I^{2}SL Best Practices Guide Series

Laboratory Water Efficiency

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Learning Objectives

At the end of this session, participants will be able to:

- Understand water management strategies to ensure water consumption and efficiency are considered in coordination with other sustainability and energy goals;
- Identify water-using equipment within laboratories and associated best practices to operate, retrofit, and/or replace equipment to achieve maximum water efficiency;
- Understand useful strategies for optimizing water efficiency within cooling towers and steam boilers; and
- Pursue additional resources from I^{2}SL, WaterSense, the Federal Energy Management Program (FEMP), and others that support water management, efficiency, auditing, and identification of alternative sources of water.

Agenda

- Introduction to WaterSense
- Why water efficiency matters
- Laboratory water management
- Laboratory equipment best practices
- Optimize cooling tower performance
- Minimize steam boiler water use
- Other common water use areas
- Additional resources
- Questions

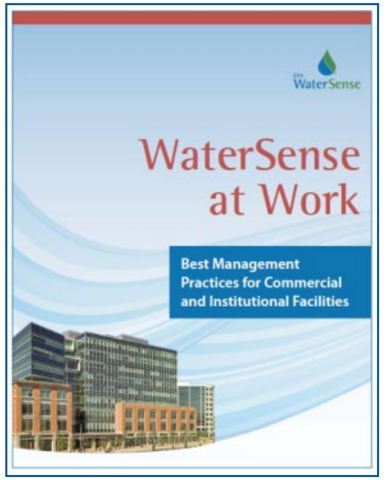
What Is WaterSense?

WaterSense is a voluntary program launched by EPA in 2006 that provides a simple way to identify water-efficient:

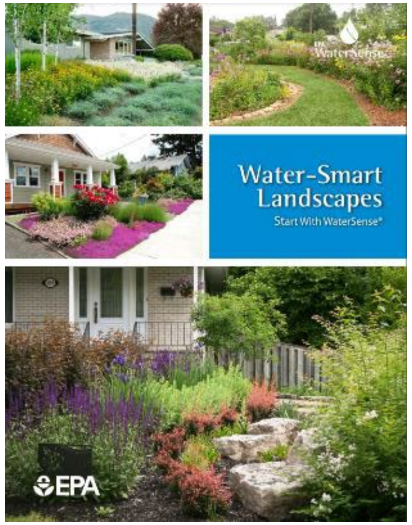
- Products
- Programs
- Practices
- Homes

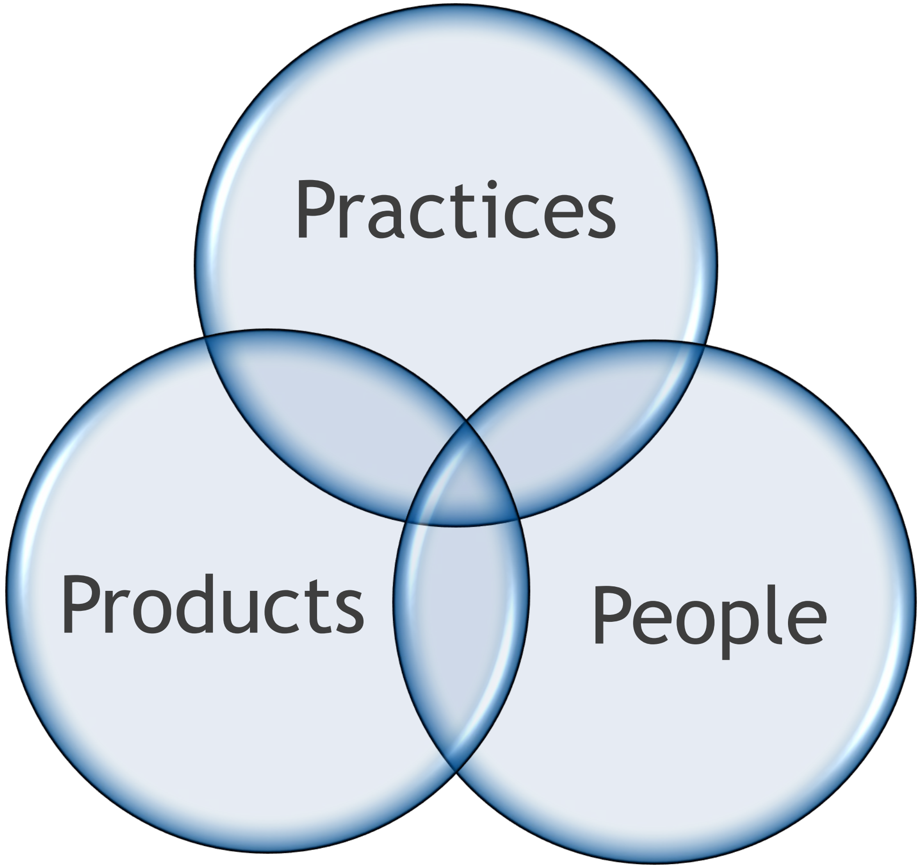
Products are independently certified for water efficiency **and** performance

WaterSense Program Overview



Actions that can be taken to reduce water use at home, outdoors, and at work

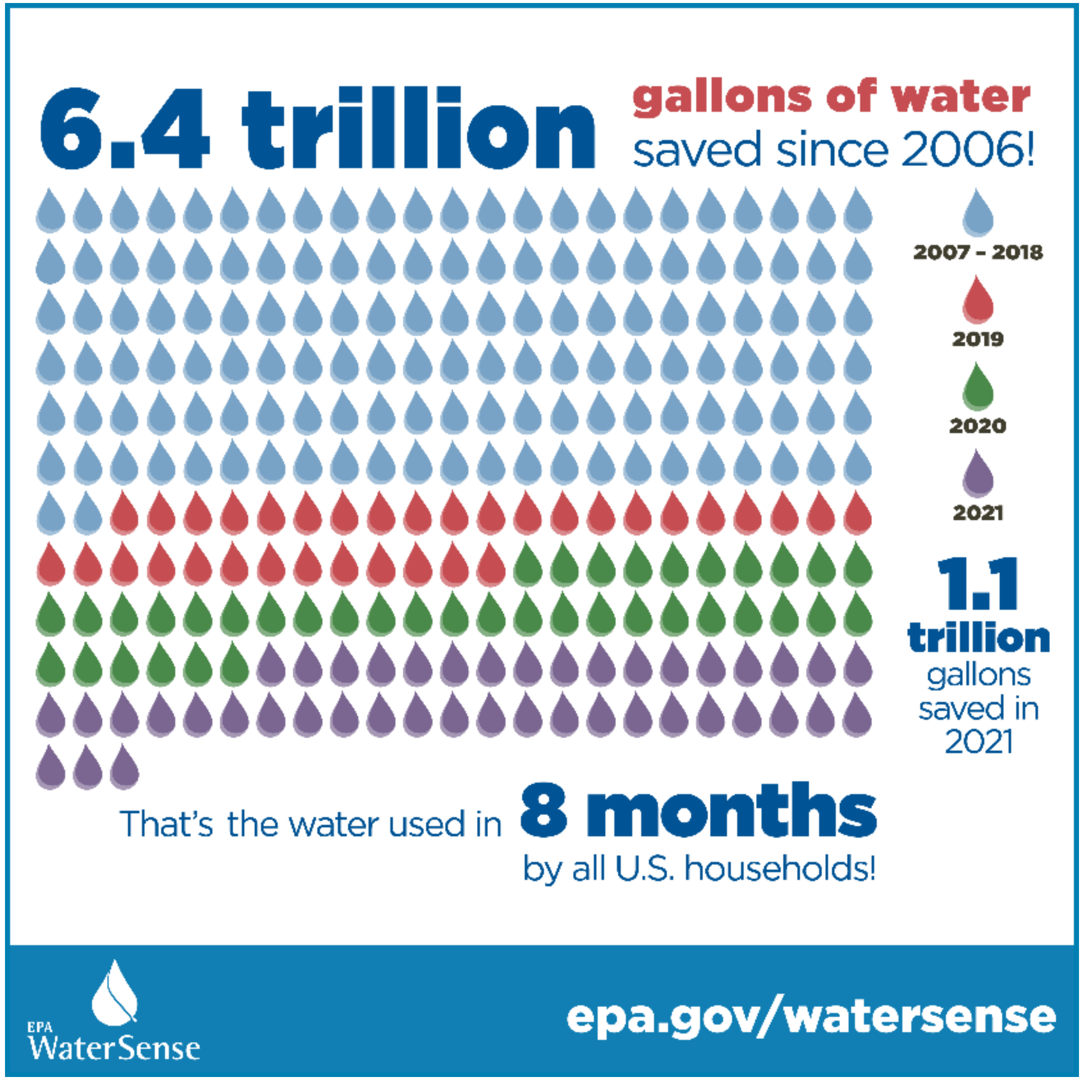


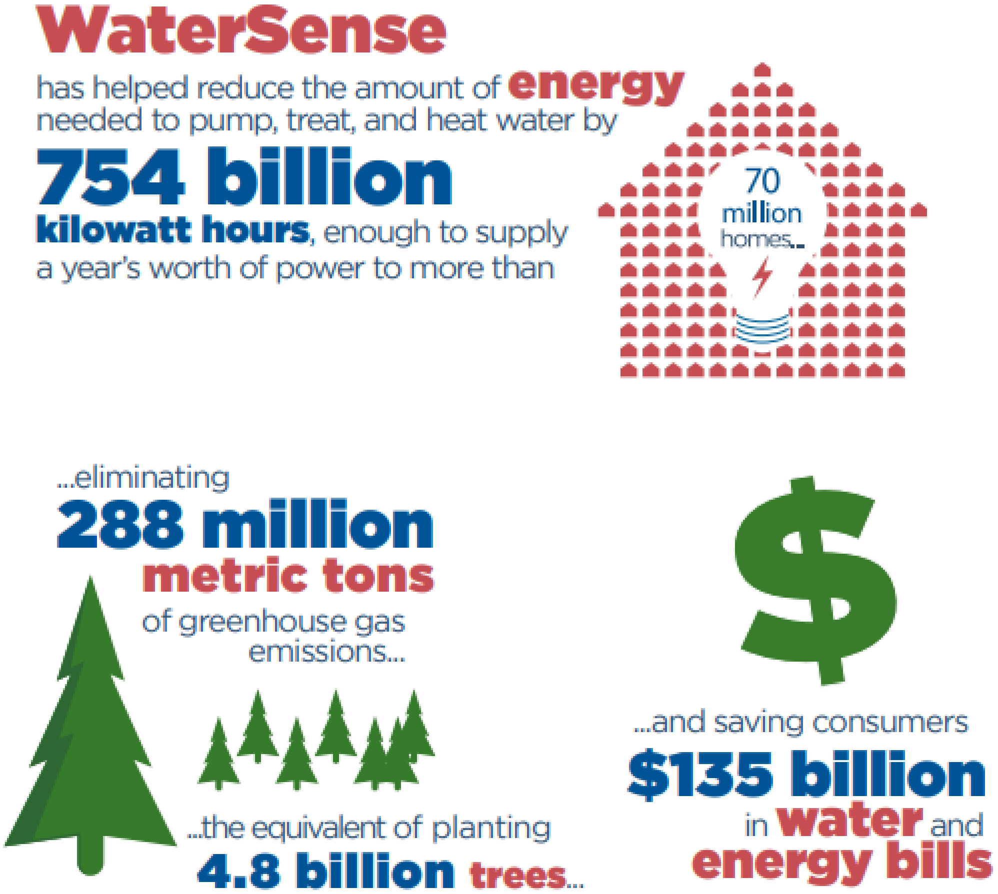


Fixtures and technologies save water

Partners reach users to change behavior

Accomplishments





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Why Water Efficiency Matters

Lake Mead nears dead pool status as water levels hit another historic low

If the reservoir dips below 895 feet – a possibility still years away – Lake Mead would reach dead pool, carrying enormous consequences for millions of people across Arizona, California, Nevada and parts of Mexico.

How Bad Is the Western Drought? Worst in 12 Centuries, Study Finds.

Fueled by climate change, the drought that started in 2000 is now the driest two decades since 800 A.D.

Drought-hit Colorado River water supplies near "moment of reckoning"

Rebecca Falconer

California's largest reservoirs at critically low levels - signaling a dry summer ahead

Images from Lake Oroville and Lake Shasta compiled by the state show 'a shocking drop in water levels' compared to years past

West Texas farmers and ranchers fear the worst as drought, heat near 2011 records

2011 was the driest year on record for Texas, causing an estimated cost of $7.62 billion in crop and livestock losses. A dry and hot June has many sounding alarm bells about 2022.

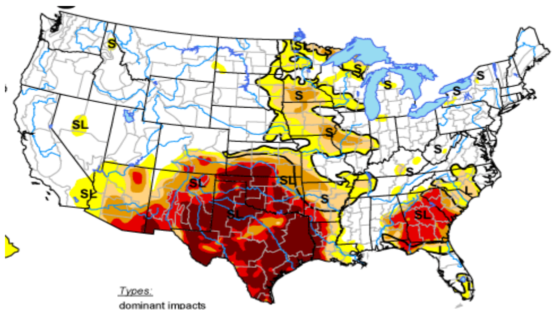
BY JAYME LOZANO JUNE 28, 2022 5 AM CENTRAL

COPY LINK REPUBLISH

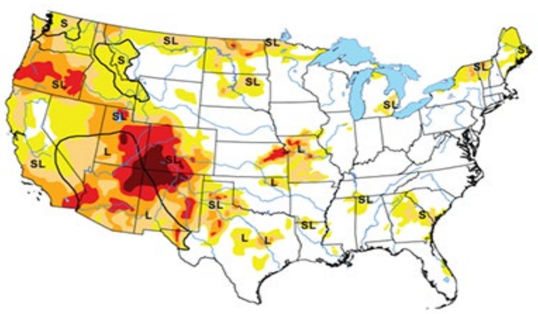
Water Supply Reliability Is a Challenge

Sep. 2007

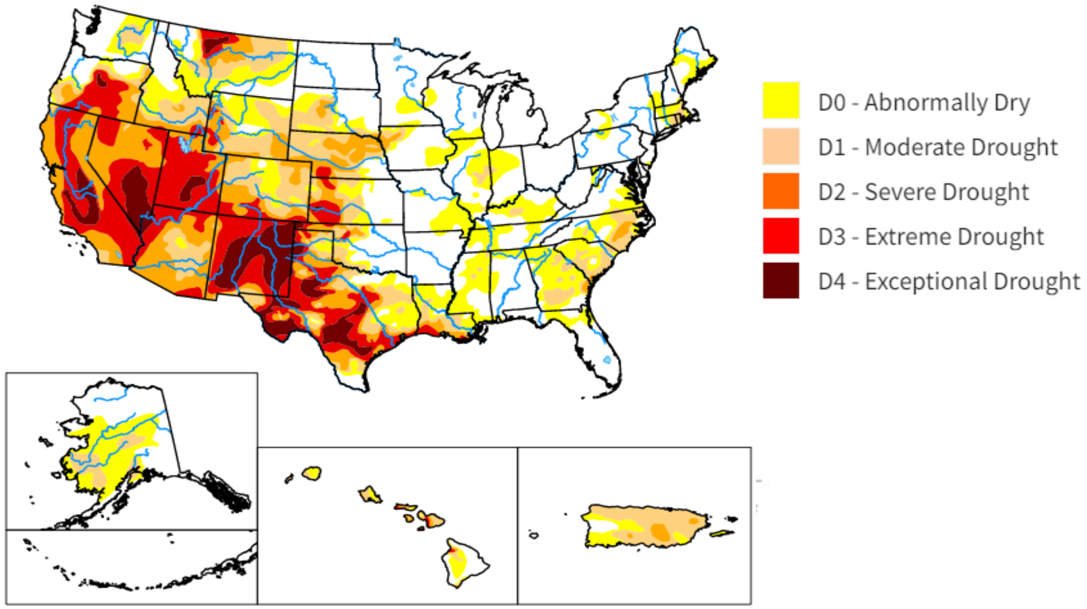
Oct. 2011



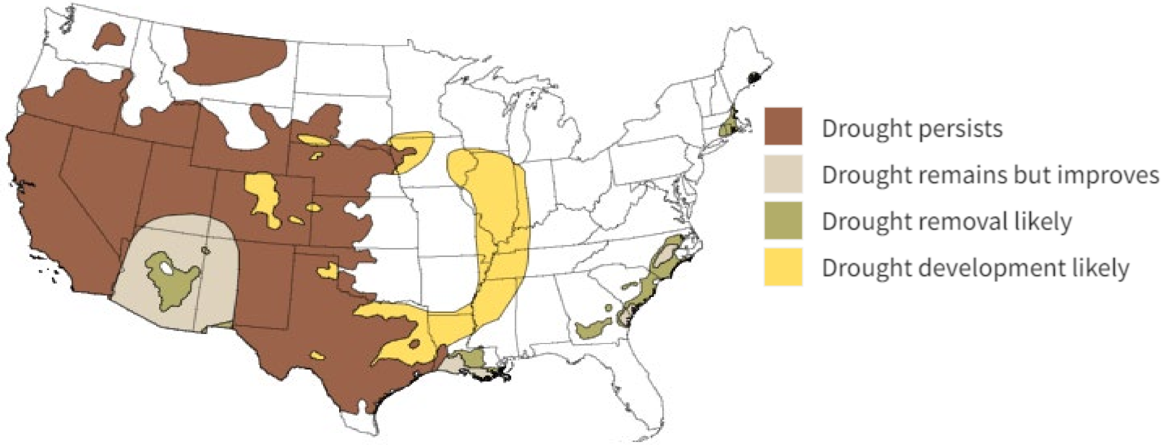
Oct. 2018



June 2022



Seasonal Drought Outlook



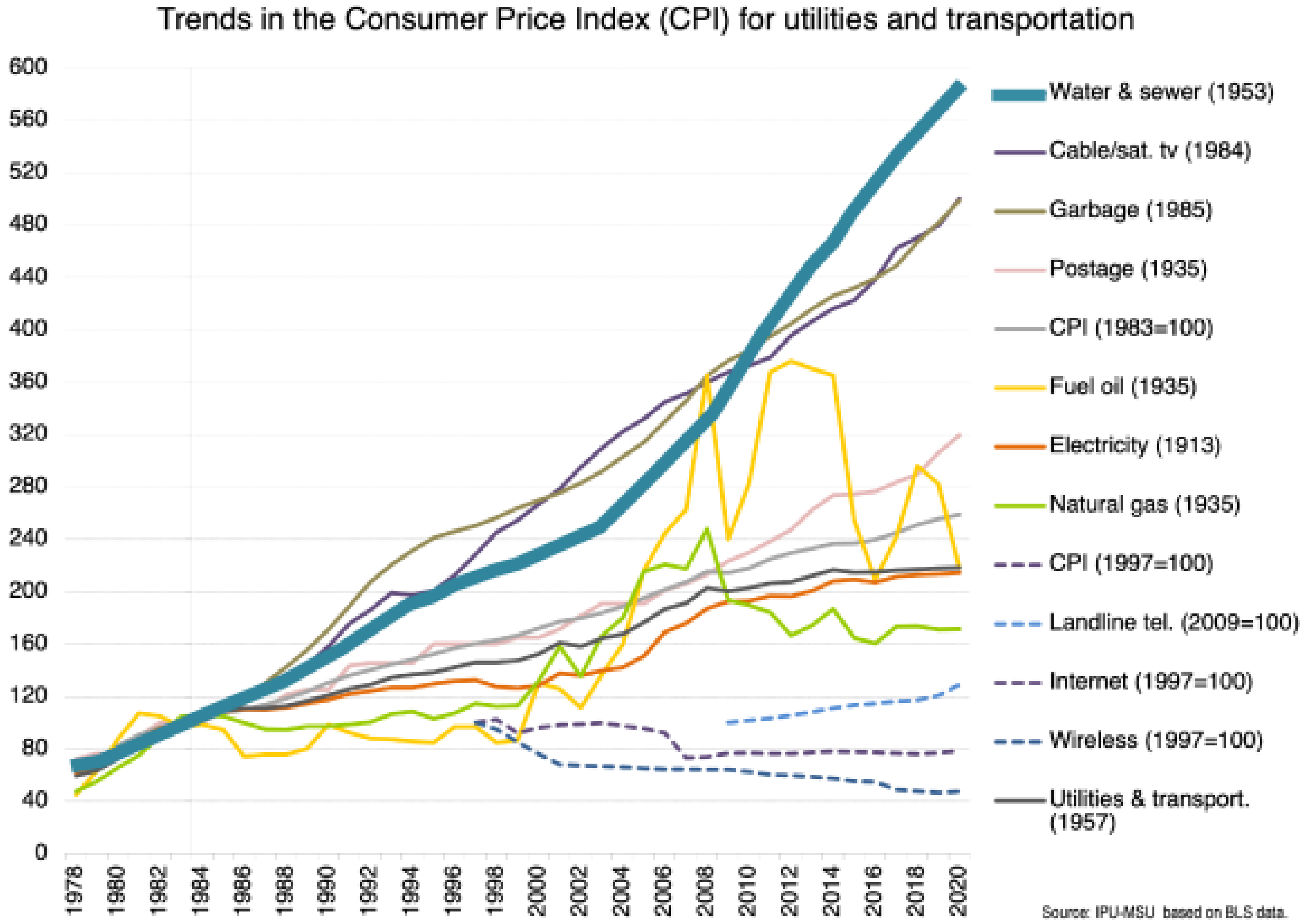
- Drought happens somewhere every year
- Extreme weather changes increase uncertainty and concern about water scarcity and risk
- Competition for supplies to meet public, agricultural and energy needs will increase

Maps obtained from Drought.gov

Why Does It Matters for Labs?

Save operational costs

- Water and sewer rates have risen well above the Consumer Price Index, so improvements insulate budgets from future rate increases
- Average 2020 combined commercial water and sewer rates were $11.09 per Kgal.
- Improving system efficiency can reduce maintenance requirements



Why Does Water Matter for Labs?

Water-energy nexus

- Every gallon of water has an energy footprint needed to pump, move, heat, and treat water
- Saving water can save energy, and vice versa
  - 8 percent of commercial buildings' energy use is to heat water—about the same as energy used for cooling and ventilation
  - Large savings from reducing hot water usage in mechanical systems, laboratory equipment, commercial kitchen equipment, and laundry and sanitary systems

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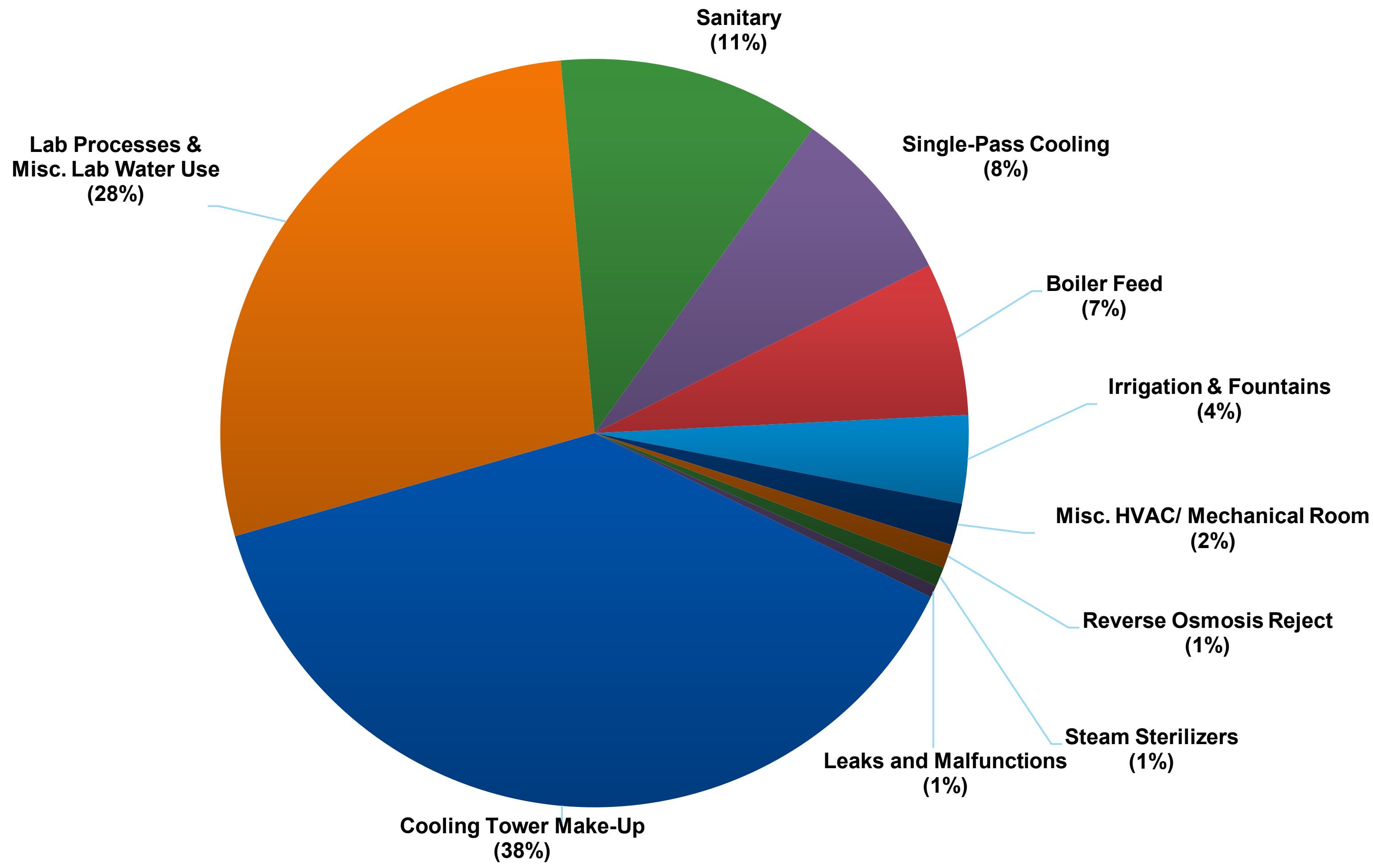
Just Add Water!

Adding water into existing energy efficiency work can help facility managers:

- Understand where and how water is used
- Identify leaks and other operational malfunctions to correct immediately
- Develop and evaluate a comprehensive project list of water savings opportunities
- Set and achieve water management goals

Water Use Profiles of a Laboratory



Typical EPA laboratory building water use, based on data collected during water assessments conducted at EPA's laboratories between 2011 and 2019.

Steps of Assessing Laboratory Water Use

Gather information on water sources (metered and unmetered) and collect/review water bills

Establish a baseline using water use data from a typical year

Inventory major water-using fixtures, equipment, systems, and processes

Create a water balance for your facility

Identify projects and opportunities to save water, energy, and money

www.energy.gov/eere/femp/articles/water-evaluation-tools

Meter and Monitor Water Use

You can't manage what you don't measure!

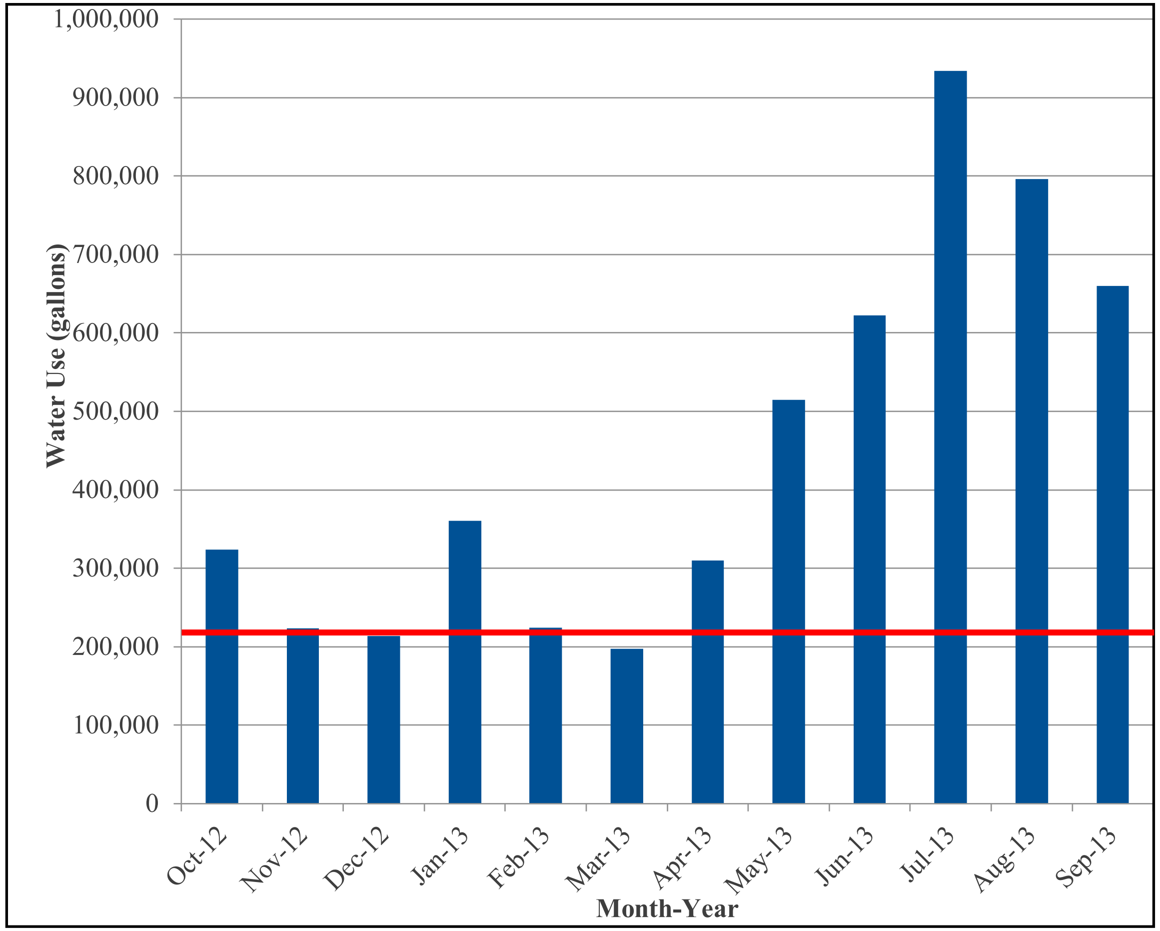
- Accurately measuring water use can help labs identify areas for targeted reductions
- Submeters can help identify leaks and equipment inefficiencies or malfunctions

Meter all sources of water

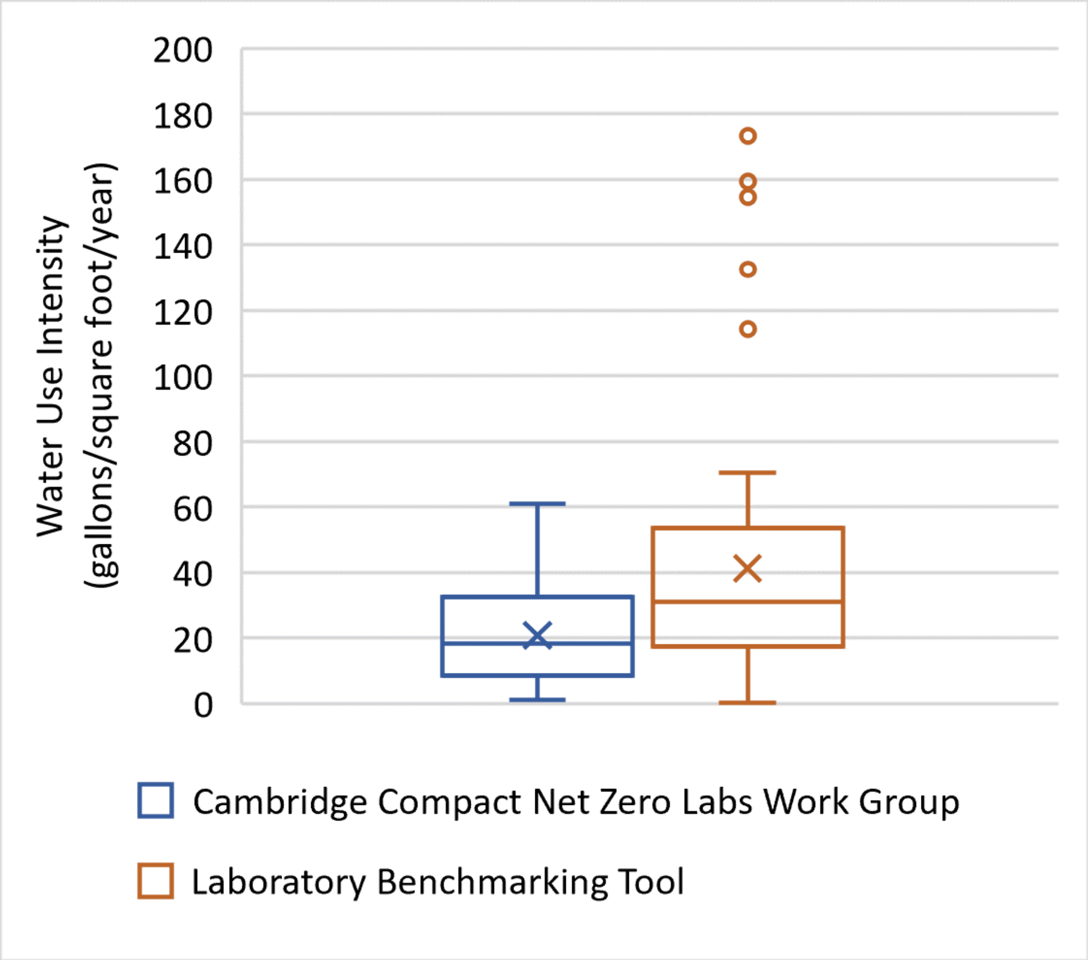
- City potable, reclaimed water

Submeter specific end uses

Integrate submeters with BAS or utility management systems



Laboratory Benchmarking



Laboratory Benchmarking Tool (LBT)

- Evaluate how your lab utility consumption compares to other laboratories
- Includes survey questions about other labs' energy management strategies and barriers
- Can be linked to ENERGY STAR Portfolio Manager account

lbt.i2sl.org

Assign Staff

Ensure staff are assigned responsibility for water management activities

- Reviewing and tracking water bills
- Collecting and recording submeter data at least monthly
- Conducting regular walk-throughs to put eyes on water-using equipment (e.g., cooling towers, boilers, steam sterilizer, irrigation systems)
- Communicating goals and best practices to laboratory staff

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Eliminate Single-Pass Cooling

Single-pass or once-through cooling systems use water to remove heat and cool equipment

Types of equipment that could use single-pass cooling include:

- Air conditioners
- Refrigeration systems
- Air compressors
- Condensers
- Ice machines
- Vacuum pumps

Use approximately 40 times more water to remove the same heat load than a cooling tower

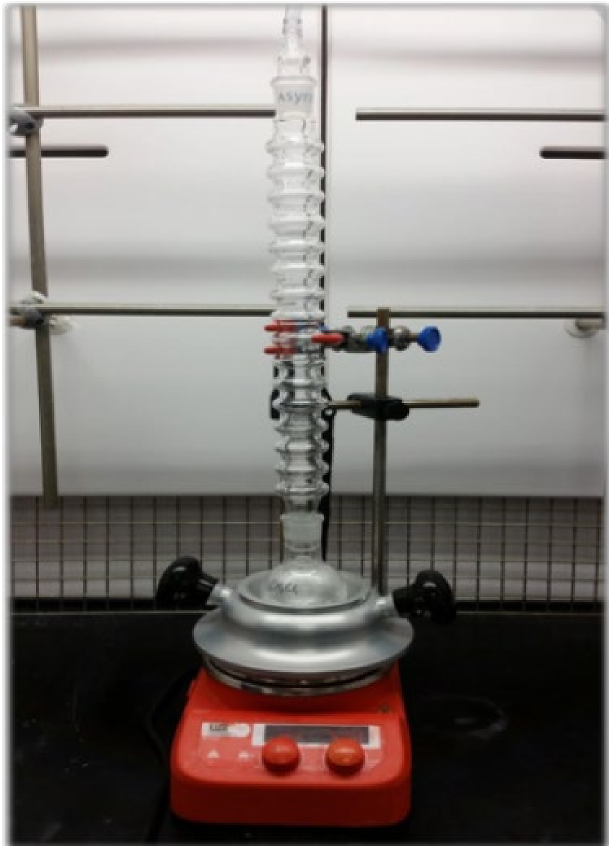
Single-Pass Cooling Alternatives

Eliminate all instances of single-pass cooling

- Replace with air-cooled equipment
  - Vacuum pumps, ice machines, and condensers all have air-cooled models that are readily available and extremely cost effective.
- Consider a closed-loop recirculation system
  - Use an air-cooled point-of-use chiller
  - Connect cooling lines to existing chilled water loops

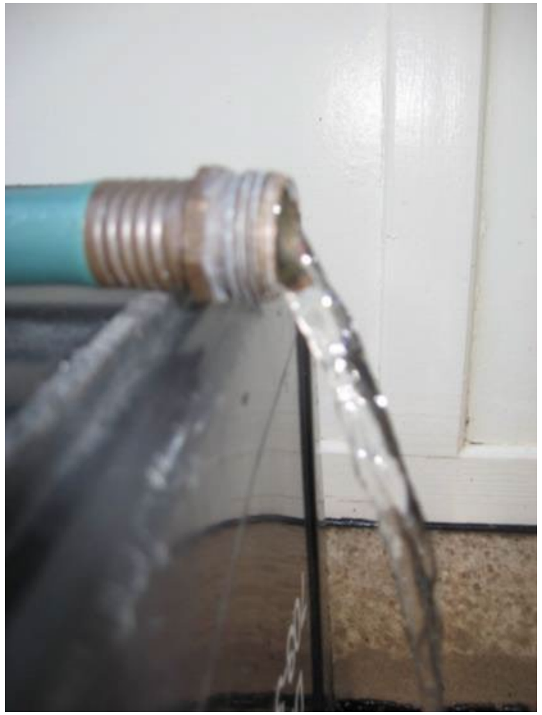
If you can’t retrofit or replace your water-cooled equipment

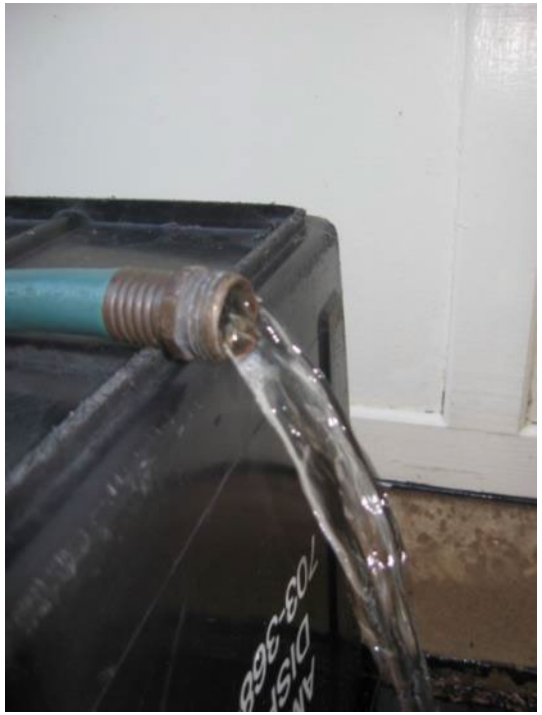
- Use minimum flow rate required for cooling
- Install a control valve to turn off cooling water when there is no heat load
- Regularly check operation of the water control valve
- Identify methods for reusing single-pass cooling water



Waterless condenser

Single-Pass Cooling Savings Potential





1 gpm	2 gpm	6 gpm
525,000 gal/year	1,050,000 gal/year	3,150,000 gal/year
$5,800/year*	**$11,600/year***	**$34,900/year***

*At national average commercial cost of $11.09 per 1,000 gallons

Water Purification Systems

Best Practices

- Identify the minimum quality of water required
- Avoid oversizing treatment systems; consider POU systems where highly purified water use is limited
- Backwash filters and regenerate carbon, ion, and resin beds only when necessary, based on volume treated rather than on a set schedule
- Select RO and other membrane-based treatment systems with high recovery ratings
- Explore opportunities to reuse reject water for other purposes (e.g., graywater, cooling tower make-up).

Lab RO treatment system

Autoclaves/Steam Sterilizers

How They Use Water

- Water is used to produce steam
- Tempering of steam condensate prior to discharge
- Sometimes to create a vacuum for drying (e.g., liquid ring vacuum pump or venturi-based water ejector)

Autoclaves/Steam Sterilizers

Best Practices

- Turn off or set to idle when not in use
- Retrofit older models that apply tempering water continuously with a temperature actuated valve and/or cooling tank
  - Up to 90 percent reduction in water use
- Inspect regularly and educate lab staff to identify when a problem occurs
- Install systems that can recover/recirculate water used to create vacuum
- Newer models are often designed with water and energy efficiency in mind and have many of these options built in

DID YOU KNOW?

A FAILED SOLENOID VALVE IN AN AUTOCLAVE COULD WASTE 2.6 MILLION GALLONS OF WATER A YEAR!

IF YOU NOTICE A GURGLING SOUND NEAR THE DRAIN OF THIS AUTOCLAVE BETWEEN CYCLES, PLEASE NOTIFY THE UGA GREEN LAB PROGRAM AT GREENLAB@UGA.EDU OR 706-542-7884. THANK YOU!

Vacuum Systems

How They Use Water

- Liquid ring vacuum systems and aspirators use water to create a vacuum seal
- Water is sometimes also used for equipment cooling
- Can use ~0.5 to 1.0 gpm per horsepower

Lab vacuum system using ~900,000 gallons per year

Vacuum Systems

Best Practices

- Eliminate use of “aspirator” type systems
- Turn off the vacuum system when not in use
- Monitor water use to make sure it’s within the manufacturer’s specified range
- Consider installing a water recovery system that recirculates vacuum seal and cooling water
  - Between 50 and 80 percent savings
- Replace older, wet or water-cooled vacuum systems with dry, air-cooled models

Glassware Washers

Best Practices

- Newer models include flow control and sensing capabilities, which allow less water
- Staff education
  - Only use the number of wash/rinse cycles to get the desired level of cleanliness
  - Run full loads
- When purchasing new systems
  - Compare energy and water consumption
  - Don’t oversize new equipment
  - Consider add-on efficiency features, such as water recycling systems or heat recovery

Lab glassware washer

Cage, Rack, and Bottle Washers

How They Use Water

- Batch systems go through pre-rinse, washing, and final rinse cycles
- Tunnel washers use a conveyor system
- Often times, hot and high purity water is used, making them very resource intensive
- Tempering water sometimes needed to cool wastewater prior to discharge

Cage, Rack, and Bottle Washers

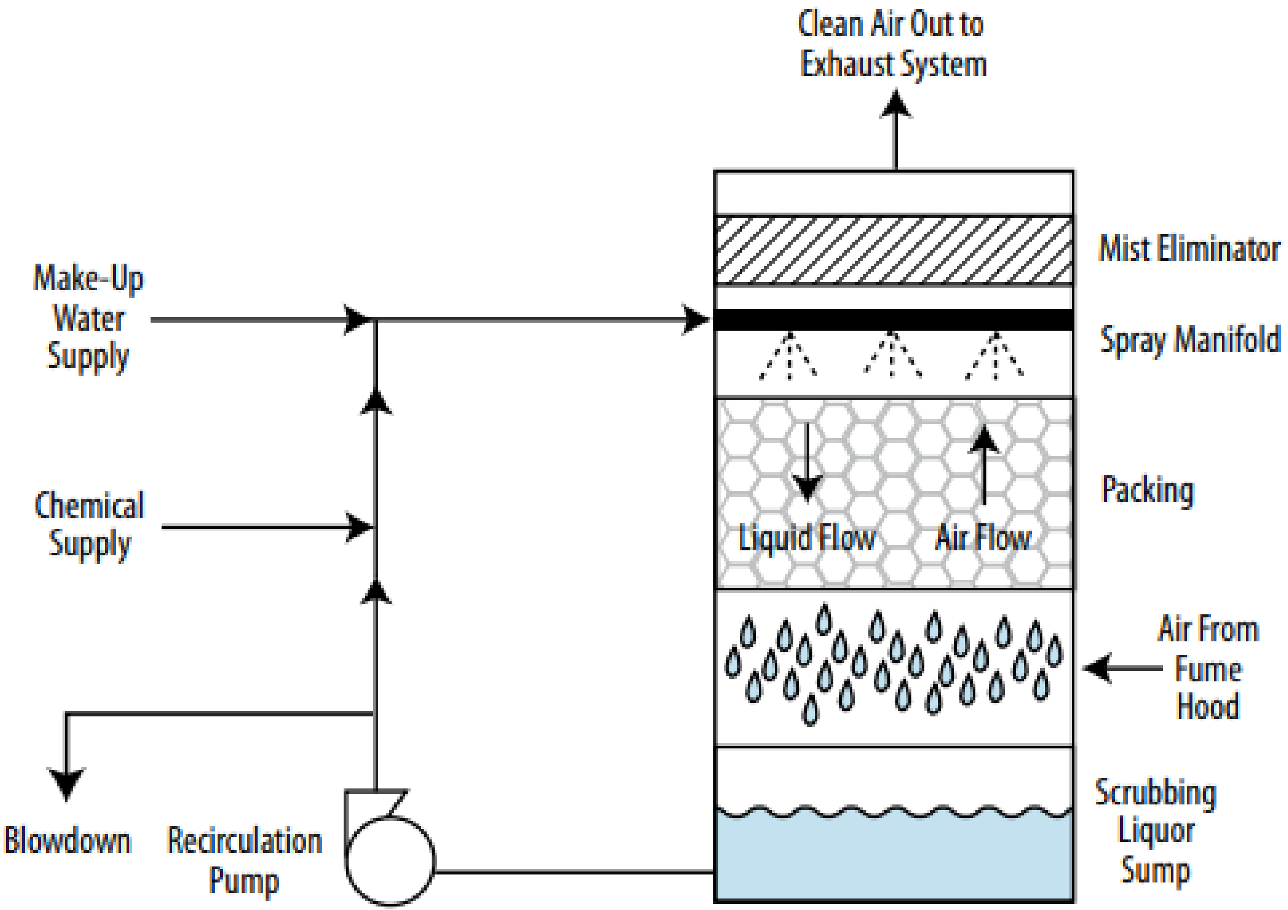
Best Practices

- Wash only full loads for batch washers
- Schedule tunnel washer runs to maximize equipment washed
- Use high-quality water (e.g., RO/DI) only for final rinse cycle
- Choose minimum wash and rinse cycles
- When purchasing new equipment
  - Consider batch systems (potential for 20 to 30 percent less water use!)
  - Select models that can reuse final rinse water in pre-rinse cycles
  - Select models that minimize water (and energy) use

Fume Hood Wet Scrubbers

How They Use Water

- Contaminated air from fume hoods pass through water spray or wetted media, which absorbs contaminants
- Water lost to evaporation
- Some water needs to be periodically blown down to control minerals and contaminants



Fume Hood Wet Scrubbers

Best Practices

- Turn off wet scrubber systems when not needed
- Shut the sash to reduce airflow and evaporation
- Use recirculating systems for scrubber fluid
- Maintain liquid level controller and water make-up valves
- Control blowdown based on scrubber fluid chemistry (using pH, ORP, or conductivity controller) rather than allow continuous or timed blowdown

Perchlorate/Perchloric Acid Wash Down Systems

How They Use Water

- Water is sprayed on fume hood and associated ductwork daily or after a procedure is complete

Best Practices

- Follow ANSI/ASSP Z9.5 and NFPA 45 standard
- Minimize ductwork during design
- Use automatic shut off valves to control flow of water when hoods are not in use
- Reduce operation while ensuring health and safety is maintained
- Work with equipment suppliers to design and operate with water efficiency in mind

Additional Lab Equipment

Other Equipment in BPG

- Animal watering systems
- Humidifiers
- Photographic and Xray equipment

www.i2sl.org/resources/bpg.html

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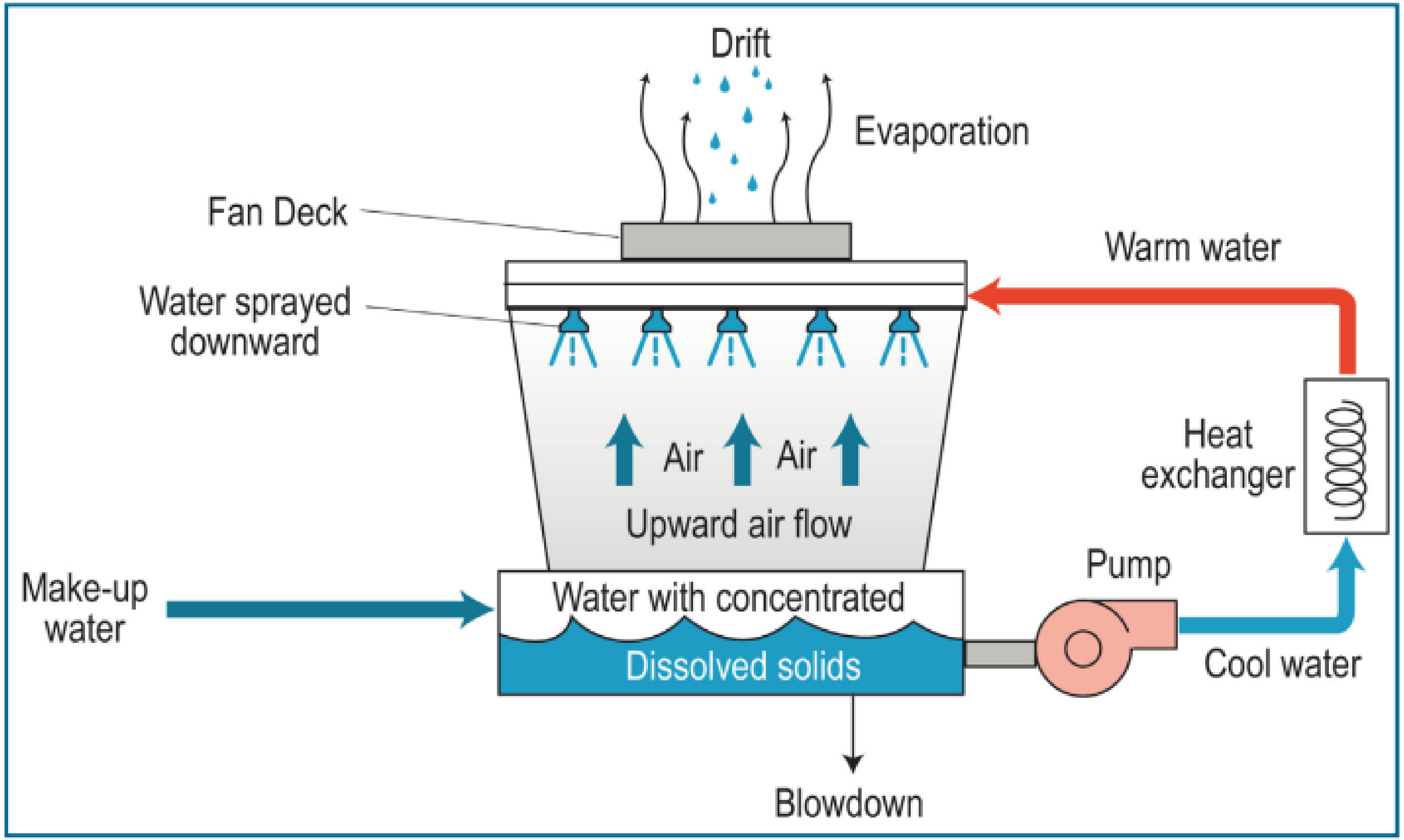
Cooling Tower Overview

Cooling towers can account for 50% of more of a laboratory's water use



- Reduce the evaporative heat load on the cooling tower
- Reduce blowdown
- Provide alternate make-up water supply

Reduce Evaporative Heat Load

- Every ton of cooling (12,000 Btu/hour) requires evaporation of ~1.8 gallons of water/hour
- Building energy-saving projects provide direct water savings
- Classic example of the water-energy nexus
- Evaporated water is a consumptive use!

What Is Blowdown?

- Blowdown help limit the concentration of minerals in the recirculating water system that occurs as water is evaporated
- Helps prevents scale, corrosion, or other issue
- A measure of cooling tower water efficiency is cycles of Concentration (CoC)

$$\text{CoC} = \frac{Conductivity\ of\ Blowdown}{Conductivity\ of\ Make\text{–}Up\ Water} = \frac{Make\text{–}Up\ Volume}{Blowdown\ Volume}$$

- Increasing CoC can reduce the need for blowdown, which reduces the needs for make-up water

Target Water Properties

Table 6.3.2.3 Recirculating Water Properties for Open-Circuit Cooling-Tower Construction

Recirculating Water Parameters	Maximum Value
Conductivity (micro-ohms)	3300
Total dissolved solids (ppm)	2050
Total alkalinity as $CaCO_3$ (ppm) excluding galvanized steel	600
Total alkalinity as $CaCO_3$ (ppm) galvanized steel (passivated)	500
Calcium hardness as $CaCO_3$ (ppm)	600
Chlorides as Cl (ppm)	300
Sulfates (ppm)	250
Silica (ppm)	150
Langelier Saturation Index (LSI)	+2.8

From ASHRAE 189.1-2020 *Standard for the Design of High-Performing Green Buildings*

Controlling and Limiting Blowdown

Best Practices

- Control blowdown using a conductivity controller
- Install submeters to monitor cooling tower make-up and blowdown (some utilities offer sewer deduction based on metered blowdown)

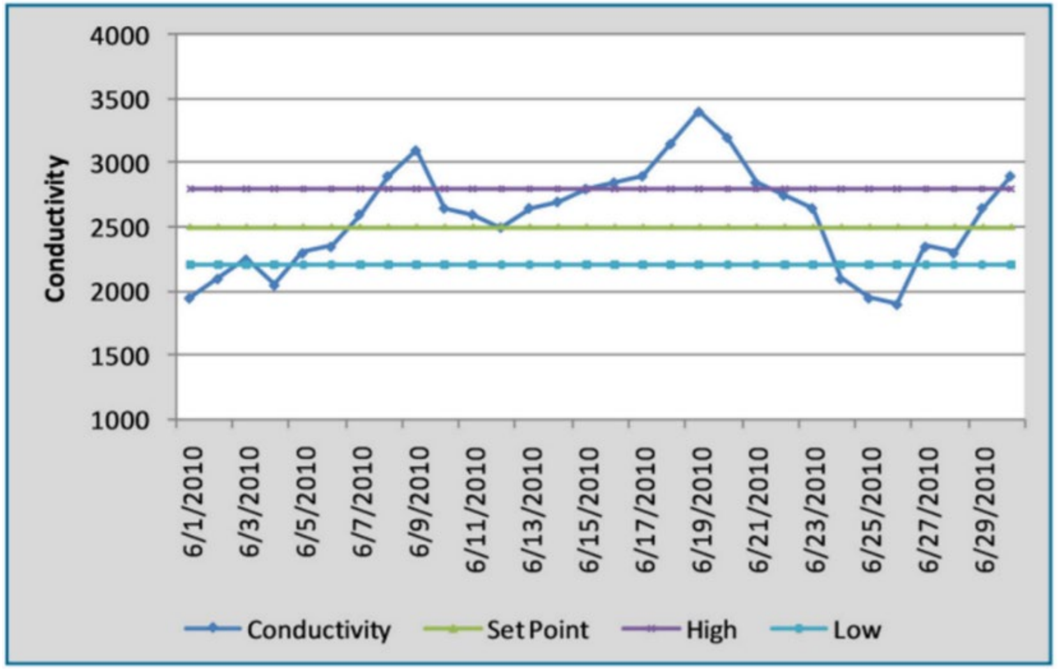


Figure 8. Conductivity trend using manual or timed control. Source: Federal Energy Management Program.

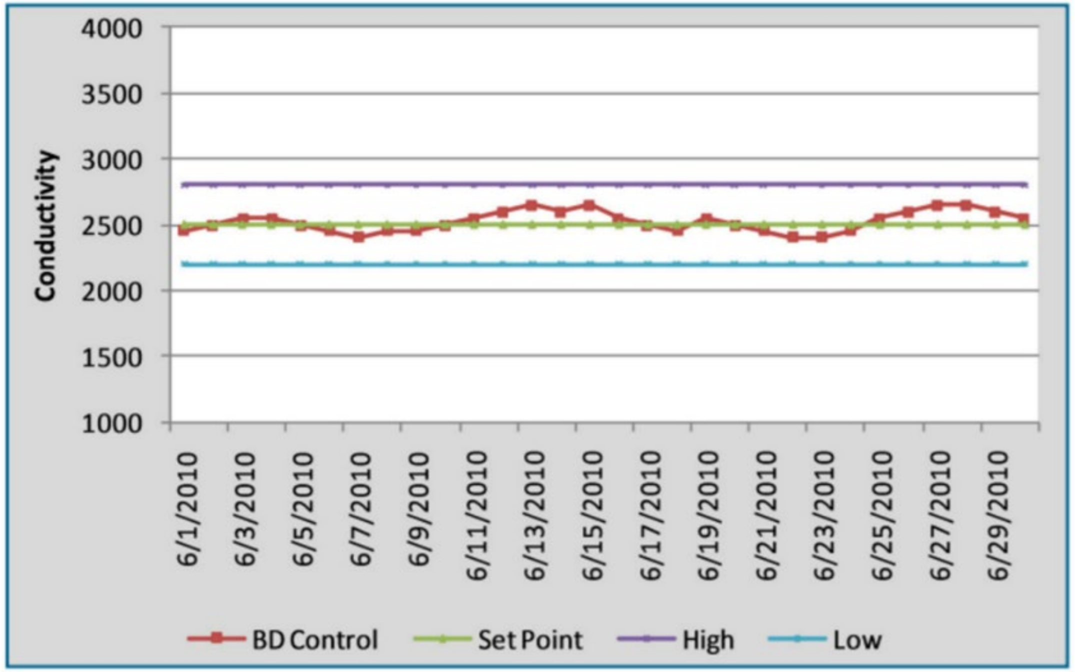


Figure 9. Conductivity trend using a conductivity controller to initiate blowdown. Source: Federal Energy Management Program.

Controlling and Limiting Blowdown

Best Practices

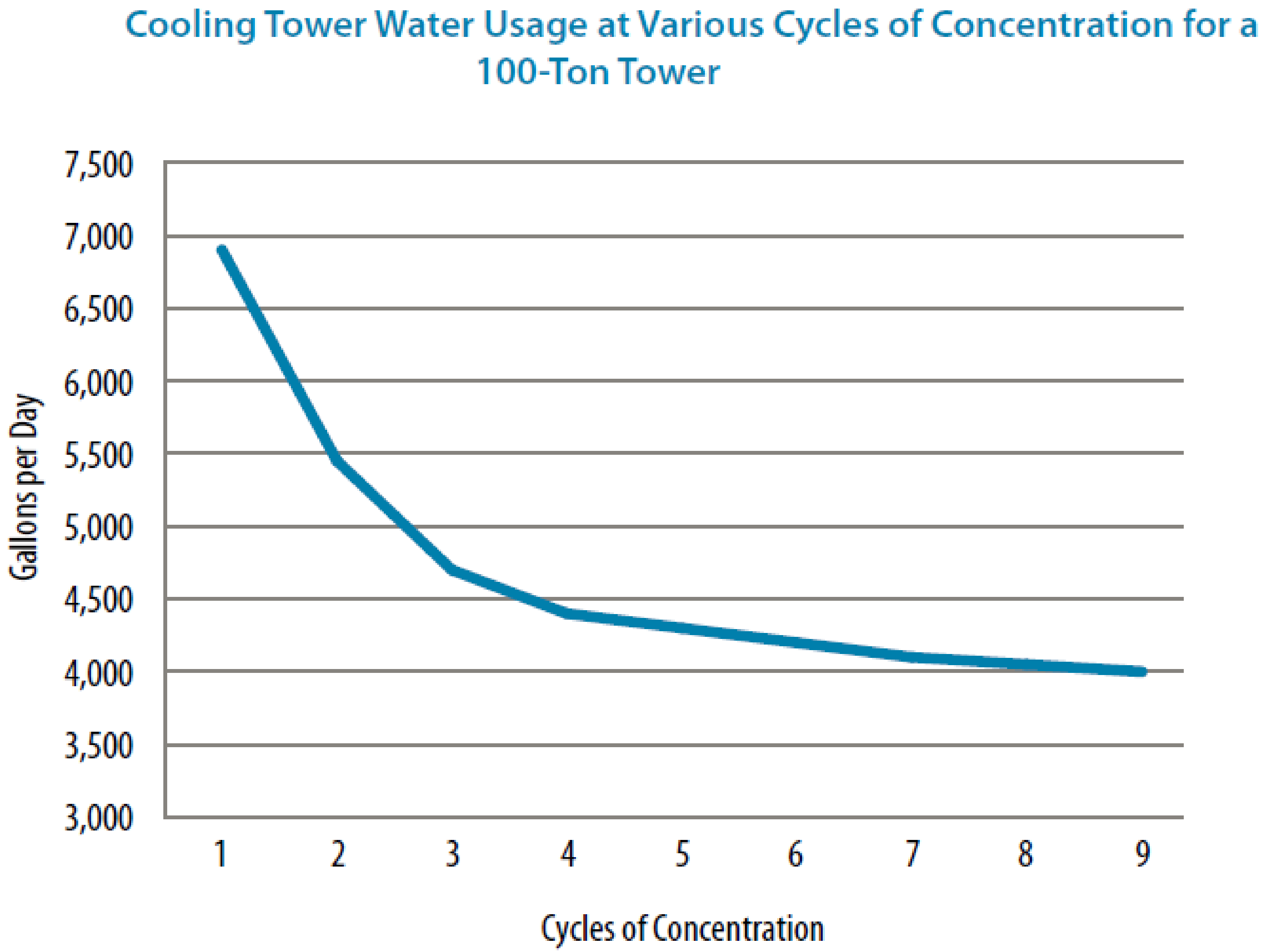
- Keep minerals in solution by managing water chemistry
  - pH control
  - Corrosion inhibitor
  - Scale inhibitor. Regularly check steam and hot water lines for leaks
- Work with a qualified water treatment vendor
- Regularly monitor monthly/quarterly treatment reports to make sure CoC target is met
- Improve incoming and recirculating water quality through side stream filtration, water softening, or basin cleaning

Savings Potential From Increased Cycles

Increasing cycles of concentration from three to six reduces cooling tower water usage by **20 percent**

Initial Concentration Ratio (Cri)	New Concentration Ratio (CRf)										
		2	2.5	3	3.5	4	5	6	7	8	9	10
	1.5	33%	44%	50%	53%	56%	58%	60%	61%	62%	63%	64%
	2.0	–	17%	25%	30%	33%	38%	40%	42%	43%	44%	45%
	2.5	–	–	10%	16%	20%	25%	28%	30%	31%	33%	34%
	3.0				7%	11%	17%	20%	22%	24%	25%	26%
	3.5	–	–	–	–	5%	11%	14%	17%	18%	20%	21%
	4.0	–	–	–	–	–	6%	10%	13%	14%	16%	17%
	5.0	–	–	–	–	–	–	4%	7%	9%	10%	11%
	6.0	–	–	–	–	–	–	–	3%	5%	6%	7%

Savings Potential From Increased Cycles



Alternative Sources of Make-Up Water

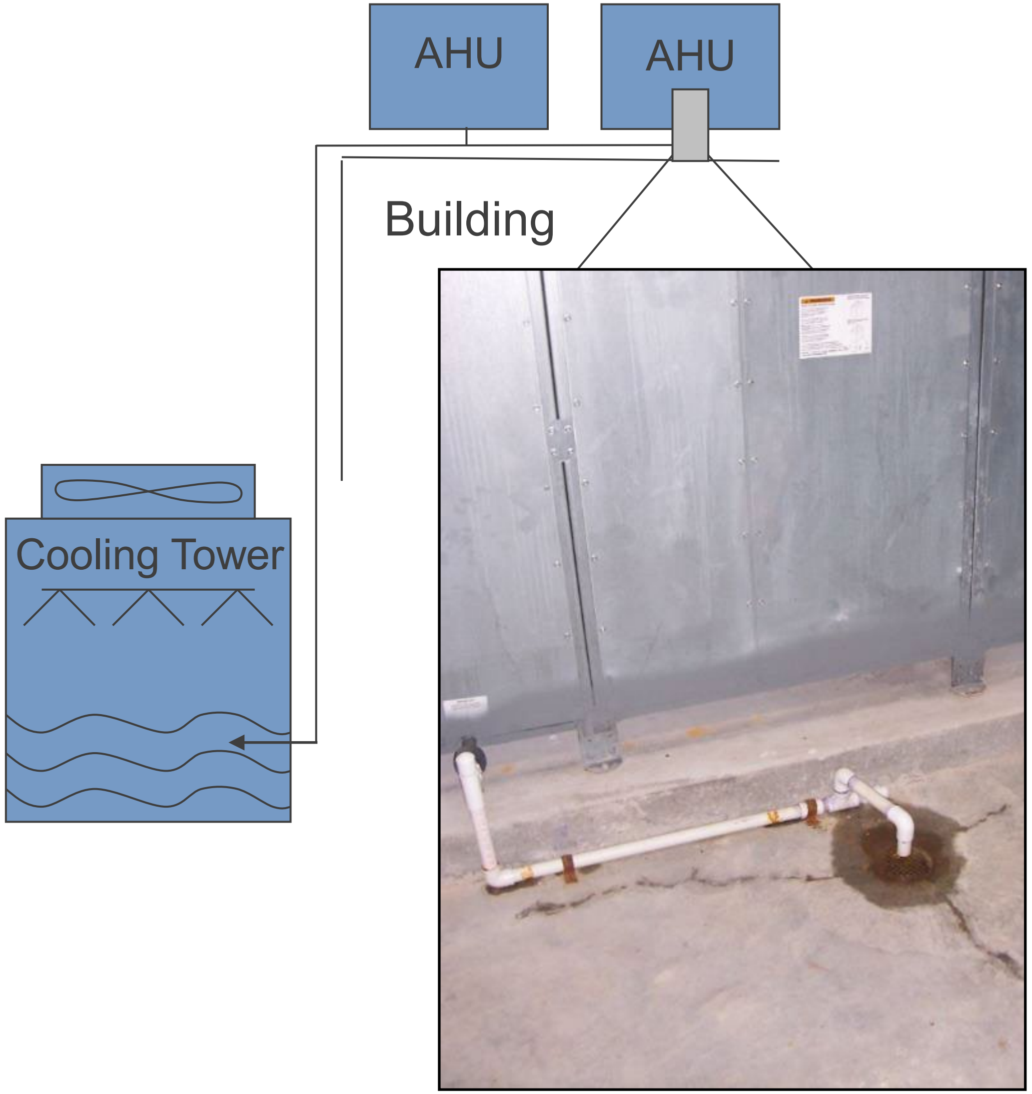
- Air conditioner condensate
- Rainwater
- Reclaimed wastewater
- Foundation drain water

Alternate source water **quality**, **quantity**, and **availability** are key considerations

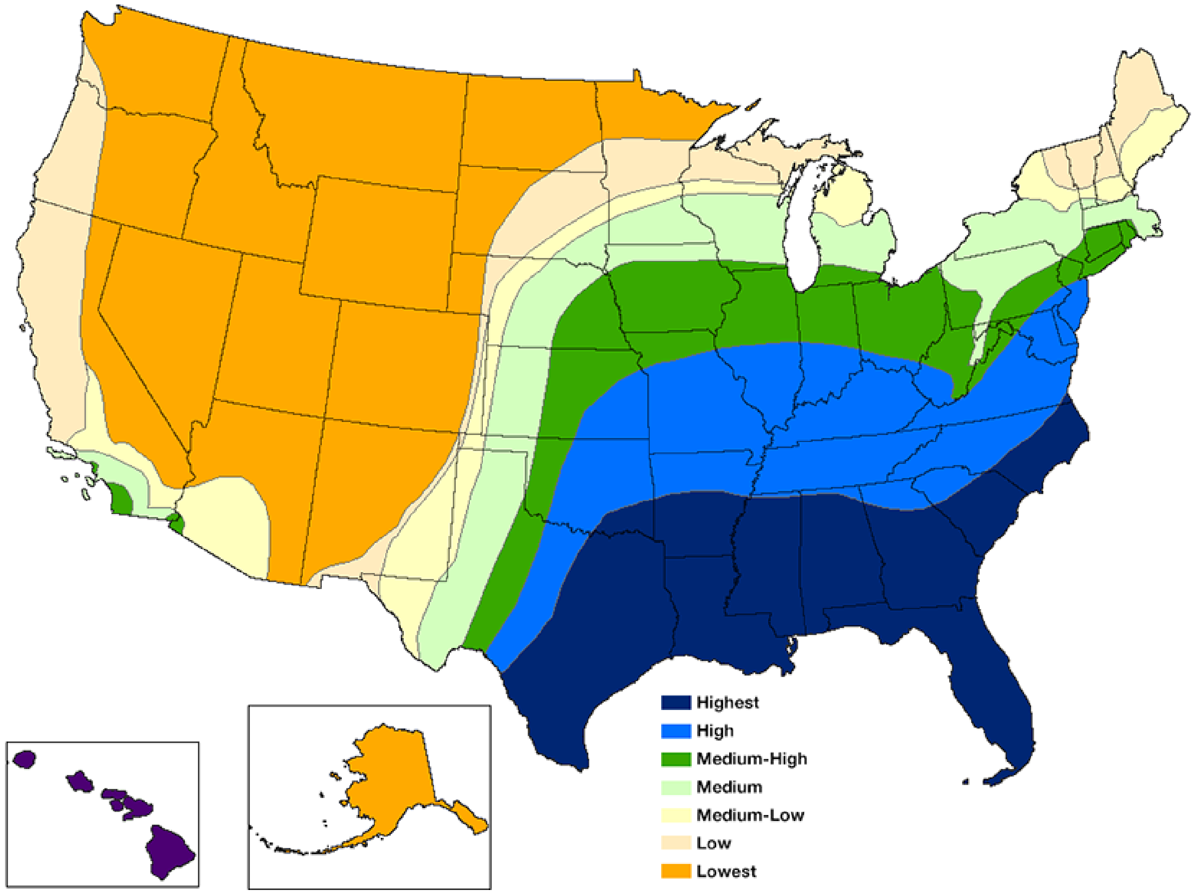
Air Handler Condensate Recovery

Water vapor in the air condenses as it comes into contact with an air conditioner's cooling coils

- Condensate is typically sent to the sewer
- Condensate generation ranges from 3 to 10 gallons per day per 1,000 square feet of air-conditioned space
- Free of minerals and total dissolved solids (TDS)
- Cooler than ambient air
- Generated in highest volumes during periods of high cooling loads



Condensate Capture Potential



www.energy.gov/eere/femp/condensate-capture-potential-map

www.epa.gov/water-research/non-potable-environmental-and-economic-water-reuse-newr-calculator

Example Savings From Cooling Tower Projects

Location	Total Cooling Tower Capacity	Annual Gallons Collected	Approximate Percent of Cooling Tower Make-Up
Ada, OK	450 tons	200,000	23%
Athens, GA	300 tons	460,000	37%
	780 tons	340,000	23%
Chelmsford, MA	Unknown	140,000	17%
Edison, NJ	400 tons	100,000	10%
Fort Meade, MD	2,400 tons	180,000	8%
Gulf Breeze, FL	450 tons	450,000	18%
Kansas City, KS	1,400 tons	310,000	18%

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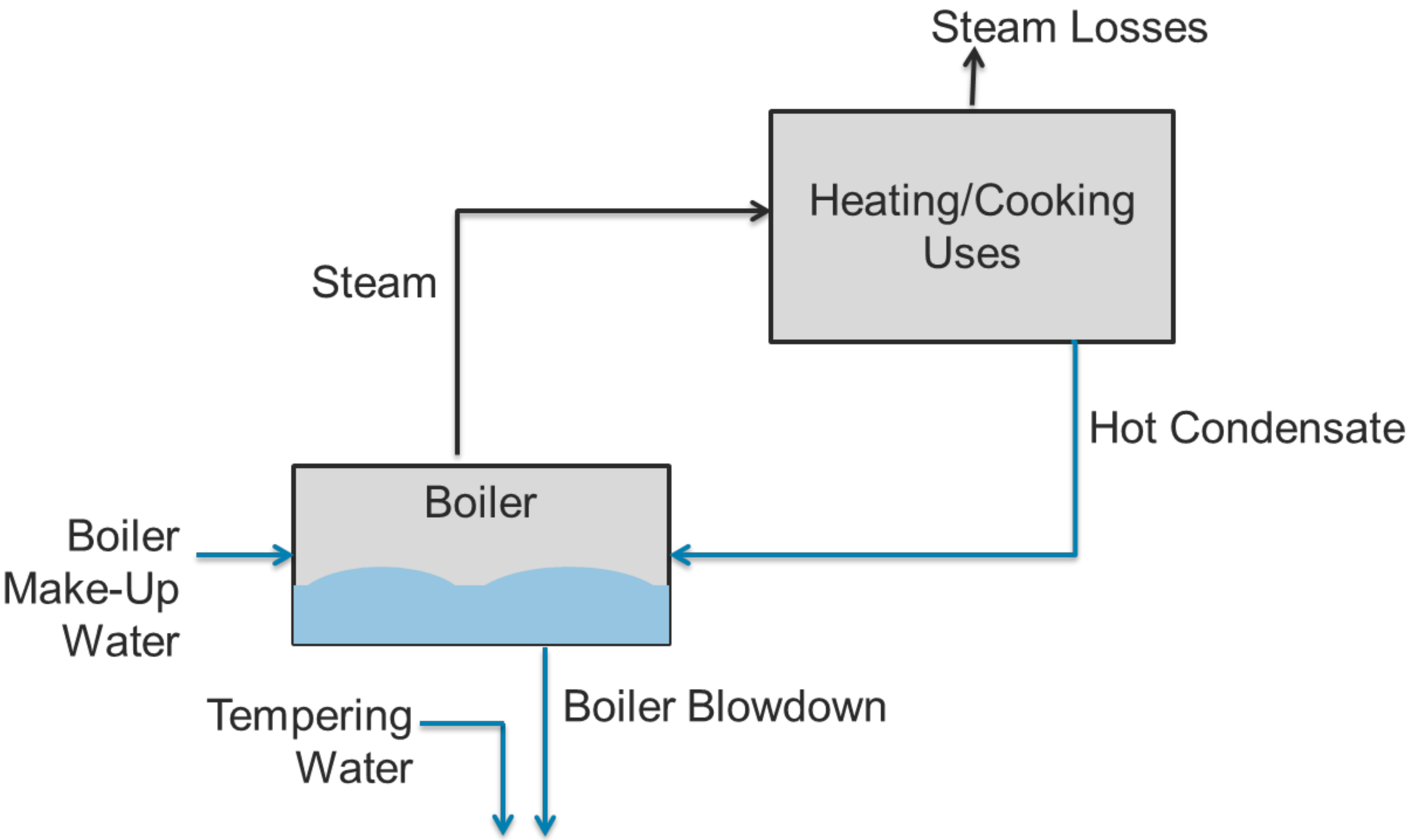
Steam Boiler System Overview



Steam Boiler Condensate Recovery

Install and maintain a condensate recovery system

- Reduces the amount of make-up water required
- Eliminates need to add tempering water to cool condensate before discharge
- Reduces frequency of blowdown, as condensate is highly pure and adds little to no additional TDS
- Steam trap and condensate pump maintenance is critical

Other Steam Boiler Best Management Practices

Maintain boilers, steam lines, and steam traps

- Regularly check steam and hot water lines for leaks
- Regularly clean and inspect boiler water and fire tubes
- Develop and implement an annual boiler tune-up program
- Properly insulate piping and the central storage tank to conserve heat

Ensure tempering water is only applied when needed

- Employ an expansion tank to temper hot condensate, rather than adding water to cool it
- Use heat recovery/heat exchange to minimize or eliminate tempering water

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Restrooms

Restrooms can account for up to 40 percent of water use

Restroom fixtures are often leaky because of wear and tear

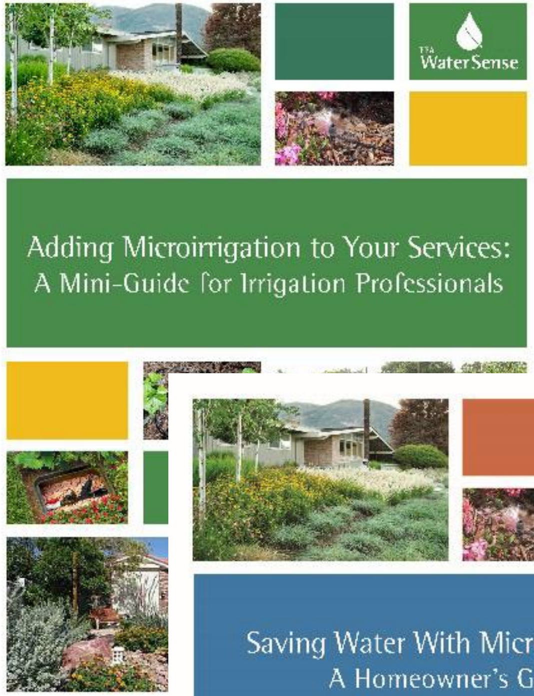
Regular maintenance is vital—there is no substitute

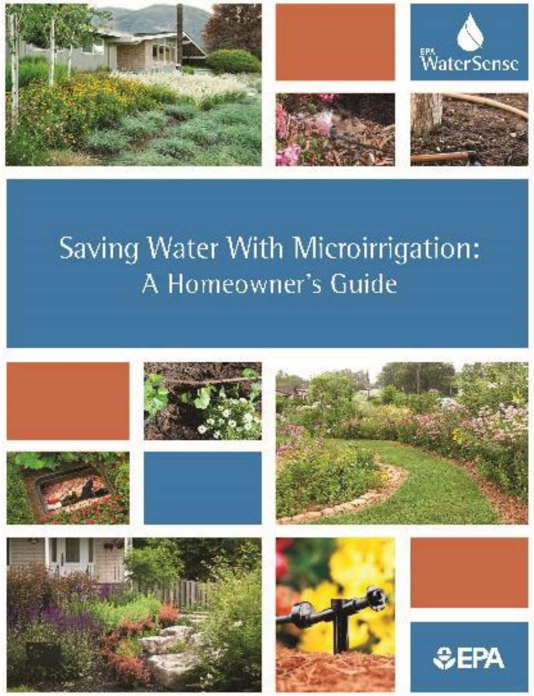
- Regularly inspect valves and toilet flappers - replace all worn parts
- Verify faucet flow rates and check for tampering
- Remove scale build-up especially from fixtures using hot water
- Adjust automatic sensors on fixtures to avoid double or phantom flushes and faucets running too long

Water-Efficient Restroom Fixtures

	Older Models	Federal Standard	Private Restrooms	Public Restrooms
Toilets	3.5 to 5 gpf	1.6 gpf	Tank-type ≤ 1.28 gpf	Flushometer Valve ≤ 1.28 gpf
Lavatory Faucets	2.5 gpm	2.2 gpm	≤ 1.5 gpm	0.5 gpm
Showerheads	3 to 5 gpm	2.5 gpm	≤ 2.0 gpm	
Urinals	1.5 to 3.5 gpf	1.0 gpf	Flushing Urinals ≤ 0.5 gpf	

Outdoor Water Efficiency





www.epa.gov/watersense/outdoors

Labeled Irrigation Products and Programs

Irrigation controllers

- Weather-based
- Soil moisture-based

www.epa.gov/watersense/watersense-labeled-controllers

Spray sprinkler bodies with integral pressure regulation

www.epa.gov/watersense/spray-sprinkler-bodies

Irrigation professional certification programs

- Designers
- Installers
- Auditors

www.epa.gov/watersense/irrigation-pro

Agenda

- Introduction to WaterSense
- Why water efficiency matters
- Laboratory water management
- Laboratory equipment best practices
- Optimize cooling tower performance
- Minimize steam boiler water use
- Other common water use areas
- Additional resources
- Questions

Additional I^2SL Resources

I^2SL Best Practices Guides

- Water Efficiency in Laboratories
- Laboratory Resilience
- Principals for Building Automation Systems
- Benchmarking Energy Efficiency
- Daylighting
- And many more…

Laboratory Benchmarking Tool

Smart Labs Toolkit

www.i2sl.org/index.html


Best Practices Guide
Water Efficiency in Laboratories

MAY 2022

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Contact I^2SL: www.i2sl.org • info@i2sl.org • 703.841.5484
I^2SL is dedicated to advancing sustainable laboratories globally.

Additional WaterSense Resources

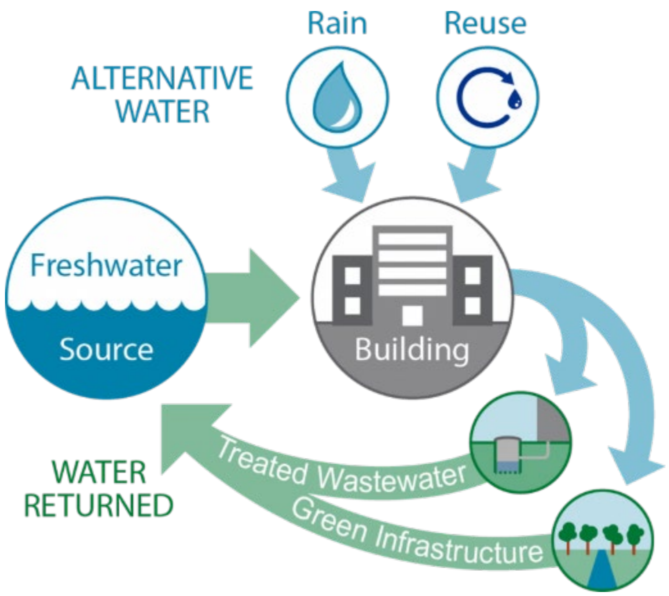
- Water use information by facility type
- Best management practices
- Water-saving tips
- Assessment tools
- Worksheets and checklists
- Live and recorded training webinars
- Case studies and more!

www.epa.gov/watersense/tools-ci-facilities

Other Additional Resources

Federal Energy Management Program

- Water metering resources
- Water evaluation tools
- Operation and maintenance tips
- Cooling tower efficiency opportunities
- Alternative water maps
- Net zero water building strategies



www.energy.gov/eere/femp/water-efficiency-federal-buildings-and-campuses

Questions?

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WaterSense

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