BMP #1 – Water Management Planning

A successful water management program starts with development of a comprehensive water management plan. This plan should provide clear information about how a facility uses its water, from the time it is piped onto the facility through its ultimate disposal. Knowing how you currently use water and what it costs will enable you to make the most appropriate water management decisions. This plan should be included within existing facility operating plans.

For more information on this and other FEMP Water Efficiency Best Management Practices (BMPs), please see the resources section.

Water Management Plan

Develop or update facility water management plans to include at a minimum the following:

Water Use Policy Statement and Goals

Senior management should indicate their support for water efficiency in a material way. They can indicate their support in two important ways: First, by providing a written policy statement that ties water efficiency into the long term operating objective of the facility or organization. Second, management must make the necessary staff and financial resources available to track water use, maintain equipment, and implement cost-effective water use reduction projects.

The facility should translate its water efficiency policy into specific water use reduction targets, in coordination with its headquarters organization. Each federal agency is directed *"Beginning in FY 2008, [to] reduce water consumption intensity, relative to the baseline of the agency's water consumption in FY 2007, through life-cycle cost-effective measures by 2 percent annually through the end of fiscal year 2015 or 16 percent by the end of FY 2015."* The numeric target will only be achieved at the agency level if specific reductions are achieved at the facility level.

The facility Environmental Management System (EMS) can serve as an excellent existing structure to establish policies and goals related to water use, and monitor progress, once water use is identified as a significant environmental aspect of the facility. See BMP #2 for additional information.

Utility Information

The purpose of this section is to identify how much you are paying for water and sewer service on a unit cost basis, verify that you are paying the right amount, and identify any services your utility might provide to help you manage your water more efficiently. Appropriate utility information should include the following:

- Contact information for all water and wastewater utilities.
- Current rate schedules and alternative schedules appropriate for your usage or facility type. You want to be sure you are paying the best rate.
- Copies of water/sewer bills for the past 2 years. This will help you identify inaccuracies and determine that you are using the appropriate rate structure.
- Information on financial or technical assistance available from the utilities to help with facility water planning and implementing water efficiency programs. Sometimes energy utilities offer assistance on water efficiency.
- Contact information for the agency or office that pays the water/sewer bills.
- Production information, if the facility produces its own wastewater.

Water Use Information

The most important step in creating a water management plan is to establish a water balance for the facility, whereby you identify, and quantify to the extent possible, how you currently use water. Most federal facilities have metered data for total water use, and may have limited to no submetering data on component uses. However, even when no submetering data are available, a walk though audit of the facility, coupled with a basic understanding of how water is being used and some engineering judgment, will enable the assessor to create a relatively complete accounting of how water is being used, and the approximate quantity used for each purpose. This basic level of understanding is crucial; once you have a good understanding of how you are using water, and how much you are using for each purpose, you will have a solid basis to identify potential water saving opportunities.

The first step in the assessment is to analyze water use trends at your facility. Plot the water use data from the utility water bills for the prior two years. Is water use increasing, deceasing, or steady? Do you know why? Is there a seasonal pattern to water use? This is often the case when irrigation water is used or cooling water demand increases in the summer months.

Second, create an inventory of all water using activities. The list of other BMPs in this guide provides a good checklist to start with (e.g., irrigation, sanitary fixtures and fittings, boiler/steam systems, single pass cooling systems, cooling tower systems, and other process related equipment). You may need to tap the expertise of others at the facility with direct knowledge of building mechanical systems and process equipment to generate a complete inventory. This step should include a walk-through audit of the facility to identify all significant water using processes and associated operating characteristics. As part of the walk-through, pay particular attention to drain lines plumbed to floor drains in building mechanical spaces and utility chases. Trace these back to the originating equipment to make sure you have them on your inventory.

Third, for any of the water uses on the inventory, obtain any submetering data that may be available. Any such data will help quantify that particular use. You can also make a quick, rough estimate of continuous uses (e.g., once though cooling) using a bucket and stopwatch technique.

Fourth, evaluate any seasonal patterns and compare this to your inventory of uses. Are any uses seasonal in nature, such as cooling tower use or irrigation? The seasonal pattern of water use (peak use) can help you quantify to these uses.

Fifth, use supplemental data to create engineering estimates of use. For example, you can estimate sanitary water use based on number of occupants and daily use per occupant, cooling tower use based on cooling capacity and load factor (see BMP #10), irrigation water use based on irrigated area and inches of water applied (discuss with your irrigation contractor), and water use of operating equipment based on water use per cycle, and frequency of cycles.

Finally, after you have been through this process, evaluate the results. Some questions to ask: Does the inventory and associated water use account for most of the metered water use? If not, have you missed something, or might there by a leak (see BMP#3)? Once you have stepped through this process, you will know what your big water using activities are, and this will help to prioritize water saving opportunities.

Note that your local water utility or headquarters organization may have water efficiency assessment staff that can help you with this assessment activity.

If you do not have metered total water use information for your facility, examine the component water uses in your estimating basis, and the relative contribution of each component. This will help you prioritize your saving opportunities.

Metering or Measurement Plan

Once you have conducted the assessment, evaluate your biggest water using activities, and the quality of data you have for that use. Consider installing submeters on high water using processes such as cooling towers and irrigation systems. You can more carefully control processes when you have accurate, quantitative data.

Your plan should assign responsibility to track water use on an ongoing basis. Continue to plot total water use as new water bills become available. Also plot any available submetered data. Evaluate trends and investigate and resolve any unexpected deviations in water use. Track water use reductions and publicize your success.

Emergency Response Information

Develop water emergency and/or drought contingency plans that will describe how your facility will meet minimum water needs in an emergency or reduce water consumption in a drought or other water shortage. This should be done in conjunction with your local water supplier.

Comprehensive Planning

Inform staff, contractors, and the public of the priority your agency or facility places on water and energy efficiency. Ensure that they take water supply, wastewater, storm water issues and water efficiency BMPs into account when making equipment purchases, and at the earliest stages of planning and design for renovation and new construction.

Opportunity Assessment

The water balance described above will provide you with an inventory of your water uses, and the relative magnitude of each use. For each of these, consider the BMPs discussed in the following sections. Include recommended operation and maintenance practices in your facility operation and maintenance documentation. Develop a comprehensive list of potential capital improvement projects that will reduce water use, noting the cost, potential water savings, and payback of each. This list should provide a prioritized basis to include these projects in your capital planning and budgeting process.

Coordination with Facility Environmental Management Systems (EMS)

Under EO 13423, EMS is the primary management approach for addressing environmental aspects under the order, establishing objectives and targets to ensure implementation of the order, as well as collecting, analyzing and reporting of information to measure performance. As such, water management planning and implementation should not be considered separate and distinct from EMS. Rather, both are part of the same whole. For example, the policy statement and goals discussed above should be consistent with your EMS. The water use information developed here should inform your evaluation of environmental impacts and aspects under your EMS. The approach you implement for water management should follow the Plan, Do, Check, Act model established under your EMS.

- Plan – Develop a water management plan, including establishing goals.
- Do – Implement the plan, including staff training and operational controls. Implementation of projects identified in the opportunity assessment.
- Check – Measure plan implementation.
- Act – Review progress and update the plan, as necessary.

Water Management Planning Resources

Arizona Municipal Water Users Association, Facility Manager's Guide to Water Management: http://www.amwua.org/conservation/facility_managers_guide.pdf

General Services Administration, Water Management Guide: http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/waterguide_new_R2E-c-t-r_0Z5RDZ-i34K-pR.pdf

North Carolina Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities: http://www.p2pays.org/ref/01/00692.pdf

BMP #2 – Information and Education Programs

Background

Educating users is very important if water efficiency technologies and methods are to be successful. Experience shows that it is not enough to install a retrofit or water saving technology in a facility. New operation procedures, retrofits, and replacements are most effective when employees, contractors and the public know what the new technology or methods are and how to use them properly.

An additional benefit to water efficiency is positive public opinion. If your facility is doing its part to save the community resources, let them know. Informing the public about your facilities commitment to reduce waste is good news. The news media is often interested in facilities that take a proactive stand on water efficiency. For more information on this and other FEMP Water Efficiency Best Management Practices (BMPs), please see the resources section.

Internal Options

- Establish a user-friendly hot line or other systems to report leaks or other wastes of water and energy. Repair leaks promptly to encourage continued participation.
- Keep employees informed about your commitment to water efficiency, your ongoing improvement programs, and any program successes. Start a water column in your building or agency newsletter featuring how much water has been saved through the water management program. Send information via e-mail.
- Share information with employees on how water is used at your facility, and how much water is used for each application. This will help them understand how their actions can help reduce water use in specific areas.
- Place sign and placards near new equipment so it is easy to understand the new technology and how to use it properly.
- Start a suggestion and incentive system to recognize and encourage water saving in your facility. Consider distributing efficiency devices. Communicate progress towards achieving water use reduction goals.
- Conduct regular training workshops for those persons that will be implementing the BMPs, including maintenance personnel to keep them up to date on operational changes and maintenance procedures.
- Integrate water management into your facility Environmental Management System (EMS). Consider water use as an environmental aspect under your EMS. Your existing EMS team and procedures can serve as a powerful method to involve and train employees, and monitor and communicate progress.

External Options

- Work with local utilities to develop comprehensive programs and share your successes with other similar facilities.
- Invite members of the local news media to tour your facility and see first-hand the efficiency program and successes you have achieved.
- Create displays presenting your water savings results for posting in your lobby and other public reception areas.
- Develop Web sites, brochures, and other materials for distribution to employees and the public describing your program, goals, and successes.

BMP #3 - Distribution System Audits, Leak Detection and Repair

Background

A distribution system audit, leak detection, and repair program can help facilities reduce water losses and make better use of limited water resources. If you are located at the average, circa 1940's, military facility it is possible that more than 10 percent of your total water production and purchases may be lost to system leaks or poor metering practices. Regular surveys of distribution systems should always be conducted prior to obtaining additional water supplies and can have substantial benefits including:

- Reduced water losses. Reducing water losses will help stretch the existing supplies to meet increasing demand. This could help defer the construction of new water facilities such as wells, reservoirs, or treatment plants.
- Reduced operating costs. Repairing leaks will save money by reducing power costs to deliver water, and reduce chemical costs to treat water.
- Increased knowledge of the distribution system. As personnel become more familiar with the system including knowing the location of mains and valves, they are able to respond more quickly to emergencies such as main breaks.
- Reduce property damage. Repairing system leaks can prevent damage to property and safeguards public health and safety.
- Improved justification for water management, By conducting routine water audits and verifying production and end point meters, better accounting will result and help validate the need to reduce water losses.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operations and Maintenance

- Complete a prescreening system audit to determine the need for a full-scale system audit using one of the following methods. Recommend that every two years:
    - Determine authorized uses
    - Determine other system verifiable uses
    - Determine total supply into the system
    - Divide authorized uses plus other verifiable uses by total supply into the system. If this quantity is less than 0.9, a full-scale system audit is indicated.

Or

- Once a system audit has been conducted, obtain and monitor minimum system flow. This is usually the flow rate at around 3 or 4 AM. Significant increases to this amount can be assumed to be leak-related and would indicate that a full-scale leak detection survey is necessary.
- When indicated, facilities shall complete full-scale water audits using the latest edition of the American Water Works Association Water Audit Software found at http://www.awwa.org/Resources/Content.cfm?ItemNumber=590

Retrofit and Replacement Options

- Repair leaks or replace pipes when leaks are found.
- For specifics on this technology, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out

the benefits of input from experienced contractors or other Governmental agencies (DOD, CERL, DOE, FEMP, etc.)

Distribution System Audits, Leak Detection and Repair Resources

Water Audits and Loss Control Programs, American Water Works Association, Manual of Supply Practices. AWWA Number M36

Kunkel, G. et al, 2003. Water Loss Control Committee Report: Applying Worldwide Best Management Practices in Water Loss Control. Journal AWWA, 95:8:65

Preventing Water Loss in Water Distribution Systems: Money Saving Leak Detection Programs. US Army Corp of Engineers Construction Engineering Research Laboratory, Technical Report Number N-86/05

BMP #4 – Water-Efficient Landscaping

Background

In most locations, traditional landscapes require supplemental water to thrive. For example, Kentucky bluegrass is native to regions that receive in excess of 40 inches per year of precipitation, but it is commonly planted in areas across the country that receive much less precipitation. To make up the difference between a plant's water requirement and the natural precipitation in your area, additional water must usually be added in the form of irrigation. Depending on your climate, water applied outdoors may be a substantial portion of your total water use. If your facility includes any irrigated landscape, then exterior water use should be an important part of your overall water efficiency program.

There are two facets of outdoor water use efficiency:

1. Designing a landscape that requires minimal supplemental water; and
2. Designing, installing, and maintaining an irrigation system that applies the appropriate amount of supplemental water in an efficient manner. (see Best Management Practice #5).

Water-efficient landscapes using native and other "climate appropriate" landscape materials can reduce irrigation water use by more than 50 percent, stand up better to drought, reduce drought loss or damage, and require less time to maintain, lowering maintenance costs. Reduced turf and other irrigated areas can also significantly reduce time and money spent mowing, fertilizing, removing green wastes and maintaining landscapes.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Periodically review all landscape service and maintenance agreements to incorporate a high priority for water, chemicals, and energy efficiency.
- Consider hiring landscape contractors that focus on water-efficient or climate appropriate landscaping. Recommend existing contractors attend courses or seminars to learn these techniques.
- Encourage landscape contractors to report and/or fix problems. Many landscape contractors not only install and maintain the plants in your landscape, but also install and maintain the irrigation system. They can help identify and report leaks or other inefficiencies in the landscape.
- Add mulch to plant beds. Mulch decreases the water lost from the soil by evaporation and also helps reduce weed growth.
- Maintain a sufficient quantity of good topsoil of 4 to 6 inches to capture the storm water as it falls and not let it run off and to release the moisture back to the plant material over time which may reduce irrigation requirements.
- Recirculate water in decorative fountains, ponds and waterfalls and shut off when possible to reduce evaporation losses. Check water recirculation systems annually for leaks and other damage. Consider using non-potable water in these systems.
- Alternate your turf mowing height between low and high levels. This encourages roots to grow deeply and helps allow plants to go longer between watering sessions.
- Keep the irrigated landscape weed free so that valuable water is consumed only by decorative landscape.
- Stop using water to clean sidewalks, driveways, parking lots, tennis courts, pool deck, and other hardscapes.

Retrofit Options

- Select drought tolerant or climate appropriate turf, trees, shrubs and ground cover when replanting landscaped areas.
- Consider reducing the area of turf in your landscape. Most turf requires substantially more water than planted beds, especially if the plants are climate appropriate and covered with mulch.
- Eliminate "strip grass" to the greatest extent possible. Small strips of grass, common in parking islands and between sidewalks and the roadway are hard to maintain and difficult to efficiently water. Use bushes, mulch, or permeable hardscape, instead.
- Implement low-impact development techniques such as making parking lot islands depressions instead of raised curb areas to capture and retain moisture.

Replacement Options

- Replace or install the entire landscape with climate appropriate, water-efficient plant material. You may be able to design a landscape that doesn't require the use of supplemental water.
- Design the landscape so plants with similar water needs are grouped together (i.e., hydrozoning). This allows for more efficient irrigation.
- Ensure the landscape is properly designed from the start. Hire a licensed landscape architect or a qualified site planner/designer. Those who design with water efficiency in mind limit the clearing of each lot allowing native vegetation to remain. This increases recharge and limits surface runoff, thereby limiting the size of the stormwater pond(s).
- Check to ensure the soil does not need improvement before installing a landscape. Depending on the soil type, it may need to be amended to ensure water is delivered to the plant in an efficient manner (i.e., good absorption and water holding capacity).
- Use turf only where it is needed, avoiding long narrow areas that cannot be irrigated effectively.
- Ensure trees are planted at the appropriate depth.
- When designing the new landscape, avoid the use of ornamental water features.

Water-Efficient Landscaping Resources

American Society for Landscape Architects. http://www.asla.org

Air Force Water Conservation Guidebook, Air Force Civil Engineer Support Agency, May 2002.
Arizona Municipal Water Users Association. "Facility Manager's Guide to Water Management." Version 2.3 March 2003.

EPA's GreenScapes Program: http://www.epa.gov/epaoswer/non-hw/green/lrgscl.htm

EPA's "Water Efficient Landscaping: Preventing Pollution and Using Resources Wisely."
http://www.epa.gov/watersense/docs/water-efficient_landscaping_508.pdf

Federal Highway Administration, Roadside Use of Native Plants:
http://www.fhwa.dot.gov/environment/rdsduse/

Military Handbook: Water Conservation. MIL-HDBK-1165. April 1997.

New Mexico Office of the State Engineer. July 1999. A Water Conservation Guide to Commercial, Institutional, and industrial Users. http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

North Carolina Department of Environment and Natural Resources. "Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities.

USDA PLANTS Database, Links Page: http://plants.nrcs.usda.gov/links.html

Xeriscape™ Colorado: http://www.xeriscape.org/

Denver Water, Principles of Xeriscape: http://www.denverwater.org/cons_xeriscape/xeriscape/xeriscapeprinciples.html

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://www.gsa.gov/pbs/centers/energy/water.htm

Local Water Utilities.

BMP #5 – Water-Efficient Irrigation

Background

Some experts estimate that more than 50 percent of commercial and residential irrigation water is wasted due to evaporation, wind, poor management, and/or improper system design, installation, or maintenance. For optimal irrigation system performance, water efficiency should be considered from the inception of the system's design, through the installation, followed by consistent management and maintenance.

An important efficiency concept associated with irrigation systems is distribution uniformity, or how evenly water is applied over the landscape. Many times extra water is applied because the system is not distributing water in a uniform manner. When water isn't applied evenly, the landscape is watered to keep the driest spot green, grossly over irrigating other areas. This issue can be addressed through a number of measures discussed below.

Once the irrigation system hardware is operating in an efficient manner, it is important to consider the irrigation schedule, which dictates the amount and timing of the water applied. Water needs change with the seasons; so should your irrigation schedule. Many landscapes are watered at the same level all year, adding unnecessary water for months at a time. Over-watering can cause more damage to plant materials than under-watering and can damage streets, curbs, other paving and building foundations.

Whether installing a new system or retrofitting an old one, there are many options to help you improve water efficiency. Most importantly, the person(s) responsible for the irrigation system should have training in proper system installation, maintenance, and management and work to maintain a current understanding of water-efficient irrigation practices and technologies. Work with your irrigation professional to increase your water efficiency outdoors.

For more information on this and other FEMP Water Efficiency Best Management Practices (BMPs), please see the resources section.

Operation and Maintenance Options

- Recommend existing contractors become familiar with water-efficient irrigation practices through partnerships, classes, seminars, and/or published guidance documents. Refer them to:
    - The Environmental Protection Agency's WaterSense program (http://www.epa.gov/watersense/partners/join/cp.htm) to learn about becoming a WaterSense irrigation partner. WaterSense partners with irrigation professionals who are certified through programs that emphasize water efficiency.
    - Locally offered courses or seminars on water-efficient irrigation practices (check with your water utility or local junior colleges for availability)
    - Best management practices and guidance documents. Many local cooperative extensions and irrigation trade associations provide best management practice and guidance documents online.
- When hiring a vendor, inquire about the water efficiency knowledge of their personnel. Request demonstration of practices that promote efficient irrigation. EPA's WaterSense program can help you locate irrigation professionals in your area that have demonstrated knowledge in water-efficient irrigation. For more information and a list of WaterSense irrigation partners in your area, visit http://www.epa.gov/watersense/pp/irrprof.htm.
- Periodically review all irrigation service agreements to incorporate a high priority for water efficiency. Consider the following options:

    - Incorporate a water budget, which can be used as a performance standard for water use. A vendor will calculate your water needs and use that information to plan an irrigation schedule to meet those needs.
    - Require a full audit of your irrigation system every three years by a qualified auditor, such as a WaterSense partner. This process is an in-depth assessment of your system and its performance to verify proper scheduling and to expose growing deficiencies from changes or growth of landscape, or an aging system as well as opportunities to employ new technologies.
- Request vendors to include in their maintenance programs, immediate reporting and repair of problems as they arise and also require regular, periodic maintenance routines as part of the overall irrigation maintenance program.
- Install an irrigation meter (sometimes known as a "deduct meter") to measure the amount of water applied to the landscape. Some water utilities offer an interruptible rate for the service or will provide a credit to the sewer charges. Your maintenance vendor should keep a record of all irrigation water use as part of its maintenance program.
- Verify that the irrigation schedule is appropriate for climate, soil conditions, plant materials, grading, and season.
    - Change your schedule based upon changing weather conditions and as part of regular, periodic maintenance. Require your maintenance vendor and/or Auditor to deliver options for automating schedule changes based on changing weather conditions.
    - Certain soil types or steep slopes may increase the chance of surface runoff. Irrigation events may need to be broken up into multiple applications depending on landscape conditions. This is commonly known as "cycle & soak" methodology. Ask your maintenance vendor to assemble and implement such schedule parameters as necessary. If currently installed irrigation controller(s) is/are not capable of such programming, replace it/them with current technology.
    - Generally, it is better to water deeply and less frequently than to water lightly and often. A deep, less frequent schedule encourages deep roots resulting in healthy plants. As part of the overall maintenance program submission by your vendor, ask your vendor to produce and implement a program that takes into account the optimal water window and other scheduling requirements that relate to the actual landscape being maintained.
    - In addition to a full audit of your system every few years, periodically monitor your system for effectiveness throughout the year. As part of the overall maintenance program, ask your vendor to produce and implement a program that makes certain sprinkler components are placed and adjusted so that they will water the cultivated plants, not the pavement. Verify that irrigation system pressure is within manufacturer specifications. To help ensure consistent uniformity, require that replacement equipment is compatible with existing equipment.
- Always attach shut-off nozzles to handheld hoses.

Retrofit Options

- Replace your existing irrigation system controller with a more advanced control system that waters plants only when they need it. There are many available technologies that use weather or soil moisture information to schedule irrigation according to plant needs. Below are a few options to discuss with your service provider, an auditor or consultant/designer (detailed product information can be found at http://www.usbr.gov/waterconservation/docs/SmartController.pdf):
    - Weather Based Irrigation Control: Products come in the form of an irrigation controller, or a device that can be added to an existing controller. They use real-

time or historical weather information, along with landscape parameters entered by the vendor, to schedule or allow for irrigation when plants need water.
    - Soil Moisture Based Irrigation Control: Products come in the form of devices inserted into the soil to measure moisture. They can be connected to an existing controller or add-on device, enabling irrigation when the plants need water.
    - Complete Central Control Systems: Products utilize demand-based control and enable a Water Manager to centrally operate and manage multiple irrigation systems at multiple locations using various means of communication.
- Consider retrofitting a portion of your trees, shrubs or plant beds with low-flow, low-volume irrigation, also called micro-irrigation or drip irrigation. Many plant beds do not require the spray heads traditionally used to water turf areas. Drip irrigation can be more efficient in part due to slow and direct water application to plant root zones, minimizing evaporation and runoff.
- Increase the efficiency of the system's sprinkler heads. Sprinklers with a fine mist are susceptible to water waste from wind drift. Also, some sprinklers don't apply water evenly over the landscape. Many times, existing sprinkler heads can be exchanged with more efficient heads designed to minimize water lost to wind and distribute water in a more uniform manner.
- Install rain sensing technology on your system to prevent irrigation from taking place during periods of sufficient moisture. Many cities, and some states, require rain sensing technology by law. Check with your state or city on relevant local laws.
- Install wind-sensing technology to interrupt irrigation cycles in the presence of significant wind.
- Install freeze-sensing technology to prevent irrigation during freeze conditions.

Replacement Options

- When installing a new system hire an irrigation design company that has a background in designing water-efficient systems, such as one that employs WaterSense partners. Also ensure that the installation and maintenance vendor has a background in water efficiency. For more information and a list of WaterSense irrigation partners in your area, visit http://www.epa.gov/watersense/pp/irrprof.htm.
- Upon completion of new irrigation systems, audit the irrigation system using a qualified irrigation auditor, such as a WaterSense partner, to determine if baseline efficiencies are compatible with design intent and to make certain minor adjustment recommendations as needed.
- Recommend that your system be designed, installed, and maintained according to irrigation best management practices, published by local cooperative extensions and irrigation or landscape trade associations. Following industry best management practices will help your irrigation contractor address efficient and water conserving techniques from design inception through installation and proper maintenance. For information related to the most widely known irrigation best management practices, go to www.irrigation.org.
- Design your system for maximum water application uniformity (distribution uniformity). Discuss the following with your designer:
    - No direct distribution of water over impermeable surfaces or non-target areas.
    - Maximize sprinkler distribution uniformity by following manufacturer recommendations for head spacing. Consider necessary spacing reductions to compensate for prevailing wind.
    - Create irrigation hydrozones by grouping turf and plants with similar water needs. Also consider varying soil conditions, sun/shade/wind exposure, slope and other site specifics that may impact watering needs.
- Consider the installation of the following components for optimal water efficiency:
    - Drip/micro irrigation for all areas suitable for such technology.

    - Install check valves in all sprinklers to retain water in lateral pipes between cycles.
    - Demand based irrigation controls (i.e., weather or sensor based controls)
    - Rain, freeze, and wind sensors to interrupt irrigation during weather conditions that are unfavorable.
    - Flow rate monitoring equipment which can interrupt irrigation if excess flow is detected. (i.e., caused by broken pipes, fittings, nozzles, emitters sprinklers, etc.)
- Use alternative sources of water, as discussed in BMP #14, where environmentally appropriate and local regulations allow.

Water-Efficient Landscaping Resources

Air Force Water Conservation Guidebook, Air Force Civil Engineer Support Agency, May 2002.

Arizona Municipal Water Users Association. "Facility Manager's Guide to Water Management." Version 2.3 March 2003.

EPA's WaterSense Program: http://www.epa.gov/watersense/

Military Handbook: Water Conservation. MIL-HDBK-1165. April 1997.

New Mexico Office of the State Engineer. July 1999. A Water Conservation Guide for Commercial, Institutional, and industrial Users. http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

North Carolina Department of Environment and Natural Resources. "Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities."

The Irrigation Association: http://www.irrigation.org.

- "Landscape Irrigation Scheduling and Water Management" (http://www.irrigation.org/gov/pdf/IA_LISWM_MARCH_2005.pdf.)
- "Recommended Audit Guidelines" (http://www.irrigation.org/certification/pdf/AuditGuidelines_FINAL.pdf)
- "Turf and Landscape Best Management Practices" (http://www.irrigation.org/gov/pdf/IA_BMP_APRIL_2005.pdf)

U.S. Department of the Interior. Bureau of Reclamation. August 2007. "Reclamation: Managing Water in the West: Weather and Soil Moisture Based Landscape Irrigation Scheduling Devices." http://www.usbr.gov/waterconservation/docs/SmartController.pdf

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://www.gsa.gov/pbs/centers/energy/water.htm

BMP #6 - Toilets and Urinals

Background

The United States uses about 4.8 billion gallons of water every day to flush waste. Since toilets and urinals account for nearly one-third of building water consumption, the potential for savings in this area is significant. Unless your facility is relatively new or has been refurbished recently, chances are that your toilets and urinals are consuming too much water. Current Federal law requires that residential toilets (flush tank type) manufactured and sold in the U.S. after January 1, 1994 must use no more than 1.6 gallons per flush (gpf). Similarly, commercial toilets (flushometer valve type) manufactured and sold after January 1, 1997 must use no more than 1.6 gpf and urinals must use no more than 1.0 gpf. Toilets rated at 1.6 gpf are termed Ultra-Low-Flush (ULF) toilets.

ULF toilet fixtures, those that meet or exceed Federal requirements, continue to be the topic of a great deal of discussion. When first introduced, these fixtures were often judged to be inadequate in terms of water savings and performance due to reports of clogging and double flushing. Problems arose with these early toilet models when tanks were modified with “early closing flappers” and other devices to reduce the volume of water per flush, without changing the bowls. The poor performance of these early models (from about 1992 to 1998) continues to cast a cloud of doubt over the ULF technology.

To address poor performance issues, manufacturers began serious re-engineering of 1.6 gpf models, addressing tank and bowl hydraulics, improving durability of tank components, and designing to more rigorous flush performance requirements. Overall, the improved design and technologies with these second generation models yielded more water savings and superior flushing capabilities, even when compared with older inefficient (3.5 gpf) toilet models. In fact, most surveys conducted to measure consumer satisfaction with the second generation models have shown an acceptance or satisfaction rate of more than 80 percent.

The third generation of toilet models resulted directly from the product development leading to the very successful 1.6 gpf toilet fixture. In 1999, the first High-Efficiency Toilet (HET) fixture was introduced into the North American marketplace. With superior hydraulic design, HETs flush at an effective flush volume of 1.28 gpf or less, or 20 percent below that required by the current national standard. Because of this design and other innovative features, HETs are now able to actually exceed the waste removal performance of the 1.6 gpf fixture.

In recognition of the advancements made in toilet performance and customer acceptance, EPA’s WaterSense program developed a performance specification to recognize and label tank-type HETs. WaterSense labeled toilets are not only 20 percent more efficient, but must also pass a rigorous waste removal performance test, something that other toilet fixtures are not required to do.

Urinal technology has also improved significantly since the implementation of the Federal law in the early 1990’s. Again, with the redesign based on the improved hydraulics of the fixture, the amount of water needed to effectively remove waste has been significantly reduced. Today, High-Efficiency Urinals (HEUs), which function at 0.5 gpf and less, are available from a range of manufacturers. Not all models from these manufacturers, however, employ the same technology, nor do they all require the same amount or frequency of maintenance. As such, it is critical that the building designer, specifier, and/or facility manager carefully weigh all of the attributes and shortcomings of the various technologies available today in the marketplace. This includes a thorough assessment of life cycle costs, with special consideration given to the maintenance and/or replacement parts needed over the product lifetime of certain technologies.

Today, HEUs come in a wide array of water use profiles, e.g., 0.5 gpf, 0.25 gpf, 0.125 gpf, and non-water fixtures. The most recent technology introduced in North America is the 0.125 gpf (1 pint per flush); the response from facilities managers who have installed these urinals is excellent. Flushing urinals have a distinct advantage over non-water urinals in that the costs of replacement components and fluids is largely avoided, the flushing action can remove concerns over odors, and facility maintenance and custodial tasks are routine.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Check for leaks every six months.
- Establish a user-friendly method to report leaks and fix them immediately.
- Periodically replace flush valves and fill valves in tank-type toilets.
- When performing maintenance, replace worn parts and adjust mechanisms to ensure that the water consumed per flush meets manufacturers' original equipment specifications.
- If non-water urinals are used, clean and replace the seal cartridges or material in accordance with manufacturer recommendations.
- Encourage cleaning or custodial crews to report problems.
- Correctly adjust and maintain automatic sensors to ensure proper operation.

Retrofit Options

- Retrofits for tank-type toilets, such as displacement dams or bags may hamper overall operation of the toilet and increase maintenance costs, as they often have a short life span and require frequent replacement or adjustment. Therefore, they are not appropriate for Federal facilities.
- For flushometer valve type toilets, infrared or ultrasonic sensors can be retrofit to automatically activate flushing, making their operation fully “hands free” and sanitary. However, these devices need to be set properly and regularly maintained to avoid multiple flushing and, while providing sanitary advantages, should not be considered as a water-saving device.
- For some commercial flushometer valve type toilets (diaphragm type only), the existing flush valve can be retrofit with a dual-flush valve capable of delivering a reduced flush or a full flush depending upon the demand (i.e., liquids only or solid and liquid waste). Note that this type of retrofit may require significant user education to be fully successful. In addition, the existing bowl must be compatible with the reduced flush volume.
- Early closure or valve insert or replacement devices can reduce flush volumes from 0.6-2 gpf. However, they often require frequent replacement or adjustment, may lead to clogging and other flush performance problems, and may void warranties on the fixture itself. Therefore, they are not appropriate for Federal facilities.
- Consider using non-potable water for toilet and urinal flushing (see BMP #14). Package graywater treatment systems are now available that provide water filtered and treated sufficiently for these uses. If using non-potable water for toilet and urinal flushing, monitor flapper valves and seals to determine if there is an impact on their useful life.

Replacement Options

- Replace 3.5 to 5 gpf toilets with flushometer valves and bowls specifically designed to use 1.6 gpf or less. For maximum water savings and performance, purchase the valve and bowl in hydraulically matched combinations that are compatible in terms of their designed flushing capacity. Avoid replacing only the existing flushometer valve or tank

with a more efficient 1.6 gpf or less model if the bowl is designed to handle 3.5 gpf or more. Site specific evaluation of existing waste lines, water pressure, distance, usage, settling, and types of users (employees, residents, occasional members of the public, high visitor populations, etc.) is necessary to determine the appropriate models for a specific site. Where appropriate, recycle used parts such as tank trim and metal flush valves (only the interior mechanism needs to be replaced), to minimize landfill impacts.

- If replacing tank-type toilets (gravity or pressure assist), select toilets with the WaterSense label. These have an effective flush volume of 1.28 gallons or less (20 percent savings per flush over traditional 1.6 gpf toilets) and have been independently tested and certified for performance. For a list of WaterSense labeled high-efficiency tank-type toilet models, please visit http://www.epa.gov/watersense/pp/find_het.htm.
- Replace urinals with HEU models designed to use 0.5 gpf or less.
- In remote areas, consider replacing water-using toilets with alternative technologies such as composting or incinerator toilets.
- For specifics on this technology, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out the benefits of input from water utilities, experienced contractors or other Governmental agencies (FEMP, EPA's WaterSense Program, etc.)

Toilets and Urinals Resources

EPA's WaterSense Program, http://www.epa.gov/watersense/

FEMP Purchasing Specification for Urinals,
http://www1.eere.energy.gov/femp/procurement/eep_urinals.html

BMP #7 - Faucets and Showerheads

Background

Tremendous amounts of water and energy are wasted using inefficient faucets and showerheads. Federal guidelines mandate that all lavatory and kitchen faucets and faucet aerators manufactured and sold in the U.S. after January 1, 1994, must use no more than 2.2 gallons per minute (gpm). In addition, metering faucets - those that, when activated, dispense water of a predetermined volume or for a predetermined period of time - must discharge no more than 0.25 gallons per cycle (gpc). Federal guidelines also mandate that all showerheads manufactured and sold in the U.S. after January 1, 1994 must use no more than 2.5 gpm.

Advances in technology and differentiation between faucets intended for public verses private use provide even more water and energy savings potential. In 2007, EPA's WaterSense Program released a specification for residential bathroom lavatory faucets and faucet accessories (e.g., aerators or laminar devices) requiring a maximum flow rate of 1.5 gpm or less, a 32 percent decrease in flow rate over Federal guidelines. Only lavatory faucets intended for "private" use (i.e., residential housing, barracks, and other dwelling units, including hotel guest rooms and hospital rooms) are eligible for the WaterSense label. To address lavatory faucets intended for public use, the American Society of Mechanical Engineers (ASME) A112.18.1/ Canadian Standards Association (CSA) B125.1 *Plumbing Supply Fittings* specifies that "public" lavatory faucets (all faucets other than those defined as "private" above), other than metering, must have a maximum flow rate of 0.5 gpm.

To address efficiency and advances in showerhead technology, in 2006 the Federal Energy Management Program (FEMP) released a purchasing specification for showerheads. The specification calls for Federal Agencies to purchase showerheads with flow rates of 2.2 gpm or less. For more information on the FEMP purchasing specification for showerheads, please visit, http://www1.eere.energy.gov/femp/pdfs/pseep_showerheads.pdf.

If your facility still uses older faucets and showerheads, or uses faucets with flow rates greater than 0.5 gpm in public restrooms, there is a significant opportunity to save both water and energy costs. For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Establish a user-friendly method to report leaks and fix them immediately. Encourage cleaning or custodial crews to report problems.
- Test your system pressure to make sure it is between 20 and 80 psi. If the pressure is too low, then high-efficiency devices won't work properly, if it is too high they will consume more than their rated amount of water.
- Install expansion tanks, pressure reducing valves, and reduce water heater settings, where appropriate, to prevent temperature and pressure relief valves from discharging water.
- Correctly adjust and maintain automatic sensors to ensure proper operation.
- Encourage users to take shorter showers.
- Post energy/water awareness information to encourage efficiency from users.

Retrofit/Replacement Options

- Avoid retrofitting existing inefficient showerheads with flow control inserts or flow control valves (designed to restrict flow or temporarily shut off flow of water, respectively) to

reduce the flow rate. Flow control inserts and flow control valves may increase the risks of thermal shock and scalding and may not provide adequate flow in some Federal facilities, particularly those with low water pressure.

- When installing new showerheads, to maximize water and energy savings, choose models with flow rates that are less than Federal guideline maximums. Specifically check for showerhead models that meet FEMP's Federal purchasing specification performance requirement of 2.2 gpm or less. When replacing a showerhead with a flow rate of less than 2.5 gpm, verify that the hot and cold water plumbing lines are routed through an auto-compensating mixing valve (either thermostatic or pressure balancing) designed for the flow rate of the showerhead. This valve will prevent against significant fluctuations in water pressure and temperature if designed for the flow rate of the showerhead and can reduce risks of thermal shock and scalding. Check with a local plumber, and if necessary, install an auto-compensating mixing valve designed for the flow rate of the showerhead you plan to install.
- For kitchen faucet retrofits, install aerators or laminar flow devices that achieve a flow rate of 2.5 gpm.
- For lavatory faucet retrofits in public restrooms install faucets or faucet aerators or laminar flow devices that achieve the 0.5 gpm flow rate requirement. For lavatory faucet retrofits in private restrooms (residential housing, barracks, hotel guest rooms and hospital rooms), install WaterSense labeled high-efficiency lavatory faucets or faucet aerators or laminar flow devices. For more information on WaterSense labeled high-efficiency lavatory faucets, please visit http://www.epa.gov/watersense/pp/bathroom_faucets.htm.
- Install temporary shut-off or foot-operated valves with faucets. These valves cut off the water flow during intermittent activities like scrubbing or dishwashing. The water can be reactivated at the previous temperature without the need to remix the hot and cold water.

Faucets and Showerhead Resources

EPA's WaterSense Program, http://www.epa.gov/watersense/

FEMP Purchasing Specification for Showerheads,
http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

BMP #8 - Boiler/Steam Systems

Background

Boilers and steam generators are commonly used in large heating systems, institutional kitchens, or in facilities where large amounts of process steam are used. This equipment consumes varying amounts of water depending on the size of the system, the amount of steam used, and the amount of condensate returned.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Develop and implement a routine inspection and maintenance program to check steam traps and steam lines for leaks. Repair leaks as soon as possible.
- Provide proper insulation on piping and on the central storage tank.
- Blowdown, the practice of expelling live steam from the bottom of the boiler, is a common mechanism to reduce contaminant build-up. Proper control of blowdown is critical to boiler operation. Insufficient blowdown may lead to deposits or carryover. Excessive blowdown wastes water, energy, and chemicals. The American Society of Mechanical Engineers (ASME) has developed a consensus on operating practices for boiler feedwater and blowdown that is related to operating pressure, which applies for both steam purity and deposition control. See boiler/steam system resources for more information.
- Obtain the services of a water treatment specialist to prevent system corrosion and optimize cycles of concentration. Treatment programs should include periodic checks of boiler water chemistry.
- Develop and implement routine inspection and maintenance program on condensate pumps.
- Regularly clean and inspect boiler water and fire tubes. Reducing scale buildup will reduce the amount of blowdown necessary as well as improve the energy efficiency of the system.
- Employ an expansion tank to temper boiler blowdown drainage rather than cold water mixing.
- Install meters on boiler system blowdown and make up lines.
- Install meters on make up lines to recirculating closed water loop heating systems so that leaks can be easily detected.

Retrofit Options

- Install and maintain a condensate return system. By recycling condensate for reuse, water supply, chemical use, and operating costs for this equipment can be reduced by up to 70 percent. A condensate return system also helps lower energy costs as the condensate water is already hot and needs less heating to produce steam than water from other make-up sources.
- Install an automatic blowdown system based on boiler water quality to better manage the treatment of boiler make-up water.
- Add an automatic chemical feed system controlled by make-up water flow.
- To optimize cycles of concentration and reduce the frequency of blowdown, an inert fluorescent tracer can be added to the boiler water treatment chemicals to accurately measure blowdown cycles and chemical feed rates. Since the tracer is an integral part of the treatment chemicals added to the feedwater, the exact concentration ratio of the chemical treatment to the tracer is known. Boiler cycles can be determined by

measuring the concentration of tracer in the feedwater and in the blowdown. Monitoring the tracer continuously can allow better control and adjustment of the chemical feed rate to optimize the number of blowdown cycles.

Replacement Options

- Replacement options vary depending on the size of the facility and existing equipment. Consider performing an energy audit to reduce heating load and ensure that the system is sized appropriately. Reducing the size of the boiler system can reduce water requirements.
- Always purchase the most life cycle cost-effective boiler available for new installations or major renovations.
- Consider installing a small summer boiler, distributed system or heat-capture system for reheat or dehumidification requirements instead of running a large boiler at part load. Also consider alternative technologies such as heat pumps.
- For specifics on this technology, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out the benefits of input from experienced contractors or other Governmental agencies (DOE, FEMP, etc.).

Boiler/Steam System Resources

Council of Industrial Boiler Owners, *Energy Efficiency Handbook*,
http://www1.eere.energy.gov/industry/bestpractices/pdfs/steamhandbook.pdf

Federal Energy Management Program, *Boiler System Efficiency Improves with Effective Water Treatment*,
http://www.eere.energy.gov/industry/bestpractices/energymatters/articles.cfm/article_id=185

American Society of Mechanical Engineers,
Consensus Operating Practices for Control of Feedwater/Boiler Water Chemistry in Modern Industrial Boilers, 1994. To order:
http://catalog.asme.org/ConferencePublications/PrintBook/2006_Consensus_Operating.cfm

Federal Energy Management Program, Steam Trap Performance Assessment, DOE/EE0193 July 1999. http://www1.eere.energy.gov/femp/pdfs/FTA_SteamTrap.pdf

BMP #9 - Single-Pass Cooling Equipment

Background

Single-pass or once through cooling systems provide an opportunity for significant water savings. In these systems, water is circulated once through a piece of equipment and then is disposed down the drain. The types of equipment that typically use single-pass cooling include: CAT scanners, degreasers, hydraulic equipment, condensers, air compressors, welding machines, vacuum pumps, ice machines, x-ray equipment, and air conditioners. To remove the same heat load, single-pass systems use 40 times more water than a cooling tower operated at 5 cycles of concentration. To maximize water savings, single-pass cooling equipment should be either modified to recirculate water or if possible, should be eliminated altogether.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Provide proper insulation on piping, chiller, or storage tank.
- Inventory cooling equipment and identify all single-pass cooling systems.
- Check entering and leaving water temperatures and flow rates to ensure that they are within the manufacturer's recommendations. For maximum water savings, water flow rates should be near the minimum allowed by the manufacturer.
- Keep coil loops clean to maximize heat exchange with the refrigerated enclosure.
- Check operation of water control valve. Water control valves adjust the flow rate of water based on demand. Regular valve maintenance will ensure that water is used as efficiently as possible.

Retrofit Options

- To maximize water savings, eliminate single pass cooling by modifying equipment to operate on a closed loop that recirculates the water instead of discharging it.
- If modification of equipment to a closed loop system is not feasible, add an automatic control to shut off the entire system during unoccupied night or weekend hours. This option should only be considered where shutdown would have no adverse impact on indoor air quality.
- Installation of a chiller or cooling tower is also an economical alternative. Excess cooling capacity may already exist within the building that can be utilized.
- Find another use for the single-pass effluent, in boiler make-up supply or landscape irrigation, and implement. Note some equipment effluent may be contaminated such as degreasers, and hydraulic equipment. This effluent must not be used in boilers.

Replacement Options

- Replace water-cooled equipment with air-cooled equipment or best available energy/water-efficient technology.
- Replace the once through cooling systems with a multi-pass cooling tower or closed loop system.
- For specifics on this technology, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out the benefits of input from experienced contractors or other Governmental agencies (DOE, FEMP, etc.).

BMP #10 - Cooling Tower Management

Background

Cooling towers regulate temperature by dissipating heat from recirculating water used to cool chillers, air-conditioning equipment, or other process equipment. Heat is rejected from the tower primarily through evaporation. Therefore, by design, cooling towers consume significant amounts of water. The thermal efficiency and longevity of the cooling tower and equipment used to cool depend on the proper management of water recirculated through the tower.

Water leaves a cooling tower system in any one of four ways:

1. Evaporation: This is the primary function of the tower and is the method that transfers heat from the cooling tower system to the environment. The quantity of evaporation is not a subject for water efficiency efforts (although improving the energy efficiency of the systems you are cooling will reduce the evaporative load on your tower).
2. Drift: A small quantity of water may be carried from the tower as mist or small droplets. Drift loss is small compared to evaporation and blow-down, and is controlled with baffles and drift eliminators.
3. Blowdown or bleed-off: When water evaporates from the tower, dissolved solids (such as calcium, magnesium, choride, and silica) are left behind. As more water evaporates, the concentration of dissolved solids increases. If the concentration gets too high, the solids can come out of solution and cause scale to form within the system, or the dissolved solids can lead to corrosion problems. The concentration of dissolved solids is controlled by blowdown of some water from the tower. Carefully monitoring and controlling the quantity of blowdown provides the most significant opportunity to conserve water in cooling tower operations.
4. Basin leaks or overflows: Properly operated towers should not have leaks or overflows.

The sum total of water that is lost from the tower must be replaced by make-up water:

Make-up = Evaporation + Blowdown + Drift

A key parameter used to evaluate cooling tower operation is “cycles of concentration” (sometimes referred to as cycles or concentration ratio). This is calculated as the ratio of the concentration of dissolved solids (or conductivity) in the blowdown water compared to the make-up water. Since dissolved solids enter the system in the make-up water, and exit the system in the blowdown water, the cycles of concentration are also approximately equal to the ratio of volume of make-up to blowdown water.

Therefore, from a water efficiency standpoint, you want to maximize your cycles of concentration, which will minimize your blowdown water quantity, and reduce your make-up water demand. However, this can only be done within the constraints of your make-up water and cooling tower water chemistry. As cycles of concentration increase, dissolved solids increase, which can cause scale and corrosion problems unless they are carefully controlled.

In addition to carefully controlling blowdown, other water efficiency opportunities arise from using alternate sources of make-up water. Sometimes water from other equipment within a facility can be recycled and reused for cooling tower make-up with little or no pre-treatment, including the following:

- Air handler condensate (water that collects when warm, moist air passes over the cooling coils in air handler units). This reuse is particularly appropriate because the

condensate has a low mineral content, and typically is generated in greatest quantities when cooling tower loads are the highest.
- Water used in a once through cooling system.
- Pretreated effluent from other processes, provided that any chemicals used are compatible with the cooling tower system.
- High-quality municipal wastewater effluent or recycled water (where available).

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Calculate and understand your “cycles of concentration.” Check the ratio of conductivity of blowdown and make-up water. Work with your cooling tower water treatment specialist to maximize the cycles of concentration. Many systems operate at 2 to 4 cycles of concentration, while 6 cycles or more may be possible. Increasing your cycles from 3 to 6 will reduce cooling tower make-up water by 20 percent. The actual number of cycles you can carry will depend on your make-up water quality and cooling tower water treatment regimen. Depending on your make-up water, treatment programs may include corrosion and scaling inhibitors, along with biological fouling inhibitors.
- Install a conductivity controller to automatically control your blowdown. Working with your water treatment specialist, determine the maximum cycles of concentration you can safely achieve, and the resulting conductivity (typically measured as microSiemens per centimeter, *u*S/cm). A conductivity controller can continuously measure the conductivity of the cooling tower water and discharge water only when the conductivity set point is exceeded.
- Install flow meters on make-up and blowdown lines. Check the ratio of make-up flow to blowdown flow. Then check the ratio of conductivity of blowdown water and the make-up water (you can use a handheld conductivity meter if your tower is not equipped with permanent meters). These ratios should match your target cycles of concentration. If both ratios are not about the same, check the tower for leaks or other unauthorized draw-off. If you are not maintaining target cycles of concentration, check system components, including conductivity controller, make-up water fill valve, and blowdown valve.
- Read conductivity and flow meters regularly to quickly identify problems. Keep a log of make-up and blowdown quantities, conductivity, and cycles of concentration. Monitor trends to spot deterioration in performance.
- Consider using acid treatment such as sulfuric, hydrochloric, or ascorbic acid, where appropriate. When added to recirculating water, acid can improve the efficiency of a cooling system by controlling the scale buildup potential from mineral deposits. Acid treatment lowers the pH of the water, and is effective in converting a portion of the alkalinity (bicarbonate and carbonate), a primary constituent of scale formation, into more readily soluble forms. Make sure that workers are fully trained in the proper handling of acids. Also note that acid overdoses can severely damage a cooling system. The use a timer or continuous pH monitoring via instrumentation should be employed. Additionally, it is important to add acid at a point where the flow of water promotes rapid mixing and distribution. Be aware that lowering pH may mean you may have to add a corrosion inhibitor.
- Select your water treatment vendor with care. Tell vendors that water efficiency is a high priority and ask them to estimate the quantities and costs of treatment chemicals, volumes of blowdown water and the expected cycles of concentration ratio. Keep in mind that some vendors may be reluctant to improve water efficiency because it means the facility will purchase fewer chemicals. In some cases, saving on chemicals can outweigh the savings on water costs. Vendors should be selected based on "cost to treat

1,000 gallons make-up water" and highest "recommended system water cycle of concentration."
- Consider measuring the amount of water lost to evaporation. Some water utilities will provide a credit to the sewer charges for evaporative losses, measured as the difference between metered make-up water minus metered blowdown water.

Retrofit Options

- Install a sidestream filtration system that is composed of a rapid sand filter or high-efficiency cartridge filter to cleanse the water. These systems draw water from the sump, filter out sediments and return the filtered water to the tower, enabling the system to operate more efficiently with less water and chemicals. Sidestream filtration is particularly helpful if your system is subject to dusty atmospheric conditions. Sidestream filtration can turn a troublesome system into a more trouble-free system.
- Install a make-up water softening system when hardness (calcium and magnesium) is the limiting factor on your cycles of concentration. Water softening removes hardness using an ion exchange resin, and can allow you to operate at higher cycles of concentration.
- Install covers to block sunlight penetration. Reducing the amount of sunlight on tower surfaces can significantly reduce biological growth such as algae.
- Consider alternative water treatment options such as ozonation or ionization, to reduce water and chemical usage. Be careful to consider the life cycle cost impact of such systems.
- Install automated chemical feed systems on large cooling tower systems (over 100 ton). The automated feed system should control blowdown/bleed-off by conductivity and then add chemicals based on make-up water flow. These systems minimize water and chemical use while optimizing control against scale, corrosion, and biological growth.

Replacement Options

Get expert advice to help determine if a cooling tower replacement is appropriate. New cooling tower designs and improved materials can significantly reduce the water and energy requirements for cooling. However, since replacing a cooling tower involves significant capital costs, the facility manger should investigate every retrofit and O&M option available and compare their costs and benefits to a new tower. For specifics on this technology, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out the benefits of input from experienced contractors or other governmental agencies (DOE, FEMP, etc.)

Cooling Tower Resources

North Carolina Water Efficiency Manual for Commercial, Industrial, and Institutional Facilities
http://www.p2pays.org/ref/01/00692.pdf

GSA
http://www.gsa.gov/gsa/cm_attachments/GSA_DOCUMENT/waterguide_new_R2E-c-t-r_0Z5RDZ-i34K-pR.pdf

Cooling Technology Institute
http://www.cti.org/

Western Area Power Administration
http://www.wapa.gov/es/pubs/techbrf/cooling.htm

BMP #11 – Commercial Kitchen Equipment

Background

Commercial kitchen equipment used by the food service industry represents a large set of water users in the non-residential sector. Commercial kitchen equipment water efficiency is especially important because the high volume applications typically require the use of mostly hot water. Therefore, making sure commercial kitchen equipment uses water efficiently affords both significant water and energy savings. Types of water-using commercial kitchen equipment include: pre-rinse spray valves, wash tanks and sinks, commercial dishwashers, food steamers, steam kettles, commercial ice makers, and combination ovens (combination oven/steamer).

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Educate staff about the benefits of water efficiency and the importance of hand scraping before loading a dishwasher.
- Establish a user-friendly method to report leaks and fix them immediately. Encourage cleaning or custodial crews to report problems.
- Only run dishwashers if they are full. Fill each rack to maximum capacity.
- Immediately replace any damaged dishwasher racks.
- Check equipment's water temperatures and flow rates to ensure that they are within the manufacturer's recommendations. For maximum water savings, water flow rate should be near the minimum allowed by the manufacturer.
- Test system pressure to make sure it is between 20 and 80 psi. If the pressure is too low, then high-efficiency devices won't work properly, if it is too high they will consume more than their rated amount of water.
- For dishwashers, observe final rinse pressure to make sure it is at the manufacturer's recommended setting, typically 20 ± 5 psi. If the pressure is too low, then the dishes may not be rinsed and sanitized properly, if it is too high they will consume more than their rated amount of water.
- Ensure all equipment is installed and operated in accordance with the manufacturer's instructions.
- Use the combi-mode of combination ovens sparingly and appropriately as this mode consumes water and significantly increases energy usage. Combi-mode should be minimized and convection mode maximized. By moderating use at the beginning of the cook cycle, the benefit of the combi-mode can be achieved without using the mode for the entire cooking event. When adjusting the use of the combi-mode be sure to consider the impact on cook times and product yield.
- For steam cooking, use batch production as opposed to staged loading of food pans (i.e., do not continuously open the door to load and unload food pans) – this uses a lot of energy and wastes water. If possible, fill the steamer to capacity as opposed to cooking one pan in a five pan steamer.
- Some pre-rinse spray valves may be easily taken apart to perform routine cleaning or to clean when performance is noticeably impacted, however, because pre-rinse spray valves are relatively inexpensive, it may be more viable to replace plugged or poorly performing valves with new efficient models. If cleaning or maintenance is necessary, avoid drilling out holes to remove scale and buildup.
- Garbage disposals can waste significant amounts of water. Eliminate or minimize the use of garbage disposals by using strainers or traps that employ a mesh screen to collect food waste.

Retrofit Options

- Install dishwashers with rack sensors to allow water flow only when dishes are present.
- Check to see if ice machines operate with single-pass cooling. To maximize water savings, eliminate single-pass cooling by modifying equipment (if possible) to operate on a closed loop that recirculates the water instead of discharging it, otherwise replace the ice-making head with an air-cooled unit.
- Flow restrictors can be installed in existing pre-rinse spray valves to reduce the flow rate to 1.6 gpm or less. Flow restrictors, however, may not provide adequate performance in most situations and purchasing new more efficient and inexpensive pre-rinse spray valves may provide a better alternative for saving water.

Replacement Options

- For commercial dishwashers, check volume of service and size the dishwasher accordingly. Be sure to consider the energy tradeoff associated with increased tank heat that may be required for larger machines.
- Purchase high-efficiency commercial dishwashers with the ENERGY STAR® label. If possible, install low-temperature machines that rely on chemical sanitizing over high water temperature. If purchasing a low-temperature chemical sanitizing machine, carefully consider the cost of chemicals and verify water use with the distributor or manufacturer to ensure that the machine uses less water than an equivalent high-temperature machine.
- Replace water cooled commercial ice makers with high-efficiency air cooled commercial ice makers with the ENERGY STAR label.
- For low to medium volume steam cooking needs, purchase high-efficiency steam cookers with the ENERGY STAR label or purchase boilerless (connectionless) commercial steam cookers. Specifically look for steamers with improved insulation, standby mode, and closed-system design, to ensure that steamers are used most efficiently. Select a steamer based on projected use (i.e., balance production demand with steamer production capacity).
- Purchase high-efficiency pre-rinse spray valves. The Energy Policy Act of 2005 requires that pre-rinse spray valves manufactured after January 2006 must have a maximum flow rate of 1.6 gpm. In 2007, the Federal Energy Management Program (FEMP) released a purchasing specification for pre-rinse spray valves, which requires Federal Agencies to purchase pre-rinse spray valves that have flow rates of 1.25 gpm or less and that meet ASTM F2323-03, *Standard Test Method for Performance of Pre-Rinse Spray Valves*. For ease of maintenance and to increase operational life purchase pre-rinse spray valves that can be easily taken apart and cleaned.
- Consider steaming needs when purchasing steam kettles. Direct steam kettles may be appropriate for bulk cooking (more than 50 servings at a time), however, may require more maintenance as they are supplied with steam from an external boiler and may need to be “blown down” daily to eliminate condensate buildup in the steam supply line. For smaller steaming needs, purchase self-contained steam kettles. Self-contained kettles may require regular monitoring of water levels and maintenance of control components.

Commercial Kitchen Equipment Resources

ENERGY STAR®, http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

Food Service Technology Center, http://www.fishnick.com/appliances/types/ and http://www.fishnick.com/saveenergy/sprayvalves/

FEMP Purchasing Specifications for Energy Efficient Products,
http://www1.eere.energy.gov/femp/procurement/eep_requirements.html

BMP#12 – Laboratory/Medical Equipment

Background

Equipment used in hospitals and laboratories can use significant amounts of water, but also offer the opportunity for substantial water savings by making a few small changes to how and when the water is used by the equipment. The Environmental Protection Agency (EPA) and the Department of Energy (DOE) recognize the importance of incorporating water efficiency products and practices in laboratory settings. These Agencies have teamed up under a program called *Laboratories for the 21st Century (Labs 21)* to provide architects, engineers, and facility managers with information about technologies and practices that can be used to create and maintain sustainable, high-efficiency laboratories. Focusing on reducing water use from equipment such as water treatment systems, sterilization/disinfection systems, photographic and x-ray equipment, vacuum systems, glassware washers, and vivarium equipment such as automatic animal watering systems and cage and rack washers can go a long way towards helping Federal facilities achieve water efficiency goals.

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- Establish a user-friendly method to report leaks and fix them immediately.
- When performing maintenance replace worn parts and adjust mechanisms to ensure that the water consumed continues to meet manufacturers' guidance.
- Encourage cleaning or custodial crews to report problems.
- Shut off units that are not in use, or install an automatic shut-off feature if it does not interfere with the unit's normal operation.
- Check solenoids or automatic shut-off valves regularly to ensure that they are working properly. Verify that water is not flowing when equipment is in stand-by mode.
- Install a pressure-reducing device on equipment that does not require high-pressure. Lowering the pressure can reduce water use.
- Set equipment to the minimum flow rates acceptable or recommended by the manufacturer and post signs nearby equipment to increase employee awareness and discourage tampering with equipment flow rate.
- Run glassware washers only when full, use newer, cleaner rinsing detergents, and reduce the number of rinse cycles whenever possible.

Retrofit Options/Replacement Options

<u>Water Purification Systems</u>

- Evaluate the laboratory's requirements for high-quality water, including the total volume and the rate at which it will be needed, so that the system can be properly designed and sized.
- Choose systems with a higher recovery rate – the ratio of filtered purified water to the volume of feed water. Some proprietary systems claim recovery rates up to 95 percent. Conventional reverse osmosis systems have recovery rates between 50 and 75 percent.
- Consider reusing concentrate produced by reverse osmosis treatment systems for non-potable applications such as in bathroom commodes. Water quality should be monitored to avoid fouling other systems.
- Determine the quality of water required in each application; use the lowest appropriate level of quality to guide the system design. For example, reverse osmosis units should only be used in processes that require very pure water.

- Evaluate the quality of the water supply for a period of time before the water purification system is designed. This evaluation allows designers to accurately characterize the quality of the water supply and helps them determine the best method for attaining the quality level required.

Disinfection/Sterilization Systems

- Replace older inefficient equipment with new equipment only that is designed to recirculate water or allows the flow to be turned off when the unit is not in use, or both.
- If purchasing new equipment is not feasible, consider purchasing a water efficiency retrofit kit; many are now available for older units. They reduce water use by either controlling the flow of tempering water or by replacing the venturi mechanism for drawing a vacuum. Tempering kits sense the discharge water temperature and allow tempering water to flow only as needed.
- Install a small expansion tank instead of using water to cool steam for discharge to the sewer. Check with the manufacturer to make sure this will not interfere with the unit's normal operation.
- Use high-quality steam for improved efficiency.
- Use uncontaminated, noncontact steam condensate and cooling water as make-up for non-potable uses, such as in cooling towers and boilers.

Photographic and X-Ray Equipment

- Replace older equipment with digital x-ray and photography equipment and computerized printing. If transitioning to digital equipment is not feasible, look for models with a squeegee that removes excess chemicals from the film. The squeegee can reduce chemical carryover and reduce the amount of water needed for the wash cycle.
- If the purchase of new equipment is not feasible, adjust the film processor flow to the minimum acceptable rate. If necessary install a control valve and flow meter in the supply line to monitor flow rate.
- Recycle rinse bath effluent as make-up for the developer/fixer solution.

Vacuum Systems

- Install a laboratory vacuum system or use small electric vacuum pumps instead of employing faucet-based aspirators to create a siphon vacuum source.

Glassware Washers

- Replace older inefficient glassware washers with new dishwashers that use less water. Choose models that allow the operator to select the number of rinse cycles or that can reuse final rinse water as wash water for the following load.
- Install a water recycling system for glassware washer wastewater.

Vivarium Equipment

- Replace older inefficient cage and rack washers with new more efficient models. Look for models that recycle water through four stages of cleaning using a counter-current rinsing process. In counter-current rinsing, the cleanest water is used only for the final rinsing stage; water for early rinsing tasks (in which the quality of rinse water is not as important) is water that was previously used in the later stages of rinsing operations.
- Retrofit existing cage and rack washer to make use of counter-current flow system to reuse final rinse water from one cage-washing cycle in earlier rinses in the next washing cycle.
- Use tunnel washers for small cage cleaning operations.
- Sterilize and recirculate water used in automatic animal watering systems instead of discharging water to the drain. Where water cannot be recycled for drinking due to

purity concerns consider using in other non-potable applications such as cooling water make-up, or for cleaning cage racks and washing down animal rooms.

Laboratory and Medical Equipment Resources

Labs for the 21st Century, Sponsored by the US Environmental Protection Agency and Department of Energy, http://www.labs21century.gov/ and http://www.labs21century.gov/pdf/bp_water_508.pdf

BMP #13 – Other Water Use

Background

Many other high water using processes are found at federal facilities including vehicle wash systems, maintenance facilities, cleaning/laundry services, single pass air conditioners, water softening systems, and others. You should identify and analyze all high-water using processes for potential water and energy efficiency improvements.

Laundry facilities are often found at federal facilities. The laundry facility may be a self-serve laundry where residents and personnel wash their own clothing, a commercial-type laundry service where residents drop off laundry to be washed or dry cleaned, or it may be an industrial laundry facility where large volumes of government-owned linens and uniforms are cleaned. Large amounts of water are regularly used in industrial laundries, making them highly suitable for a water efficiency program.

Evaporative coolers, also known as swamp coolers and desert coolers, work on the same principle as cooling towers. Air is cooled and humidified as it passes through porous pads that are kept moist by water dripped on their upper edges. Unevaporated water trickles down through pads and collects in a pan for either discharge or recirculation. Since the cooling relies on evaporation, these coolers work best in arid climates. When water evaporates it leaves behind scale and mineral deposits on the pads. This reduces the volume of air flowing through the pads and compromises the performance of the cooler. Bleed-off water serves to dilute the mineral concentration of pan water and reduces scale and dirt build-up on the pads. There are two types of bleed-off systems: once-through and recirculating. The once-through or pumpless type is simpler and less expensive than the recirculating or pump type, but it consumes more water and requires constant drainage.

In many areas of the country additional water softening should not be necessary for most operations. When water softeners are required, look for systems that generate a minimal amount of waste brine per gallon of water softened.

The military maintains facilities for washing and rinsing its aircraft and vehicles. These washrack facilities encompass aircraft, wheeled vehicles, and truck vehicles such as tanks and are an excellent candidate for water efficiency. There are five typical washrack groups based on the type of wastewater emitted: aircraft rinsing, aircraft washrack platform, automotive vehicle washrack, tracked vehicle washrack, and automotive vehicle maintenance. The amount of water used per item washed varies from about 100 to 3,000 gallons. Newer, commercially available washrack equipment will usually include some retrofit and recycling options that can significantly reduce the amount of water used per item washed.

Get expert advice to help determine if water efficiency improvements of the other high water using processes are appropriate. New system designs and improved materials can significantly reduce the water and energy requirements. However, since this may involve significant capital costs, the facility manager should investigate every retrofit or O&M option first. Your first resource should be your local or higher headquarters engineers, but do not overlook or rule out the benefits of input from experienced contractors or other Governmental agencies (DOE, FEMP, etc.)

For more information on this and other FEMP Water Efficiency Best Management Practices, please see the resources section.

Operation and Maintenance Options

- If practical, consider metering or otherwise measuring the amount of water used in other high water using processes.
- As with all water-using equipment, locate and repair leaks in plumbing connections.
- If applicable, ensure that procedures are in place to turn off the water supply when the equipment is not in operation. Some equipment allows water to constantly run, even when the equipment is turned off.
- If applicable, check flow rates to ensure they are within manufacturers' recommendations. For maximum water savings the flow rate should be near the minimum allowed by the manufacturer. This can produce significant water savings.
- To reduce water used by evaporative coolers, keep a tight rein on the amount of bleed-off water. For most small coolers, bleed-off volumes should be less than a few gallons per hour for each 1,000 cubic feet per minute of air flow. Also, replace worn or torn pads and inspect the recirculation pump and reservoir level controls periodically during the warm months when the system is running.
- For water softeners, set the softener controls to start the softening and regeneration process only when needed. Softeners with timers should be avoided.
- For existing washing machines, encourage users to wash only full loads. If the water level is able to be set by the user, encourage using only as much water as needed for that load. Also consider separating laundry by cycles needed.
- Large commercial laundry equipment should be easily programmable to use no more water than is required for the degree of soiling of the items being washed.
- For washrack cleaning facilities that use detergents, use high quality detergents to shorten the length of time required to clean each vehicle or aircraft.

Retrofit and Replacement Options

- If applicable, replace water-cooled equipment with air-cooled equipment, or the best available technology for achieving energy and water efficiency.
- Avoid single-pass or pumpless coolers. Recirculation saves water and increases the thermal efficiency.
- New water softener models may come with water-efficient regeneration cycles.
- For existing washrack cleaning facilities, there are several low cost measures that are capable of saving significant amounts of water. Timers and automatic spray heads are useful in aircraft rinsing facilities, but not for washrack units since each vehicle or aircraft must be washed until sufficiently clean. Automatic shutoff nozzles are designed for facilities with manual rinsing. Since water is usually left on during the entire time a vehicle or aircraft is washed and rinsed, the automatic shutoff spray nozzle can save tens to hundreds of gallons per run. Low flow and high pressure hot water units can reduce the amount of water and solvents used by facilities for cleaning engine components. Pre-wash areas are recommended for tracked vehicle washracks with recycling systems, to eliminate a majority of the coarse dirt so that it will not enter into and clog up the treatment system. Where feasible, include water reuse equipment on vehicle washing equipment. Also consider using self-closing valves on chamois wringers.
- For washrack cleaning facilities, choose new rollover and conveyor equipment that uses less than 35 gallons per vehicle for automobiles and light trucks and less than 75 gallons per vehicle for bus and large truck washes.
- The costliest, but most highly effective way to reduce water usage at wash and rinse facilities is to implement a wastewater recycling system (see BMP #14). Where possible reuse reverse osmosis or nanofiltration reject water for vehicle washing in rollover and conveyor type systems.

- Replace old commercial clothes washers (vertical axis) with new high efficiency washers (horizontal axis) that use significantly less energy, water, and detergent. Look for ENERGY STAR® labeled washers with a water factor of 8.5 gallons of water used per cubic foot or less. Most full-sized ENERGY STAR qualified washers use 18–25 gallons of water per load, compared to the 40 gallons used by a standard machine. These efficient washers have the potential to reduce combined utility costs by as much as 50 percent.
- For large industrial or commercial type laundries, consider replacing old washers with tunnel washers, or ozone laundering. Tunnel washers, also known as continuous batch washers, are heavy-duty, multi-tank systems for use in large industrial laundries. They are capable of handling up to 2,000 pounds of laundry per hour. Tunnel washers use counter current wash methods to maximize water efficiency. These are costly to install, but are capable of saving up to 70 percent of the volume of water used with a washer-extractor, and require less operating and maintenance labor. Tunnel washers typically use about 2 gallons or less per pound of laundry.
- Technologies for reducing water use in laundry operations include ozone laundering. Ozone laundering is suited for lightly to moderately soiled laundry and uses no detergent, uses only cold water, and recycles water. Ozone-generating equipment is attached to the washer as a closed-loop system.

Additional Resources

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://www.gsa.gov/pbs/centers/energy/water.htm

Air Force Water Conservation Guidebook, Air Force Civil Engineer Support Agency, May 2002.
A Water Conservation Guide for Commercial, Institutional and Industrial Users. New Mexico Office of the State Engineer, July 1999.

Military Handbook: Water Conservation. MIL-HDBK-1165. April 1997.

BMP #14 – Alternate Water Sources

Background

Many facilities may have water uses that can be met with non-potable water from alternate water sources. There are four major categories of alternative water sources potentially available to facilities: municipal supplied reclaimed water, treated gray water from on-site sanitary sources, treated gray water from on-site non-sanitary sources, and rainwater. Alternate on-site sources of water are most economic to capture if included in the original design. Common uses for these sources include landscape irrigation, ornamental pond and fountain filling, cooling tower makeup, and toilet and urinal flushing. One additional water source category that is not widely used is storm water.

Municipal supplied reclaimed water has been treated and recycled for non-potable use. This water is often available at a significantly lower rate than potable water, however, use of reclaimed water is often restricted by local codes. Sanitary gray water is water that is generated by bathroom sinks, showers, and clothes washing machines and can contain pathogens. Non-sanitary gray water is water generated by industrial processes or equipment such as reverse osmosis reject water and cooling tower condensate and can contain chemicals, minerals, and solids.

Traditionally, centralized municipal sewage treatment facilities have been the primary source of water disposal for government facilities. However, heightened concerns about the availability of our water supply have encouraged facility managers to consider on-site recycling of their wastewater. In a typical gray water recycling system, water that would normally be discharged for municipal sewage treatment is collected, treated to remove suspended solids and contaminants, and reused. On-site wastewater recycling applications are currently found in states with persistent drought conditions. However, all arid, semiarid, and coastal areas that have experienced water shortages, as well as major urban areas where sewage treatment plants are overloaded and expansion is constrained, are potential candidates for on-site recycling. The recycled water is typically used as flush water for toilets and urinals, landscape irrigation, supply water for ornamental ponds, and make-up water for cooling towers.

At its most basic, gray water treatment consists of removing suspended solids from the water. Filtering with no additional treatment may be applicable for rinse water from laundries or car washes and air handler condensate. At its most sophisticated, treatment may consist of biological treatment with membrane filtration, activated carbon, and ultraviolet light or ozone disinfection to destroy pathogens. The basic gray water system will include storage tanks, color-coded piping, filters, pumps, valves, and controls.

Rainwater harvesting captures, diverts, and stores rainwater for later use. Captured rainwater is often used in landscaping, because the water is free of salts and other harmful minerals and does not have to be treated. It is also useful in attracting and providing water for wildlife. Rainwater harvesting can also help to prevent flooding and erosion, turning storm water problems into water supply assets by slowing runoff and allowing it to soak into the ground. Reducing run-off also helps to reduce the contamination of surface water with sediments, fertilizers, and pesticides in rainfall run-off.

Rainwater can be collected in cisterns and used with little or no treatment for a variety of non-potable purposes. The major components of a rainwater harvesting system include the catchment area/roof or surface upon which the rain falls, gutters and downspouts to carry the water to storage, leaf screens to remove debris, cisterns/storage tanks to store the harvested rainwater, conveyances to deliver the stored water either by gravity or pump, and a water treatment system to settle, filter, and disinfect the water, if required.

Like rainwater, storm water can be harvested and reused for washdown, cooling tower make-up or process water, dust suppression, and vehicle washing. Storm water harvesting differs from rainwater harvesting as the runoff is collected from drains or creeks, rather than roofs. The characteristics of storm water harvesting and reuse schemes vary considerably between projects, but most schemes include collection, storage, treatment, and distribution. Storm water is generally collected from a drain, creek, or pond and then stored temporarily in dams or tanks to balance supply and demand. Storages can be on-line (constructed on the creek or drain) or off-line (constructed some distance from the creek or drain). Captured water is typically treated to reduce pathogens and pollution levels through the use of constructed wetlands, sand filters, and disinfection techniques including chlorine, UV radiation and membrane filtration. The degree of treatment required depends on the proposed use, particularly the level of public exposure. Urban storm water harvesting and reuse is a relatively new field of water management and most of the projects constructed to date have been pilot projects in drought areas in Australia and the United States. Successful storm water harvesting and reuse scheme needs specialist input from a number of areas including storm water management, water supply management, environmental management, and public health. The potential limitations and disadvantages to storm water harvesting and reuse schemes include variable rainfall patterns, environmental impacts of storages, potential health risks, and high relative unit costs of treated storm water. Although this is not a practice that would be feasible at many Federal facilities, storm water harvesting and reuse is an emerging practice that may be useful in specific situations.

To develop an efficient and successful reclaimed water project you must have a reliable source of wastewater of adequate quantity and quality to meet your non-potable water needs. These projects are economically more viable when the cost of water is high, there is a lack of high-quality freshwater supply, reuse is the most cost-effective way to dispose of wastewater effluent, and there are local policies that encourage the use of reclaimed water, or water efficiency.

For more information on this and other FEMP Water Efficiency Best Management Practices (BMPs), please see the resources section.

Operation and Maintenance Options

- As described in other BMPs, potential non-potable water use should be identified while reviewing current water use practices. The use of non-potable water is generally most cost-effective when included in the design of new facilities.
- For specifics, consult with experts in the field. Your first resource should be your local or higher headquarters engineers, but do no rule out the benefits of input from experiences from contractors or other Governmental agencies.
- Facilities using alternative on-site water sources must comply with all applicable backflow prevention requirements.

Municipal Supplied Reclaimed Water

- Municipal supplied reclaimed water pipes must be color coded with purple tags or tape according to standards set by the American Water Works Association to minimize cross-connection problems.
- Signs should be used liberally to indicate that reclaimed water is non-potable. Place them in public places such as in front of a fountain and on valves, meters, and fixtures.
- Keep the pressure of reclaimed water to 10 psi lower than potable water mains to prevent backflow and siphonage in case of accidental cross-connection.
- Run reclaimed water mains at least 12 inches lower in elevation than potable water mains, and horizontally at least 5 feet away.

- Review the quality of reclaimed water to ensure there will be no harmful effects, such as salt buildup, from long-term use.

Gray Water Recycling Systems

- The pathogenic organisms in sanitary gray water must not come into contact with either humans or animals. This can be accomplished by treating the water to eliminate pathogens or avoid their introduction into water by not mixing sanitary gray water with any potable water source. Human exposure can be prevented by not collecting or storing it in an open container.
- Sanitary gray water used for irrigation should not be applied directly through a spraying device, but rather injected directly into the soil through drip irrigation. Drip irrigation allows you to receive the benefits of using recycled water and at the same time avoid contaminating animals, humans, and edible plants.
- If you install a gray water recycling system, consider using biodegradable cleaning products that do not contain sodium, chlorine, or boron. Cleaning products that contain high chemical levels may make their way into the gray water recycling system and could poison plants for damage soil through the buildup of inorganic salts.
- Rain or excessive irrigation could cause ground saturation and result in pools of gray water on the surface. To help eliminate this situation, turn off the gray water system and divert the gray water to the sanitary sewer line during rainy periods.
- A maintenance program for a gray water system must include the following steps, all of which must be performed regularly:
    - Inspecting the system for leaks and blockages
    - Cleaning and replacing the filter bimonthly
    - Replacing the disinfectant
    - Ensuring that controls operate properly
    - Periodically flushing the entire system

Retrofit and Replacement Options

Gray water Recycling System

- The use of on-site wastewater recycling systems should be considered when constructing new buildings. Even though many of these systems are costly to purchase, the payback period in savings from discharging less wastewater can be as little as 10 years or less.
- Gray water systems must be installed in accordance with local plumbing codes and by professional, licensed plumbing contractors. Installing a gray water system requires the retrofitting of existing plumbing, and all alterations to the plumbing system must be approved by local authorities.
- All counties and cities that permit gray water recycling require building inspections to inspect sites and, after the installation, verify compliance and proper operation of the gray water system.
- Local authorities may require that gray water supply systems be clearly distinguished from potable water supplies. Methods of doing so may include extensive labeling of the system or the use of different piping materials for the different systems. All graywater outlets must be clearly labeled to indicate that they dispense non-potable water. Local codes also may require marking gray water supplies by adding biodegradable dye. Additionally, backflow preventers also must be installed to ensure the proper separation of potable water and gray water supply system.
- For buildings with slab foundations, recoverable gray water maybe limited to washing machine discharge, because most drain pipes such as for sinks are buried beneath the slab and thus not easily accessible without a significant additional expense.

- For buildings with perimeter foundations, gray water may be recoverable from most sources due to accessibility to piping from crawl spaces.
- Depending on the gray water source, application, recycling scheme, and economics, one gray water treatment method (e.g., media filtration, collection and settling, biological treatment units, reverse osmosis, sedimentation/filtration, physical/chemical treatment) may be more appropriate than the other.

Rain Water Harvesting

- Rain water collection and distribution systems can be incorporated into almost any existing site, although it is easier to incorporate them into new construction.
- Rain water collection and distribution systems can be incorporated into almost any existing site, although it is easier to incorporate them into new construction.
- According to The Texas Manual on Rain Water Harvesting, you can collect 600 gallons of water per inch rain per 1,000 square feet of catchment area. To determine how much water you could collect in a year (1) calculate the roof catchment area, (2) multiply the collection area in square feet by 0.6 gallons per square foot per inch of rain times the collection factor (which measures your collection efficiency; 80 percent or 0.8, would be a good efficiency) times the average rainfall, (3) divide this figure by 365, and that will give you your daily collection figure.

Alternate Water Sources Resources

Water Management: A Comprehensive Approach for Facility Managers, General Services Administration, http://www.gsa.gov/pbs/centers/energy/water.htm

Air Force Water Conservation Guidebook, Air Force Civil Engineer Support Agency, May 2002.
A Water Conservation Guide for Commercial, Institutional and Industrial Users. New Mexico Office of the State Engineer, July 1999.

Military Handbook: Water Conservation. MIL-HDBK-1165. April 1997.

The Texas Manual on Rainwater Harvesting. 3rd Edition. July 2005
http://www.twdb.state.tx.us/publications/reports/RainHarv.pdf

Managing Urban Stormwater: Harvesting and Reuse, Department of Environment and Conservation NSW Australia. ISBN 1 74137 875 3. April 2006.
http://www.environment.nsw.gov.au/resources/managestormwatera06137.pdf

Labs for the 21st Century, Sponsored by the US Environmental Protection Agency and Department of Energy, http://www.labs21century.gov/ and
http://www.labs21century.gov/pdf/bp_water_508.pdf