-2008 drought. With a campus covering 375 acres, including a main administrative and research laboratory building and several support service facilities, the efforts listed below resulted in considerable water savings.

- Optimized chilled water system operations to minimize cooling tower loading
- Identified and repaired utility system water leaks
- Eliminated outdoor watering
- Modified laboratory practices to minimize water use
- Used disposable trays and biodegradable utensils in the cafeteria
- Retrofit lab autoclaves to minimize water use
- Began installing waterless urinals as part of a facility-wide replacement project
- Installed low-flow aerators on restroom, break room and lab faucets
- Modified washing procedures for laboratory support equipment
- Disabled auto-flushing mode on commodes to eliminate false flushing
- Eliminated support vehicle washing
- Installed waterless hand sanitizers in all restrooms
- Deferred water-consuming maintenance and testing where possible
- Investigating and initiating design and installation of long-term water conservation measures such as condensate capture and reuse, low-flow commode installations and municipal gray water use
- Established internal water conservation Web page and distributed drought updates via all-hands e-mail and electronic newsletters

Key Terms in a Local Water Shortage Plan

Water Use Classification: Water supplier will define a list of water uses and their classification. These classifications will typically fall into three categories:

Class 1: Essential : Those uses necessary for maintenance of public health and safety.*
Class 2: Socially or Economically Important: Those uses that fall between Class 1 and 3.
Class 3: Non-essential: Water uses that can be restricted or totally banned without significant social or economic impact.

Levels of Water Shortage Severity: Local systems will define three stages or levels of water shortage severities that include instructions and requirements. Levels are determined by a specific measurement or "trigger" of available supply, demand and system condition.

Level 1: Voluntary Conservation: Conditions indicate potential for water supply shortages; voluntary conservation is encouraged.
Level 2: Mandatory Restriction: Water supplies are measurably lower than the seasonal norm and are diminishing. Mandatory restriction measures are imposed. Some mandatory levels will have multiple stages. Some local governments use the word "stage" in place of "level."
Level 3: Emergency Response: The system is experiencing a water shortage; drinking water supply is clearly inadequate, and more stringent restriction measures must be imposed.

Triggers: A trigger is a specific indicator of water supply storage based on an accurate assessment of available water supply. Triggers are used to initiate and remove restrictions. Triggers will be unique for each type of water supply (e.g., reservoir, run-of-river and groundwater) and will be established for each of the three levels of water shortage).

Enforcement: Local water supply plans will list existing or proposed ordinances, codes and regulations to enforce the measures of the plan. Facility managers should be aware of penalties and enforcement activities.

Variances: The local water shortage plan should address the procedure to receive variances to water use restrictions. There should be clear evaluation criteria established for the review of these variances.

Emergency Price Rates: Some water suppliers will enact emergency pricing rates for water during severe drought levels. Find out if, how and when these rate changes could affect your facility. Many water supply systems are moving toward permanent conservation pricing rates, which increase with increased water usage or impose a demand surcharge on excess use.

*N.C. Session Law 2008-134 defined "essential water use" to include water necessary to satisfy federal, sate and local laws for the protection of public health, safety, welfare and the environment and natural resources. It also includes "a minimum amount of water necessary to maintain the economy of the State, region or area." The 2008-134 session law also increased authority of state officials to mandate local drought response actions.

8 Definitions, Resources & References

DEFINITIONS*

Account	A connection to a water system, which is billed for service.
Acre-foot	Enough water to cover an acre of land one-foot deep (i.e., 325,851 gallons, or 43,560 cubic feet).
Adjustment factor	A decimal fraction used to modify reference evapotranspiration to reflect an efficiency standard.
Aerate, aerification	Also called coring. Mechanical cultivation of turfgrass using hollow tines to remove cores of turf, thatch and soil; improves soil texture and increases air and water movement in root zone.
Allocation billing	Used interchangeably with RUBS (see RUBS). Also, see Utility Allocation.
Allocation types	The basis by which utility expenses are apportioned to users. Common types include unit count, occupant count, occupant ratio, square footage and a combination of occupant count and square footage. Less common types include bathroom count and fixture count.
Apparent losses	In a distribution system water audit apparent losses represent the "paper" losses that occur when volumes of water reach a use, but are not properly measured or recorded. They include customer meter inaccuracies, unauthorized consumption and data handling error in customer billing systems. Apparent losses cause water utilities a loss of revenue but also interject a degree of error in the assessment of customer consumption, making it more difficult to evaluate the success of water conservation and loss control measures.
Application rate	The depth of water applied to a given area over time, usually measured in inches per hour.

The definitions, units of measure and acronyms provided here are from the American Water Works Associaton's WaterWiser program.

Applied water	The portion of water supplied by the irrigation system that reaches the soil surface.
Appropriative water rights	An exclusive right to take water as specified by the amount, source, use, location and period of time of its physical control. 'First in time, first in right.'
Area	Square footage or acreage measured or estimated from scale plans, photographs or from on-site measurements.
Arid climate	A climate characterized by less than 10 inches of annual precipitation.
As-built plans	Site plans reflecting the actual constructed conditions of a landscape irrigation system or other facility installation.
Avoided cost	The cost of an activity or facility that could be avoided by choosing an alternative course of action.
Backflow prevention device	A safety device used to prevent contamination of the potable water supply from the reverse flow of water from an irrigation system or other customer activity back into the potable distribution system.
Backwash	The use of water to clean filters. Water under high-pressure is pumped in reverse through filters, removing trapped sediment and other material.
Ballcock	A float actuated valve, part of the toilet trim in the toilet tank that controls the refill water flowing into the toilet tank when it is not full.
Beneficial rainfall	The portion of total rainfall that is available for use by the plant (effective rainfall).
Best management practice	A practice or combination of practices established as the most practicable means of increasing water use efficiency.
Bill stuffer	An advertisement or notice included with a utility bill.
Billing cycle	The regular interval of time when customer's meters are read and bills are issued, generally every month (monthly) or two months (bi-monthly).
Billing period	The elapsed time between two specific consecutive meter reads for billing purposes.
Billing unit	The unit of measure used to bill customers, either 100 cubic feet (abbreviated HCF or CCF) or 1,000 gallons (kgals).
Bleed-off	Draining off the water in a cooling tower reservoir to avoid the buildup of excess dissolved solids. Also referred to as blowdown.
Blowdown	Draining off the water in a cooling tower reservoir to avoid the buildup of excess dissolved solids. Also referred to as bleed-off.
Blow-out toilet	A type of toilet, normally found in hospitals or sites subject to high use, that has an extra wide trapway, is generally supplied by at least a two-inch service line to the building, uses extra water (with a powerful flush) to remove waste from the bowl.
Bluegrass	A variety of cool-season turfgrass of the genus Poa. Commercially produced turfgrass mixes usually are a blend of bluegrass varieties.

Bubbler	A type of sprinkler head that delivers a relatively large volume of water to a level area where standing water gradually infiltrates into the soil. The flow rate is large relative to the area to which the water is delivered. Bubblers are used to irrigate trees and shrubs.
Business Classification Code	A numeric classification of customers into groups with similar uses or processes. See SIC code.
Calcium	(Element abbreviation CA) A mineral that is commonly found in water. It contributes to the hardness of water.
Capita	Latin for 'person.'
Catch-can test	Measurement of a sprinkler system's application rate. Test involves placing graduated containers at evenly spaced intervals throughout an irrigated area and measuring the depth of water collected in the cans over a given period of time.
Categorical variables	Variables that are not scaled, but are "nominal," that is, there is no direction or number associated with the levels.
Central irrigation control system	A computerized system for programming irrigation controllers from a central location; using a personal computer and radio waves or hard wiring to send program information to geographically distant controllers.
Check valve	A device that prevents drainage of water down to the low points of an irrigation system after the system is shut off. Also called anti-drain valve. A valve that allows flow in only one direction, preventing backflow.
Class	Customers having similar characteristics (commercial, single-family residential, etc.) grouped together for billing or program purposes.
Climate factor	Evapotranspiration minus precipitation. One of the four factors used to determine landscape water use.
Coliform bacteria	Microorganisms (e.g., Escherichia Coli) common to the intestinal tract of warm blooded animals. The organisms' presence in water is an indicator of fecal pollution.
Commercial user	Customers who use water at a place of business, such as hotels, restaurants, office buildings, commercial businesses or other places of commerce. These do not include multi-family residences, agricultural users or customers that fall within the industrial or institutional classifications.
Commodity rate	Charging for water based on the volume of use. Not a flat or fixed rate.
Compound meter	A meter with two measuring chambers, generally a turbine for high flows and a positive displacement for low flows.
Conjunctive use	The coordinated use and storage of surface and ground water supplies to improve water supply reliability and potentially increase the overall availability of water.
Connection fee	A charge assessed to a new account by a water utility that generally covers the cost of hooking up to the system and compensates the utility for prior water system improvements that made the capacity available.

Conservation rate structure	A pricing structure billed by the quantity of commodity delivered and tied to the costs associated with that delivery, designed to provide an accurate price signal to the consumer. An increasing block rate structure, if the top tier equals the utility's marginal cost of new water, is one example of a conservation rate structure.
Consumer surplus	The difference between what a commodity is worth to a consumer and what she actually pays for it.
Continuous variables	Variables that are numerical and can be scaled.
Conversion factor	A decimal fraction used to convert one unit of measure to another, such as inches of depth over a square foot to gallons (0.623).
Cooling tower	A mechanical device that cools a circulating stream of water by evaporating a portion of it. A cooling tower is part of a system that provides air conditioning or equipment cooling. It usually includes a heat exchanger, recirculating water system, fans, drains and make-up water supply.
Cool-season grass	Grass that does not ordinarily lose its color unless the average air temperature drops below 32° F (0° C) for an extended period; it is not usually damaged by subfreezing temperatures. Cool-season grasses grow actively in cool weather of spring and fall and slowly in summer heat. Examples include bluegrass, fescue and ryegrass.
Coring	Mechanical cultivation of turfgrass using hollow tines to remove cores of turf, thatch and soil; improves soil texture and increases air and water movement in root zone. (See Aerification.)
Cost-effective	When the present value of benefits exceeds the present value of costs.
Cost-effectiveness	An analysis that compares the financial benefits of water savings to the costs needed to achieve those savings.
Costs	The resources needed for a course of action.
Crop coefficient	A factor used to adjust reference evapotranspiration and calculate water requirements for a given plant species. (Also called plant factor or landscape coefficient.)
Curb stop	Shut-off valve between the customer meter and the street service line from the water main.
Customer class	A group of customers (residential, commercial, industrial, wholesale and so on) defined by similar characteristics or patterns of water usage.
Declining block rate	A commodity rate whose unit price decreases with increasing water use.
Dedicated metering	Metering of water service based on a single type of use, such as metering for landscape irrigation separately from interior domestic use.
Demand management	Measures, practices or incentives deployed by utilities to change the pattern of demand for a service by its customers or slow the rate of growth for that service.

Demand side measures	In the water industry, programs which encourage customers to modify the amount or timing of water use. These measures may include encouraging customers to implement hardware or behavior changes, or change the volume or timing of their use, depending on the time of day or time of year.
Desalination	The process of removing salt from brackish water or sea water, producing water suitable for fresh water uses and a concentrated brine.
Developed water	Water that has been captured in reservoirs, diverted from rivers/streams or accessed by wells for use by society.
Discount rate	The financial rate used to calculate the present value of future benefits and costs.
Distribution facilities	Pipes, meters, storage, pumps and other facilities used to distribute water to end users.
Distribution uniformity	An expression of how evenly water is applied to a landscape by an irrigation system. DU is calculated in the field by analyzing the results of catch-can tests.
Door hanger	An advertisement, notice or product hung on a resident's doorknob – often used to promote customer participation in water conservation programs.
Door-to-door-drop-off or canvas	Refers to a method of retrofit kit delivery involving a person leaving a kit at the door and, in the case of a canvas, returning later to offer installation assistance or verify owner installation.
Drip irrigation	The slow, accurate application of water directly to plant root zones with a system of tubes and emitters usually operated under reduced pressure.
Drought	An extended period of below-average precipitation resulting in a reduction of water in available storage that can result in a cutback in water service to customers.
Dual and multiple programming	The capacity of an irrigation controller to schedule the frequency and duration of irrigation cycles to meet varying water requirements of plants served by a system. Grouping plants and laying out irrigation stations by similar water requirements facilitates multiple programming.
Dye test	A test for water leaks, specifically by putting dye in a toilet tank to see if it appears in the bowl.
Effective precipitation	The portion of total rainfall that is available for use by the plant.
Efficiency standard	A value or criteria that establishes target levels of water use for a particular activity.
Effluent	Something that flows out, such as wastewater, treated or untreated, that flows out of a wastewater treatment plant, sewer or industrial outfall.
Emitter	A drip irrigation component that dispenses water to plants at a known rate, measured in gallons per hour.
End use	A fixture, appliance or other specific object or activity that uses water.

Escalation rate	The average rate of increase in the inflation-adjusted future cost of water supply.
Estimated water use	The amount of water estimated to be needed by the landscape during one year.
Estuary	The lower course of a river where its flow is commingled by the sea, resulting in brackish water.
ET factor	A factor used to set a landscape water efficiency goal. Also know as an "adjustment factor."
Evapotranspiration	The quantity of water evaporated from soil surfaces and transpired by plants during a specific time.
External costs and benefits	An external cost is when one party adversely affects another party either by reducing its productivity or well being. An external benefit is where one party beneficially affects another party either by increasing its productivity or its well being, or lowering its costs.
Externalities	External costs and benefits.
Faucet aerator	A flow reduction device that screws on the end of the kitchen or lavatory faucet to add air to the water flow.
Fecal coliform	The coliform bacteria group that are present in the intestinal tracts and feces of humans and other warm-blooded animals. Drinking water with fecal coliform can cause diarrhea and other gastrointestinal illnesses.
Filtration	A water treatment process that involves water passing through sand or other media, where particles and other constituents are trapped and removed from the flow.
Fixed costs	Costs that do not change as output level changes over the time horizon being analyzed.
Fixed rates	Part of a utility bill that is not affected by consumption.
Flapper valve	A pliable valve in the opening at the bottom of a toilet tank that regulates water flow into the toilet bowl.
Flow rate	The rate at which a volume of water flows through pipes, valves, etc. in a given period of time. Often reported as cubic feet per second (cfs) or gallons-per-minute (gpm).
Flush valve	A valve used to expel sediment from irrigation lines. Also, a type of flushing mechanism used in commercial toilets.
Flushometer	A commercial/institutional type toilet, which generates a flush by the opening of a valve directly connected to the pressurized building water system.
Graywater	Untreated (or lightly treated) domestic effluent, not including water from toilets or the kitchen, for use on the property in subsurface landscape irrigation.
Green industry	The trades, professions and disciplines related to landscape and irrigation research, design, installation and management.
Groundwater	Water that has seeped beneath the earth's surface and is stored in the pores and spaces between alluvial materials (sand, gravel or clay).

Groundwater banking	Storing surface water in a groundwater basin, or using surface water in lieu of groundwater, to increase the available groundwater supply.
Groundwater recharge	Percolating or injecting surface water into a groundwater basin to increase the available groundwater supply.
Hardscape	Landscaping that does not permit water to seep into the ground, such as concrete, brick and lumber.
Hardware efficiency	A percentage or fraction value that represents the portion of water applied by an irrigation system that is beneficial to the plants. See distribution uniformity.
H-axis clothes washer	Horizontal-axis clothes washer.
High-efficiency clothes washer	A type of clothes washer meeting certain water and energy standards. It often involves a design where the tub axis is more nearly horizontal than vertical. Clothes are tumbled through water that only fills a fraction of the tub. Also known as a horizontal axis, tumble action or front-loading clothes washer.
High-water-using plants	Plants with a crop coefficient greater than 0.7.
Historic basis	Past water consumption history.
Hot water hybrid	The practice of estimating a resident's total water usage based on metered hot water usage.
Hot water on demand system	A system of pumping hot water more quickly from the water heater to the fixture calling for water for the purpose of reducing the wait time (and associated waste) for hot water.
Hot water ratio billing	The practice of estimating a resident's total water usage based on metered hot water usage.
Hydrologic cycle	Movement of water as it evaporates from rivers, lakes or oceans, into the atmosphere, returns to earth as precipitation, flows into rivers to the ocean and evaporates again.
Hydrozone	A portion of the landscaped area having plants with similar water needs that are served by a valve or set of valves with the same schedule.
Impact head	A type of single-stream rotor that uses the impact of a stream of water to rotate a nozzle in a full or partial circle. Impact heads have large radii and relatively low precipitation rates and do not provide matched precipitation rates for varying arc patterns.
Inclining block rate	A commodity rate whose unit price increases with increasing water use.
Incremental benefits and costs	The next unit of cost required to achieve the next unit of benefit.
Individual metering	The installation of meters for each individual dwelling unit as well as separate common area metering with the local water utility providing customer read, bill and collect services.
Industrial user	Water users that are primarily manufacturers or processors of materials as defined by the Standard Industrial Classifications Code numbers 2000 through 3999.

Infiltration rate	The rate at which water permeates the soil surface, expressed as a depth of water per unit of time (inches-per-hour).
Inflation	The rate of change in a price index.
Infrastructure Leakage Index	In a water supply distribution system, the Infrastructure Leakage Index, ILI, is the ratio of the current level of annual real losses (mostly leakage) to the Unavoidable Annual Real Losses, UARL. It is a good benchmarking performance indicator for comparisons of leakage standing among drinking water utilities.
Institutional user	Water-using establishment dedicated to public service. This includes schools, churches, hospitals and government facilities. All facilities serving these functions are considered institutional regardless of ownership.
Instream uses	The beneficial uses of water within a river or stream, such as providing habitat for aquatic life, sport fishing, river rafting or scenic beauty.
Irrigated area	The portion of a landscape that requires supplemental irrigation, usually expressed in square feet or acres.
Irrigation controller	A mechanical or electronic clock that can be programmed to operate remote-control valves to control watering times.
Irrigation cycle	A scheduled application of water by an irrigation station defined by a start time and its duration. Multiple cycles can be scheduled, separated by time intervals, to allow infiltration of applied water.
Irrigation efficiency	A value representing the amount of water beneficially applied, divided by the total water applied. Also, the product of decimal equivalents representing hardware efficiency and management efficiency.
Irrigation only accounts	Accounts with a separate meter dedicated to non-sewered uses such as landscape irrigation or cooling towers.
Irrigation plan	A two-dimensional plan drawn to scale expressing the layout of irrigation components and component specifications. Layout of pipes may be depicted diagrammatically, but location of irrigation heads and irrigation schedules should be specified.
Irrigation scheduling	The process of developing a schedule for an automatic irrigation system that applies the right amount of water, matched to the plant needs, which varies daily, weekly or seasonally.
Irrigation station	A group of irrigation components, including heads or emitters and pipes, controlled/operated by a remote control valve.
Landscape irrigation auditor	A person who has had landscape water audit training and passed a certification exam.
Landscape water budget	A volume of applied irrigation water expressed as a monthly or yearly amount, based on ETo and the plant material being watered.
Law of the River	A collection of interstate agreements, international treaties, legislation and judicial decisions that form the basis of allocation decisions for the Colorado River.

Leak correlator	An electronic device that uses probes placed on exposed portions of a water distribution system to pinpoint the location of a leak.
Leak detection	The procedure of pinpointing the exact location of leaks from water pipes and fittings.
Leakage management	The organized, proactive functions of a water utility to control distribution system leakage to a economic minimum. Includes appropriate combinations of active leakage control (flow analysis, leak detection) and repair, pressure management and system rehabilitation.
Leak noise logger	A device that gathers and stores sounds used in detecting and pinpointing water distribution system leaks across a given area of the system
Leak survey	The systematic process of listening for leaks in a distribution system.
Life-cycle analysis	Examines the costs and benefits of an action over its entire expected life span.
Limited turf areas	Restriction of turfgrass to a prescribed fraction of the landscape area.
Low flow detector	A part of a water meter register that indicates any flow through the meter. Also, called a Leak Indicator.
Low flow faucet	A faucet fixture that meets 1992 EPAct standards (2.2 gpm or less at 80 psi).
Low flow showerhead	A showerhead that meets 1992 EPAct standards (2.5 gpm or less at 80 psi).
Low flow toilet	A 3.5 gpf toilet, as mandated by California in a 1977 law that took effect 1980.
Low head drainage	Drainage of water from irrigation lines at the lowest elevations in an irrigation station.
Lower basin states	The states of Nevada, Arizona and California, which form part of the Colorado River watershed.
Low-water-using plants	Plants with a crop coefficient of less than 0.3.
Makeup water	Fresh water introduced into a cooling tower to replace water lost to evaporation and blowdown.
Management efficiency	A percentage or fraction of the total applied water that represents the portion beneficially applied. This is determined by scheduling, maintenance and repair of irrigation systems.
Marginal cost	The additional cost incurred by supplying one more unit of water.
Market price	The price for a commodity in a market.
Mass mailing	Mailing information or retrofit kits to many customers – often using a mailing service.
Master meter	A single meter that measures utility usage for an entire property, or an entire building, which usually includes common areas.
Matched precipitation rates	Equal water-delivery rate by sprinkler heads with varying arc patterns within an irrigation station. Matched precipitation rates are required to achieve uniform distribution.

Matched sprinkler heads	Sprinkler heads with the same precipitation rate.
Mediterranean climate	A climate characterized by moderate temperatures throughout the year, dry summers and rainy winters.
Medium-water-using plants	Plants with a crop coefficient of 0.4 to 0.6.
Meter	Device that measures utility usage.
Meter (water)	An instrument for measuring and recording water volume.
Meter register	Mechanical device (sometimes used synonymously with the term "Face") that uses a system of gear reductions to integrate the rotation of the moving element of a meter's measuring chamber into numerical units.
Microclimate	The climate of a specific place within a given area, generally varying by wind and evapotranspiration.
Mixed use meter	A water meter that serves more than one type of end use, such as an office building and its surrounding landscape.
Mulch	A protective covering of various substances, usually organic, such as wood chips, placed on the soil surface around plants to reduce weed growth and evaporation and to maintain even temperatures around plant roots.
Multi-family	Residential housing with multiple dwelling units, such as apartments and condominiums.
Multiple linear regression	Method of determining the relationship between several independent or predictor variables and a dependent variable. The dependent variable must be a continuous variable.
Multiple start times	An irrigation controller's capacity to accept programming of more than one irrigation start-time per station per day.
Municipal and industrial	Water supplies serving humans or man-made activities, as opposed to agricultural water supply.
NAICS (formally SIC codes)	North American Industry Classification System. A consolidation of the codes for the U.S., Canada and Mexico. Produced by the U.S. Office of Management and Budget.
Native and adopted plants	Plants indigenous to an area or from a similar climate that require little or no supplemental irrigation once established.
Net present value	The present value of benefits minus the present value of costs.
Non-potable water	Water that does not, or may not, meet drinking water quality standards.
Non-revenue water	In a distribution system water audit, non-revenue water equals the volume of unbilled authorized consumption (water for fire fighting, system flushing and similar uses) added to real losses and apparent losses.
O&M	Operation and maintenance.
Off-stream	Water use occurring outside the natural stream channel.
Operating pressure	Distribution system water pressure measured in pounds-per-square-inch (psi). Municipal systems are generally maintained between 50 and 80 psi.
Opportunity costs	The true costs faced by a decision maker, measured as the highest valued alternative that is foregone when an action is taken.

Overdraft	A groundwater basin is being overdrafted when, over a number of years, the average amount of water withdrawn from the basin exceeds the average amount of water flowing into the basin.
Overspray	Application of water via sprinkler irrigation to areas other than the intended area.
Partial-capture submetering	Type of submetering where only a portion of the total water consumption in each unit is measured.
Peak use	The maximum demand occurring in a given period, such as hourly or daily or annually.
Per capita residential use	Average daily water use (sales) to residential customers divided by population served.
Per capita use	Water use per person.
Percent switch	A feature of an irrigation controller that allows percent changes in the duration of programmed irrigation.
Plant factor	See crop coefficient.
Point-of-use meter	A meter that measures water flow at the actual usage point, such as a faucet or toilet.
Positive displacement meter	A type of water meter used to measure relatively low flows (such as residential uses).
Potable water	Water that meets federal and state water quality standards for water delivered to utility customers.
Pounds-per-square-inch	A unit measure of pressure. In this case, the pressure exerted by water in a distribution system.
Precipitation rate	Application rate for sprinkler irrigation, generally measured in inches-per-hour.
Pressure assist toilet	A toilet that uses the water distribution system pressure to compress air in a bladder that fills with water after the toilet is flushed. The compressed air forces the water from the bladder into the toilet bowl at an increased velocity.
Pressure loss	The reduction in water pressure due to friction of water against the inner walls of pipe and components.
Pressure reducer	A water system component that reduces the downstream pressure of water, often used in irrigation systems, always used in drip systems.
Pressure regulation	Maintaining distribution system water pressure within certain limits.
Pressure regulating valve	1) A device, often installed downstream of the customer meter, to reduce high pressures to a set amount. Often required where the existing system pressure exceeds 85 psi. 2) A device installed on input water supply mains or irrigation systems to regulate water pressure in a zone or district metered area to protect against pressure surges and to control leakage.
Pressure testing	Subjecting a fully loaded section of a water distribution system to maximum normal pressure (or normal pressure plus a safety factor) against a closed downstream shut-off.
Pressure zone	A three dimensional zone in the water distribution system where the pressure is allowed to vary only within certain limits, generally dictated by the elevation of the water tank serving the zone.

Pressure-compensating emitter	A drip-irrigation emitter designed to deliver water at a consistent flow rate under a range of operating pressure.
Primary treatment	The first stage of a wastewater treatment process in which floating material and large suspended solids are removed by mechanical processes, such as filtration.
Public service announcement	An inexpensive or free advertisement or message on mass media that serves the public good.
Public Trust Doctrine	Doctrine rooted in Roman law, which holds that certain natural resources are the property of all, to be held in trust for the citizens by the state.
Public user	Publicly owned water customers, such as schools, parks and government buildings. Also referred to as institutional customers.
Rain shutoff device	A device connected to an irrigation controller that overrides scheduled irrigation when significant precipitation is detected.
Raw water	Untreated water.
Real losses	In a water distribution system audit, real losses are the physical loss of water from the distribution system prior to reaching the customer. Real losses include leakage from piping and reservoir walls, as well as storage overflows caused by faulty control equipment or operator error. Real losses represent a waste of water and energy resources since they are volumes of water extracted from a source, treated to prevailing standards, but never reaching beneficial use.
Receiver	In a radio frequency based AMR system, the device that re ceives the meter data transmissions for the central data collection device.
Recirculating task	Water that is employed for the same task multiple times. In a cooling tower, water is used to carry heat away from a heat source, cooled by evaporation in a cooling tower and returned to the heat source to repeat the task.
Reclaimed water	Municipal wastewater effluent that is given additional treatment and distributed for reuse in certain applications. Also referred to as recycled water.
Reclamation (water)	Treatment of degraded water for a beneficial purpose.
Recycled water	Used to describe reclaimed water.
Reference evapotranspiration	The water requirements of a standardized landscape plot, specifically, the estimate of the evapotranspiration of a broad expanse of well-watered, 4-to-7 inch-tall cool-season grass.
Remote-control valve	An electric solenoid valve, wired to an irrigation controller, that controls the flow of water to an irrigation station.
Repeater	In a radio frequency based AMR system, the device that receives and amplifies the meter RF signals in order to transmit them to the receiver.
Retention rate	The percent of devices that remain in-place over time after initially being installed or distributed.
Retrofit	1) Replacement of existing water using fixtures or appliances with new and more efficient ones. 2) Replacement of parts for a fixture or appliance to make the device more efficient.

Retrofit on resale	A regulation that requires plumbing fixtures to be upgraded to current code at the time property is sold.
Reuse	Use of treated municipal wastewater effluent for specific, direct, beneficial uses. See reclaimed water. Also used to describe water that is captured on-site and utilized in a new application.
Reverse osmosis	A process to remove dissolved solids, usually salts, from water. Salty water is forced through membranes at high pressure, producing fresh water and a highly concentrated brine.
Riparian rights	A water right based on the ownership of land bordering a river or waterway.
Runoff	Surface flow of water off of a specific area.
Seasonal block rate	A commodity rate that is higher in the peak irrigation season than the off-peak season.
Secondary treatment	The second step in most wastewater treatment systems, which removes most of the oxygen-demanding substances (organics) and light suspended solids. Disinfection is often the final step of secondary treatment.
Secondary wastewater treatment plant	A facility that employs secondary wastewater treatment.
Semiarid climate	A climate characterized by 10 to 20 inches of annual precipitation.
Sensitivity analysis	The process where the assumptions of analysis are tested to determine how much influence they have on the results.
Service area (territory)	The geographic area(s) served by a utility.
Short-term program	A temporary water conservation program put in place to deal with a specific concern such as a water shortage.
SIC Code	A system devised by the federal government to classify industries by their major type of economic activity. The code may extend from two to eight digits. This term has been superceded by the NAICS.
Single-family unit	A residential dwelling unit built with the intent of being occupied by one family. It may be detached or attached (i.e., townhouses).
Soil amendment	Organic and inorganic materials added to soils to improve their texture, nutrients, moisture holding capacity and infiltration rates.
Soil improvement	The addition of soil amendments.
Soil polymer	A natural or synthetic compound that has the capacity to hold water for use by plants. Best suited for container plants or in sandy soil. Can reduce irrigation frequency but does not reduce a plant's water requirement.
Solar radiation	Energy from the sun. The single most dominant factor in determining ET values, measured by a lysimeter.
Spray head	A sprinkler irrigation nozzle installed on a riser that delivers water in a fixed pattern. Flow rates of spray heads are high relative to the area covered by the spray pattern.

Spray irrigation	Sprinkler irrigation using spray heads on fixed or pop-up risers and having relatively high precipitation rates.
Sprinkler irrigation	Overhead delivery of water spray heads, stream rotors or impact heads. Precipitation rates will vary depending on system layout and type of head used.
Sprinkler run time	The minutes of irrigation per day, based on the weekly irrigation requirement and irrigation days per week.
Sprinkler station	A group of sprinklers controlled by the same valve.
Sprinkler valve	The on-off valve, usually electric, that controls an irrigation or sprinkler station.
Station	An irrigated area controlled by a single irrigation valve.
Storm drainage	Surface runoff of water resulting from rain or snow storms.
Stream rotors	Sprinkler irrigation heads that deliver rotating streams of water in full or partial circles. Some types use a gear mechanism and water pressure to generate a single stream or multiple streams. Stream rotors have relatively low precipitation rates, and multiple stream rotors can provide matched precipitation for varying arc patterns.
Structured plumbing system	Properly sized and well insulated hot water main and hot water risers, including a dedicated hot water main segment connecting the farthest hot water point of use to the water heater.
Submetering	The practice of using meters to measure master-metered utility consumption by individual users. Also, see partial-capture submetering and total-capture submetering.
Subsidence	The lowering of ground surface due to extraction of material from subsurface. Can be caused by water or oil extraction from the ground.
Subsurface drip irrigation	The application of water via buried pipe and emitters, with flow rates measured in gallons-per-hour.
Sunken costs	Costs that have already been incurred and are not reversible.
Supply-side measures	Increasing water supply by developing more raw water, generally building reservoirs and canals or drilling groundwater wells.
Surface water	Water that remains on the earth's surface, in rivers, streams, lakes, or reservoirs.
Tall fescue	A hybridized cool-season turfgrass characterized by deeper roots and more drought tolerance than bluegrass.
Telemetry interface unit	A device that translates meter data prior to transmission to a receiver. Also known as a Meter Interface Unit.
Thatch	The buildup of organic material at the base of turfgrass leaf blades. Thatch repels water and reduces infiltration capacity.
Toilet flapper	A pliable valve in the opening at the bottom of a toilet tank that regulates water flow into the toilet bowl.
Toilet tank fill cycle regulator	A device that reduces the amount of water that goes into the overflow tube and hence into the toilet bowl during a toilet flush.
Total-capture submetering	Type of submetering where all of the actual water consumption in each unit is measured.

Transmitter	A radio frequency system component that sends usage data from a meter to a receiver.
Transpiration	The passing of water through living plant membranes into the atmosphere.
Trihalomethanes	Four chemicals that are a reaction byproduct when chlorine is added as a disinfectant to water containing certain organic material. These chemicals are called disinfection byproducts and are regulated by the U.S. EPA. Some of them are suspected carcinogens.
Turbine meter	A type of water meter that generally utilizes a propeller to measure high flows (such as for irrigation or commercial/industrial users).
Turfgrass	Hybridized grasses that, when regularly mowed, form a dense growth of leaf blades and roots.
Unavoidable annual real losses	The low level of leakage that a well managed water distribution system could, in theory, attain assuming that state-of-the-art leakage control technologies are being effectively utilized. A calculation exists to determine the UARL and includes miles of water main, average system pressure and number of service connections as input parameters. The ratio of current annual real losses over the UARL gives the Infrastructure Leakage Index.
Ultra low flush toilet	A toilet that flushes with 1.6 gallons or less.
Uniform block rate	A commodity rate that does not vary with the amount of water use.
Uniformity	See distribution uniformity.
U.S. Bureau of Reclamation	Federal agency that built and operates water projects in the western United States. Part of the Department of Interior.
Unmetered water	Delivered water that is not measured for accounting and billing purposes.
UPC	The model plumbing code, prepared by International Association of Plumbing and Mechanical Officials, that the 22 western States use as the basis for their State plumbing codes.
Upper basin states	The states of Wyoming, Colorado, Utah and New Mexico which form part of the Colorado River watershed.
Usable groundwater storage	The quantity of additional space available for water storage in a groundwater basin without outflow.
User class	Customers having similar characteristics (commercial, single-family residential, etc.) grouped together for billing or program purposes.
Utility	Used alternately to describe a provided resource, such as water, gas, electric as well as for the provider of the resource
Utility allocation	Determining resident charges for utilities by means of a formula rather than measured usage.
Valve	Device to control the flow of water.
Variable costs	The costs that change in response to changes in level of output.

Warm-season grass	Grasses that grow vigorously in warm summer months and then generally lose their green color and are dormant in winter, if the average air temperature drops below 50 to 60° F; some may die if exposed to subfreezing temperatures for extended periods. Examples of warm season grasses include Bermuda, Zoysia and Buffalo grasses.
Wastewater	Effluent water from residences, businesses and other water users that contains contamination. Sewage.
Wastewater treatment plant	A facility designed to remove contamination from municipal and industrial wastewater prior to discharge into surface waters.
Water allowance	The quantity of water needed to maintain plants and other features in an ornamental landscape.
Water audit	1) An on-site survey of an irrigation system or other water use setting to measure hardware and management efficiency and generate recommendations to improve its efficiency. 2) For water distribution systems, a thorough examination of the accuracy of water agency records and system control equipment to identify, quantify and verify water and revenue losses.
Water banking	A process whereby unused water allocations are held in storage and made available for future water allocations.
Water budget	The quantity of water needed to maintain plants and other features in an ornamental landscape.
Water budget approach	A method of establishing water-efficiency standards for landscapes by providing the water necessary to meet the ET of the landscaped area.
Water conservation	The U.S. Water Resources Council defines water conservation as activities designed to (1) reduce the demand for water, (2) improve efficiency in use and reduce losses and waste of water, and (3) improve land management practices to conserve water.
Waterless urinal	A urinal that works without water or flush valves. Instead a cartridge filled with a sealant liquid is placed in the drain. The lighter than water sealant floats on top of the urine preventing odors from being released into the air and allowing urine to pass into the sewer system without the use of water. The urinals are installed into the regular waste lines and the cartridge and sealant must be periodically replaced, but water supply lines and flush valves are not necessary. The urinal bowl surfaces are urine repellent and daily cleaning procedures are typically the same as for flushed urinals.
Water meter size	Normally corresponds to the pipe bore, for example 1”. For some models a second designation refers to the matching pipe end connections. For example, a 5/8” x 3/4” meter has a nominal 5/8” and 3/4” straight pipe threads.
Water rationing	Mandatory water restrictions temporarily placed on customers, as with short-term or drought programs.

Water reuse	Use of treated municipal wastewater effluent for specific, direct and beneficial uses. See reclaimed water. Also used to describe water that is captured on-site and utilized in a new application.
Water right	A legal entitlement authorizing water to be diverted from a specified source and put to beneficial, non-wasteful use. It is a property right, but the holder doesn't possess the water itself – they possess the right to use it. The primary types of water rights are appropriative and riparian. There are also prescriptive (openly taking water to which someone else has the right) and pueblo (a municipal right based on Spanish and Mexican law) water rights.
Water sales	Water deliveries that are metered and billed based on the quantity of use.
Water softener	A device that reduces water hardness by replacing calcium and magnesium ions with sodium ions.
Water transfers	The exchange of a water allocation from a willing seller to a buyer, usually between irrigation district (seller) and urban water agency (buyer).
Water use efficiency	A measure of the amount of water used versus the minimum amount required to perform a specific task. In irrigation, the amount of water beneficially applied divided by the total water applied.
Water use profile	A quantitative description (often displayed graphically) of the different water uses at a residence, business site or utility service area.
Water-efficient landscape	A landscape that minimizes water requirements and consumption through proper design, installation and management.
Watershed	A land area, defined by topography, soil and drainage characteristics, within which raw waters are contained. They can collect to form a stream or percolate into the ground.
Waterworks bronze	Refers to one of two generally accepted alloys, one with a nominal composition of 81% copper, 3% tin, 7% lead and 9% zinc or another with a nominal composition of 85% copper, 5% each tin, lead and zinc.
Wetlands	A lowland area, such as a marsh or swamp, that is saturated with moisture, and often the natural habitat of abundant wildlife.
Wetting area (pattern)	The soil area wetted by a sprinkler, bubbler or low-volume emitter.
Wholesale water agency	A water utility that develops and distributes water not for delivery to individual customers, but to other retail water purveyors.
Willingness to accept	The amount one would have to pay an individual if she could be induced by a payment to go without an item.
Willingness to pay	The amount an individual would be willing to pay if she could obtain the item by making a payment.

Xeriscape	Landscaping practice based on seven principles: proper planning and design; soil analysis and improvement; practical turf areas; appropriate plant selection; efficient irrigation; mulching; and appropriate maintenance.
Zero footprint	The complete reduction and/or offset of the potable water demand of a proposed urban development project by conservation, use of recycled water or other measures.
Zero read test	A test for water leakage on customer piping using a feature of the customer's water meter.

Units of Measurement

af	acre-feet, = 325,851 gallons or 43,560 cubic feet
afa	acre-feet per annum (year)
BTU	British Thermal Unit
ccf	Hundred cubic feet = 748 gal.
cf	Cubic feet = 7.48 gal.
gal	Gallons, 1 gallon = 0.134 cubic feet
gcd	Gallons per capita per day
gpcd	Gallons per capita per day
gpd	Gallons per day
gpf	Gallons per flush (of a toilet or urinal)
gpm	Gallons per minute
gpsf	Gallons per square foot
hcf	Hundred cubic feet = 748 gal.
hr	Hours
kgal	One thousand gallons = 134 cubic feet
kWh	Kilowatt-hours
l	Liters
lcd	Liters per capita per day
lpf	Liters per flush (of a toilet or urinal)
MG	Million gallons
mgd	Millions of gallons per day
MG/yr	Millions of gallons per year
min.	minute
psi	Pounds per square inch
sf	Square feet

Acronyms

AC	Alternating current
ASCE	American Society of Civil Engineers, www.asce.org
AMR	Automatic meter reading equipment
ANSI	American National Standards Institute, www.ansi.org
ARM	Automated remote metering
ASME	American Society of Mechanical Engineers, www.asme.org
AWC	Average winter consumption

AWR	Applied water requirement, the gross amount of water that must be applied to a plant or grass to accommodate evapotranspiration including runoff and water required to overcome system efficiencies
AWWA	American Water Works Association, www.awwa.org
AwwaRF	American Water Works Association Research Foundation, www.awwarf.org
BMP	Best management practice
CALFED	A joint effort by state and federal agencies to resolve water supply and quality issues involving the San Francisco Bay and Sacramento-San Joaquin Delta
CC&Rs	Conditions, covenants and restrictions
CEE	Consortium for Energy Efficiency, www.cee1.org
CI	Commercial and industrial
CII	Commercial, industrial and institutional
CIMIS	California Irrigation Management Information System, www.cimis.water.ca.gov
CIS	Customer information system
CUSTID	Customer identification number
CUWCC	California Urban Water Conservation Council. Formed in 1991 with a memorandum of understanding between water agencies and public interest groups regarding the implementation of cost-effective urban water conservation measures in California. A voluntary, non-regulatory organization. www.cuwcc.org
DC	Direct current
DCU	Data collection unit (in an AMR system)
DU	Dwelling unit
DU	Distribution uniformity- a measure of irrigation efficiency
DEIR	Draft Environmental Impact Report
EF	Energy factor
EGLS	Estimated generalized least-squares
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency, www.epa.gov
EPAct	Energy Policy Act, first implemented in Oct. 1992
ER	Effective rainfall
ET	Evapotranspiration, water loss via evaporation from plant surfaces and soil at base of plant and transpiration from plant leaf or grass surfaces
ETo	Reference ET for a standard crop of grass 4 inches to 7 inches tall
HD	High density, refers to MF and other types of units constructed in dense configuration
HOA	Homeowners association
HUD	U.S. Department of Housing and Urban Development, www.hud.gov
IA	Irrigation Association, www.irrigation.org
IE	Irrigation Efficiency
ILI	Infrastructure Leakage Index
IRP	Integrated resources planning
KL	Landscape coefficient (includes crop coefficient, and coefficients for shade and slope)
LF	Low-flow
LEED	Leadership in Energy and Environmental Design (U.S. Green Bldg Council,) www.usgbc.org/LEED
LID	Low-impact development (for storm water quality)

MaP	Maximum performance testing (of toilets and other fixtures). This is a trademarked label.
MEF	Modified energy factor
MF	Multi-family dwelling unit
MFR	Multi-family residential
MIU	Meter interface unit. Also known as a Telemetry Interface Unit.
N	Number. The number of cases from which a summary statistic or analysis is derived.
NIST	National Institute of Standards and Technology, www.nist.gov
NPV	Net present value of a series of payments, costs or benefits
P-value	The probability value of a statistical hypothesis test; the probability of getting a value of the test statistic as extreme or more extreme than that observed by chance alone, if the null hypothesis is true
PAC	Project advisory committee
POC	Project oversight committee
POU	Point of use
PUC	Public utilities commission
PV	Present value of a series of payments, costs or benefits
OLS	Ordinary least squares
R 2	Coefficient of determination
RBC	Read, bill and collect
REUWS	Residential End Uses of Water Study (AWWA 1999)
RF	Radio frequency
RMSE	Root mean square error
RUBS	Ratio utility billing systems, a calculation method that uses a compensation factor to allocate utility costs among users, most often used in the context of multi-family or commercial billing
SCS	Soil Conservation Service now Natural Resources Conservation Service, www.nrcs.usda.gov
SF	Single-family dwelling unit (detached unless otherwise specified)
SWAT	Smart Water Application Technology: class of irrigation controllers using soil, weather or ET-based measurements to control irrigation scheduling
St. Dev.	Standard deviation
SUR	Seemingly unrelated regression
SWRS	Subregional water reclamation system
t-test	An inferential statistical test for comparing two means. A dependent or paired t-test is used to compare the mean difference score between paired measurements
UARL	Unavoidable annual real losses
ULF	Ultra-low flow
ULFT	Ultra-low flow toilet. Standard "low consumption toilets." Refers to toilets which consume 1.6 gallons (6 liters) or less of water when flushed. A bit of a misnomer as toilets do not "flow" unless they are broken and are wasting water.
UNAR	Unified North American Requirements for toilet fixtures (and other devices)
WD	Water district
WF	Water factor
WW	Wastewater

RESOURCES

North Carolina Assistance Providers Addressing Water Efficiency, Pollution Prevention and Energy Efficiency

N.C. Division of Pollution Prevention and Environmental Assistance

N.C. Department of Environment and Natural Resources
1639 Mail Service Center
Raleigh, NC 27699-1639
Phone: (800) 763-0136
Web site: http://www.p2pays.org

The North Carolina Division of Pollution Prevention and Environmental Assistance provides free, non-regulatory on-site pollution prevention assessments, including water efficiency to businesses, industries and municipalities in North Carolina. DPPEA resources also include technical fact sheets and manuals on pollution prevention and a clearinghouse of more than 44,000 references. A matching grant program is also available for innovative pollution prevention and water efficient technologies.

N.C. State Energy Office

N.C. Department of Administration
1340 Mail Service Center
Raleigh, NC 27699-1340
Phone: (800) 662-7131
Web site: http://www.energync.net

The North Carolina State Energy Office provides energy information and assistance for businesses, government agencies, community colleges, universities, schools and the residential, commercial and industrial sectors.

N.C. Division of Water Resources

N.C. Department of Environment and Natural Resources
1611 Mail Service Center
Raleigh, NC 27699-1611
Phone: (919) 733-4064
Web site: http://www.ncwater.org

The Division of Water Resources provides technical assistance to water systems with water supply planning, leak detection, water conservation and water shortage response planning.

N.C. Solar Center

N.C. State University
College of Engineering
Box 7401
Raleigh, NC 27695-7401
Phone: (800) 33-NCSUN
Web site: http://www.ncsc.ncsu.edu

The N.C. Solar Center offers assessments of potential renewable energy applications for commercial and industrial sites. Often conducted in conjunction with surveys to identify savings in energy, productivity and waste by the NCSU Industrial Assessment Center and the IES Energy Management Program, the Solar Center's assessments focus on practical ways companies can incorporate renewable energy.

N.C. State University's Industrial Extension Service

N.C. State University
College of Engineering
Raleigh, NC 27695
Phone: (919) 515-2358
Web site: http://www.ies.ncsu.edu

N.C. State University's Industrial Extension Service can provide energy audits and energy conservation courses for a small fee. This assistance targets nearly all basic unit operations of a manufacturing facility ranging from compressors to HVAC units.

N.C. State University's Industrial Extension Service Manufacturing Extension Partnership

College of Engineering
Raleigh, NC 27695
Phone: (800) 227-0264
Web site: http://www.mep.nist.gov

The N.C. Manufacturing Extension Partnership team of engineering specialists offers technical assistance to North Carolina manufactures such as industrial management, computer applications, plant engineering and material handling. Limited technical assistance, information and site visits are provided free of charge. More extensive support and consulting are priced according to project length and required resources.

N.C. Cooperative Extension Service
N.C. State University
College of Agriculture and Life Sciences
Raleigh, NC 27695
Phone: (919) 515-3173
Web site: http://www.ces.ncsu.edu
The Cooperative Extension Service can provide technical assistance, publications and research about water efficient landscaping. Also see your local county agents.

Waste Reduction Partners - West
Land-of-Sky Regional Council
339 New Leicester Highway
Suite 140
Asheville, NC 28806
Phone: (828) 251-6622
Web Site: http://www.landofsky.org/wrp

Waste Reduction Partners - Central
Triangle J Council of Governments
4307 Emperor Blvd., Suite 110
Durham, NC 27703
Phone: 919-558-2702
Web site:
http://www.tjcog.dst.nc.us/regplan/wastereduce.shtml
Waste Reduction Partners, a team of highly experienced volunteer engineers, architects and scientists, provides businesses and industries with no-cost waste and energy reduction assessments and technical assistance.

State Government Organizations

N.C. Division of Pollution Prevention and Environmental Assistance
(Technical and financial assistance to businesses, industries and municipalities)
1639 Mail Service Center
Raleigh, NC 27699-1639
Phone: (800) 763-0136 or (919) 715-6500
Web site: http://www.p2pays.org

N.C. Division of Water Resources
(Water supply assistance, planning, allocation and conservation)
1611 Mail Service Center
Raleigh, NC 27699-1611
Phone: (919) 733-4064
Web site: http://www.ncwater.org

N.C. Division of Water Quality
(Water reuse permitting, wastewater permitting, tax credits, concentration/mass-based wastewater permit issues)
512 N. Salisbury Street
Raleigh, NC 27604
Phone: (919) 807-6300
Web site: http://h2o.enr.state.nc.us

N.C. State Energy Office
(The Utilities Savings Initiative, Performance Contracting and financial assistance)
N.C. Department of Commerce
1340 Mail Service Center
Raleigh, NC 27699-1340
Phone: (919) 733-2230
Web Site: http://www.energync.net

National Water Efficiency Programs

American Water Works Association
6666 West Quincy Avenue
Denver, CO 80235
Phone: (800) 926-7337
Web site: http://www.awwa.org
The American Water Works Association is an international nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply.

N.C. American Water Works Association and Water Environment Association
3701 National Drive, Suite 205
Raleigh NC 27612
Phone: (919) 784-9030
Web Site: http://www.ncsafewater.org

U.S. EPA's WaterSense Partnership Program
Office of Wastewater Management (4204M)
1200 Pennsylvania Avenue N.W
Washington, D.C 20460
Phone: (866) 987-7367
Web site: http://www.epa.gov/watersense
WaterSense, a partnership program, seeks to protect the future of our nation's water supply by promoting water efficiency by assisting consumers in identifying water-efficient products and programs.

Waterwiser
6666 West Quincy Avenue
Denver, CO 80235
Phone: (800) 926-7337
Web site: http://www.waterwiser.org
Waterwiser offers a comprehensive clearinghouse of resources on water conservation, efficiency and demand management for conservation professionals and the larger water supply community.

Irrigation Association
6540 Arlington Blvd.
Falls Church, VA
Phone: (703) 536-7080
Web site: http://www.irrigation.org
A WaterSense partner. Industry association provides BMP for outdoor watering. International standards, advocator and certifies irrigation professionals.

Landscaping/Irrigation Associations

American Society of Irrigation Consultants
P.O Box 426
Bryron, CA 94514-0426
Phone: (925) 516-1124
Web site: http://www.asic.org

Carolina Irrigation Association
106 Main Street
Brookneal, VA 24528
Phone: (800) 682-7774
Web site: http://www.carolinasirr.org

N.C. Nursery & Landscape Association
968 Trinity Road
Raleigh, NC 27604
Phone: (919) 816-9119
Web site: http://www.ncan.com

Other Water Resource Information

Sustainable Office Tool Kit
Georgia Dept. of Natural Resources
Web site: http://www.p2ad.org/toolkit
The Sustainable Office Toolkit is a set of resources and tools developed to help offices of all types and size move toward sustainability through practices such as recycling, energy and water conservation and "green" building.

Toilet Information, testing and repair
Web site: http://www.toiletology.com
This Web site contains information on toilet care and repair including classroom-like lessons and how-to videos.

WATERGY
U.S. Dept. of Energy
Web site: http://www1.eere.energy.gov/femp/information/download_watergy.html
WATERGY is a spreadsheet model that uses water/energy relationship assumptions to analyze the potential of water savings and associated energy savings.

Water Librarian's home page
Web site: http://www.interleaves.org/~rteeter/waterlib.html
The Water Librarians' Web site provides links for dealing with water and related topics; links to subject pages, libraries, publishers, collection development and current awareness sources.

Waste Reduction Resource Center
Web site: http://wrrc.p2pays.org
The Waste Reduction Resource Center provides pollution prevention technical support to the states in EPA Region IV. WRRC's Web site contains on online library, core references for many industrial sectors, vendor library and training courses.

Vendors

Use local resources first. Many suppliers that a facility currently uses may represent manufacturers of water efficient plumbing hardware, fixtures, controls, treatment and process equipment. Visit company Web sites for more information.

Auditing Tools
MicroWier Company LLC (503) 235-0792

Commercial Bathroom Efficiency
Bradley Corporation (800) 272-3539
Chicago Faucet Company (847) 803-5000
Coyne & Delany Co. (434) 296-0166
Kohler Plumbing (800) 456-4537
Microphor Inc. (800) 358-8280
Sloan Valve Company (800) 9-VALVE-9

Cooling Tower and Boiler Water Treatment and Control
Marley Cooling Towers (913) 664-7400
Nalco Chemical Co. (630) 305-1000

Foodservice Dishwashers
Champion (877) 983-3663
Hobart Corporation Representative (937) 332-3000

Foodservice Plumbing
Fisher Manufacturing Company (800) 421-6162
Niagara Conservation (800) 831-8383
T&S Brass and Bronze Works (800) 476-4103

General Domestic/Plumbing
American Standard Inc. (800) 442-1902
Caroma (800) 605-4218 x88
Crane Plumbing (800) 546-5476
Delta Faucet Co. (800) 345-3358
Eljer Plumbingware (800) 423-5537
Elkay Manufacturing Co. (630) 572-3192
Gerber Plumbing Fixtures Corp. (888) 648-6466
Kohler (800) 456-4537
Mansfield Plumbing Products (800) 999-1459
Niboc Inc. (574) 295-3000
Niagra Conservation (800) 831-8383
Sloan Valve Co. (800) 580-7141
Toto (888) 295-8134
U.S. Brass Inc. (630) 629-9340
Universal-Rundle (800) 741-3034
Zurn Industries (800) 997-3876
Plumbing vendor Web site:
http://www.plumbingnet.com/listc.html

Irrigation Suppliers - N.C.
John Deere Landscapes -
http://www.johndeerelandscapes.com
Smith Turf Irrigation - http://www.smithturf.com

Laundry Water Reuse
GuestCare Inc. (301) 526-0922

Pressure Reducing Valves
Aqua Saver (water saving devices for gravity toilets) (888) 328-2385
Cash, A.W. Valve Mfg. (205) 775-8200
Water Saving Toilet Retrofits
Rectorseal Corp (Early Closing Flapper Valves) (800) 231-3354
Watts Regulator Co. (978) 688-1811
Wilkins (805) 238-7100

Pressurized Flush Toilet
Sloan Valve Flushmate (800) 533-3460

Spray Nozzles
FOGG-IT Nozzle Co. (415) 665-1212
Milton Industries Inc. (773) 235-9400
Spraying Systems Co. (800) 95-SPRAY

Valve Shut-off (foot controlled)
Pedal Valves Inc. (800) 431-3668
T&S Brass and Bronze Works (800) 476-4103

Waterless Composting Toilet
Bio-Sun Systems Inc. (570) 537-2200

Vehicle Washing Water Recycle
California Steam (800) 432-7999
Custom Applied Technology Corp. (888) 536-7100
Earth Care Technologies (479) 824-5511
Kleer-Flo (800) 950-8020
N/S Corp. (800) 782-1582
Sioux Steam Cleaner Corp. (888) 763-8833
Sobrite Technologies (309) 467-2335
Specified Process Equipment Co. (707) 747-3466
Waste Water Management Inc. (703) 846-0098

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