Better Plants
U.S. DEPARTMENT OF ENERGY

Industrial Water Systems
Virtual INPLT Training & Assessment

Session 5

Thursday – March 31st, 2022

10 am – 12:30 pm

Water Virtual INPLT Agenda

- Week 1 (March 3rd) – Introduction to Industrial Water Assessment and Plant Water Profiler
- Week 2 (March 10th) – Understanding System Level Water use
- Week 3 (March 17th) – True Cost of Water
- Week 4 (March 24th) – Plant Water Profiler Working Session
- Week 5 (March 31st) – Identifying Water Savings Opportunity
- Week 6 (April 7th) – Virtual Treasure Hunt
- Week 7 (April 14th) – Estimating Water Savings Opportunities
- Week 8 (April 21st) – Industrial Water System VINPLT Wrap-up Presentations

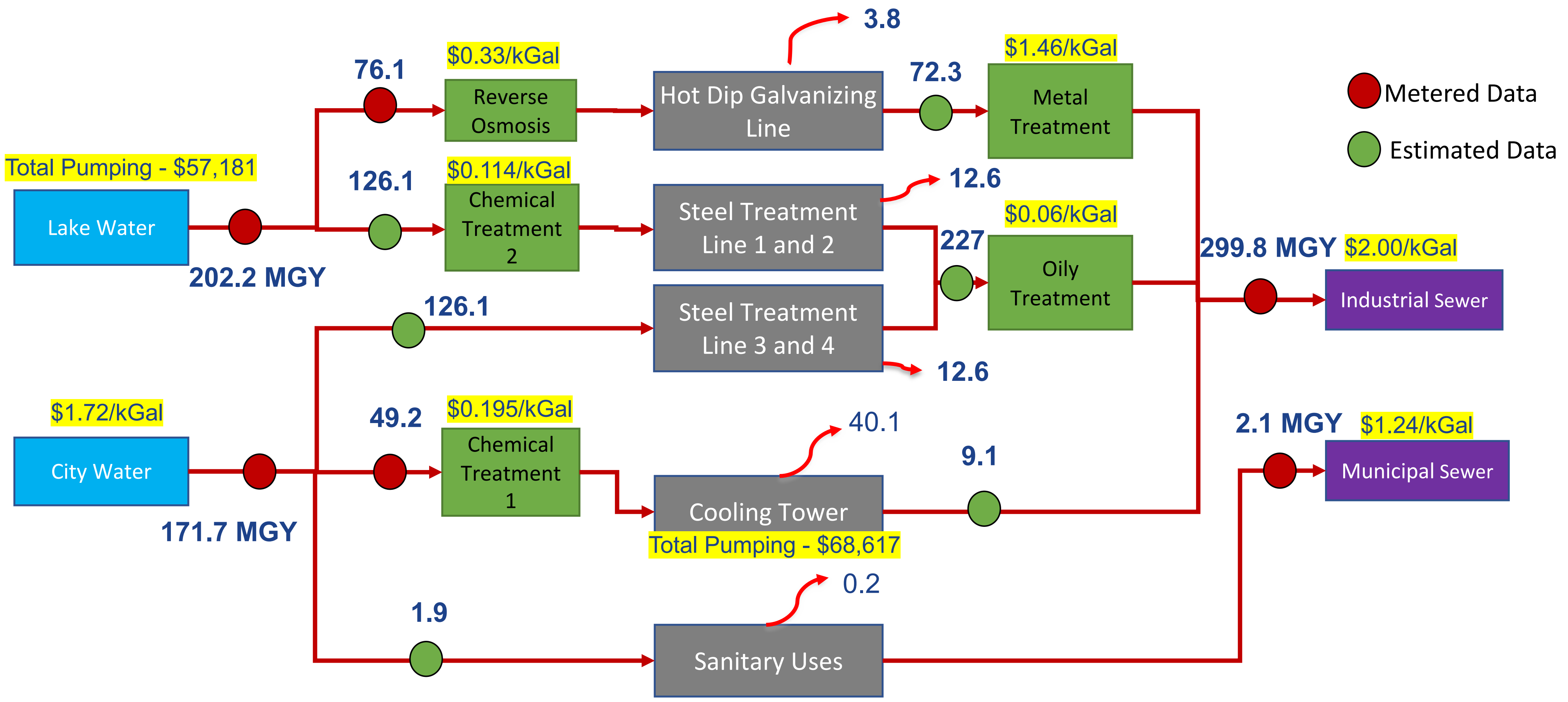
Review – Session 1 to 4

- Step 1: Water Baselining
  - Plant Water Flow diagram
  - Data Collection (system level and facility level)

- Step 2: True Cost of Water
  - Data Collection (water intake, discharge, treatment and embodied energy)

- PWP Tool

Example Facility – With Data (From Session 4)

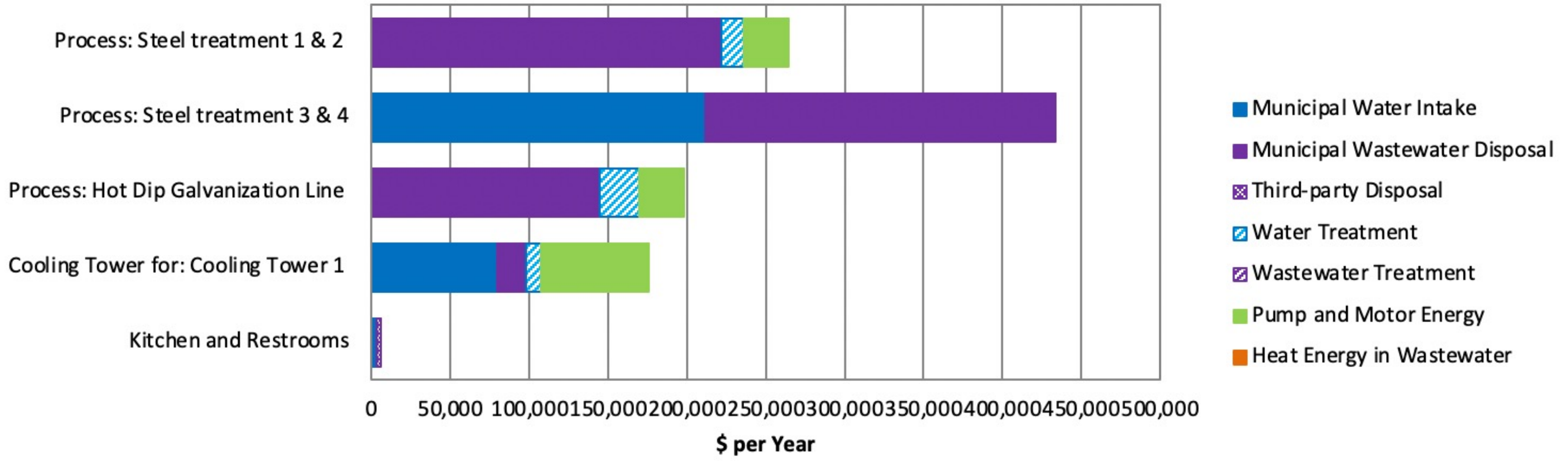


PWP Results

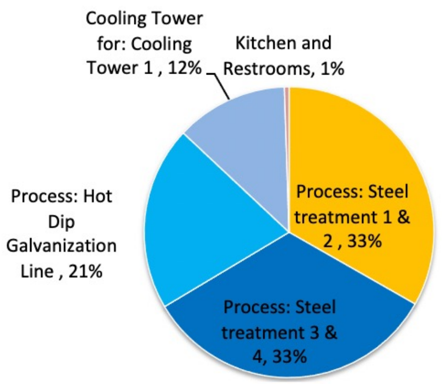
Annual Water Use and Cost Summary by System

Water-Using System	Source Water Intake	Gross Water Use	Direct Costs		True Cost of Water*		True Cost/Direct Cost
	Million Gallon per Year		$/Year	$/kGal	$/Year	$/kGal	
Process: Steel treatment 1 & 2	123.19	123.19	$ 221,742	$ 1,800	$ 264,376	$ 2,146	1.192
Process: Steel treatment 3 & 4	123.19	123.19	$ 433,629	$ 3,520	$ 433,629	$ 3,520	1.0
Process: Hot Dip Galvanization Line	76.1	76.1	$ 144,590	$ 1,900	$ 198,293	$ 2,606	1.371
Cooling Tower for: Cooling Tower 1	46.4	4,727.131	$ 98,008	$ 2,112	$ 175,673	$ 3,786	1.792
Kitchen and Restrooms	1.916	1.916	$ 5,672	$ 2,960	$ 5,672	$ 2,960	1.0
PLANT TOTAL	**370.796**	**5,051.527**	**$ 903,641**	**$ 2,437**	**$ 1,077,644**	**$ 2,906**	**1.193**

True Cost of Water by System



Percent Source Water Intake by System



Agenda – Session Five

Today's Content:

- Typical Industrial Water Savings Opportunity
- Treasure Hunt Approach
- Kahoot Quiz Game
- Q&A

U.S. DEPARTMENT OF ENERGY

Better Buildings is an initiative of the U.S. Department of Energy

Typical Industrial Water Savings Opportunity

Typical Industrial Water Users

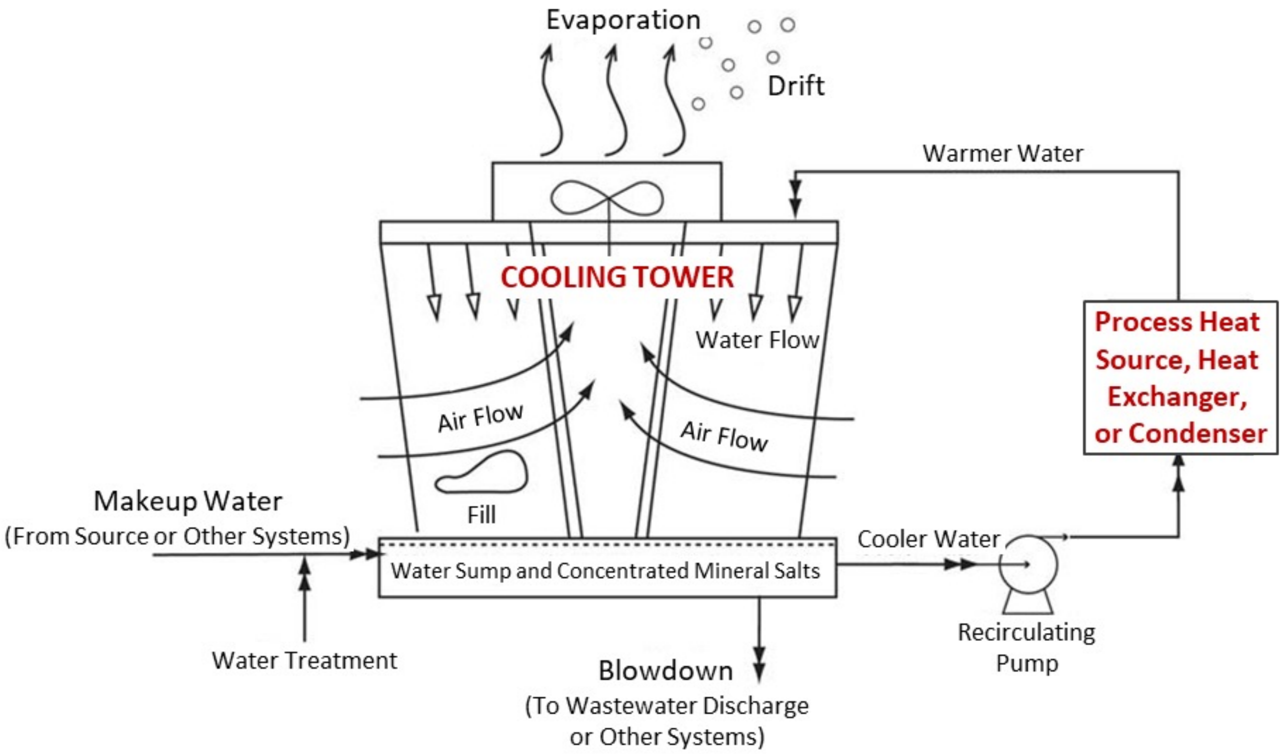
- Cooling and Condensing System
- Boiler System
- Direct Process Use
- Domestic
- Landscaping

Cooling and Condensing System Overview

Major Components

- Cooling Tower
- Pumps
- Cooling Loads
  - Process Heat
  - Heat Exchangers
  - Chiller

Water is often used as the working fluid or for heat rejection in a process cooling system.



Cooling Tower

Cooling and Condensing System – Top 5 Opportunities

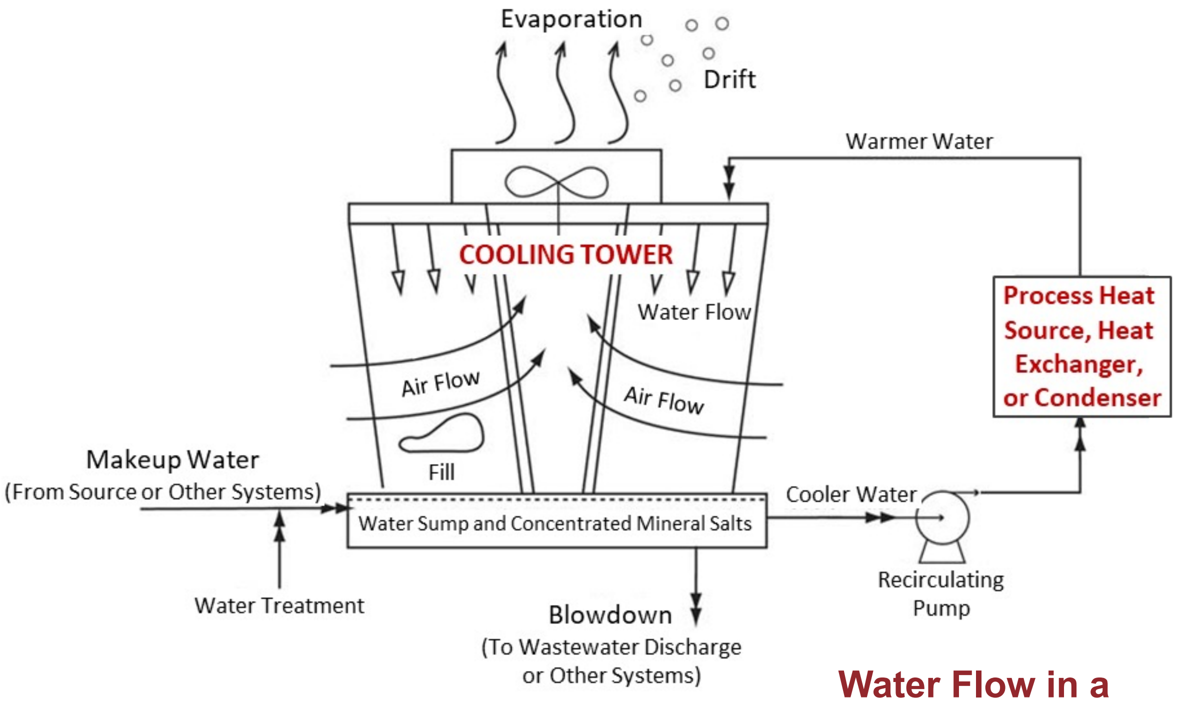
1. Optimize blowdown
2. Fix leaks
3. Use Drift Eliminators
4. Recycle and Reuse water
5. Eliminate Single Pass Cooling

Cooling and Condensing System – Top 5 Opportunities

1. Optimize Blowdown

- **Blowdown** – Water discharged to remove impurities, and sediment.
- **Cycles of Concentration** – Ratio of amount of system makeup added to amount of blowdown sent down the drain

Make-Up = Evaporation + Blowdown



Water Flow in a Cooling Tower

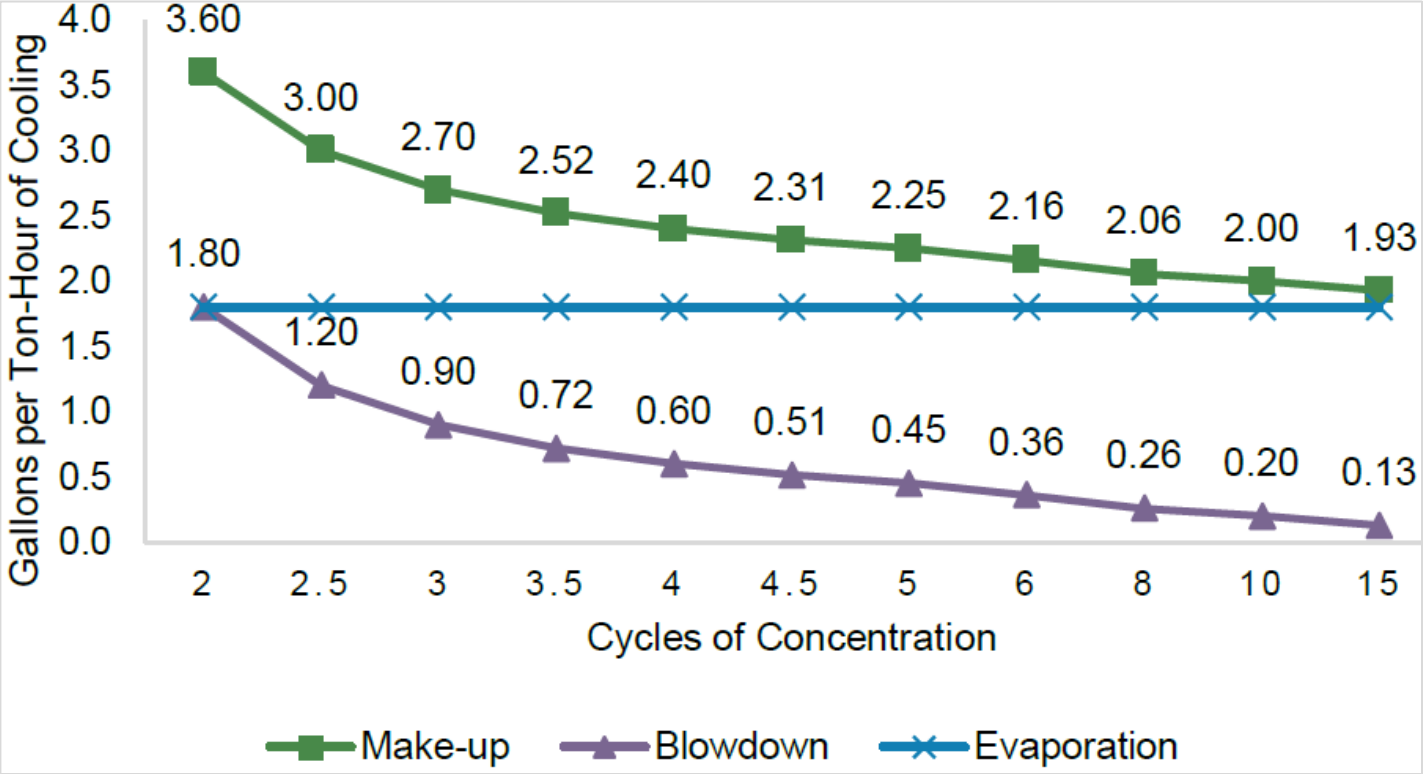
Cycles of Concentration = Volume of Make-up / Volume of Blowdown

At higher cycles of concentration, water is being recirculated longer through the system before being blown down.

Steps to Optimize Blowdown

Increase cycles of concentration: Increasing from 3 to 6 reduces cooling tower make-up water by 20% and cooling tower blowdown by 50%.

Cooling Tower Water Use per Ton-Hour Cooling



Cooling and Condensing System – Top 5 Opportunities

Steps to Optimize Blowdown

1. **Increase cycles of concentration**
   Work with a water treatment specialist to determine the maximum cycles of concentration the cooling tower system can safely achieve

2. **Improve make-up water quality:** Typical treatment programs include corrosion and scaling inhibitors along with biological fouling inhibitors.

3. **Consider Acid Treatment:** When added to recirculating water, acid can reduce the scale buildup and allow the system to run at higher cycles of concentration

4. **Install automated blowdown controls**

Automated Blowdown Controls

Automated blowdown controls continuously measures the conductivity of water and discharges only when set point is exceeded.

Blowdown Control Types

Manual Blowdown Control

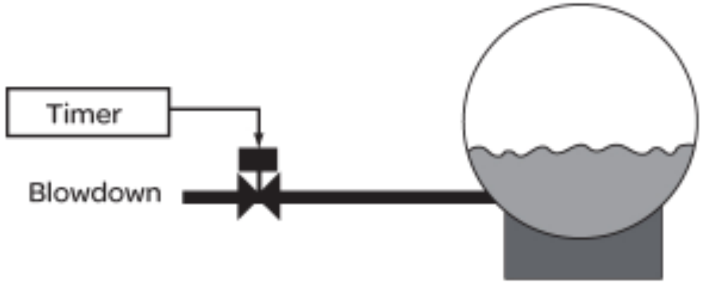
Manual system that is operated once per shift to reduce the boiler total dissolved solids (TDS) to a sufficient level well below the boiler specified maximum limit.

Automatically Timed Control

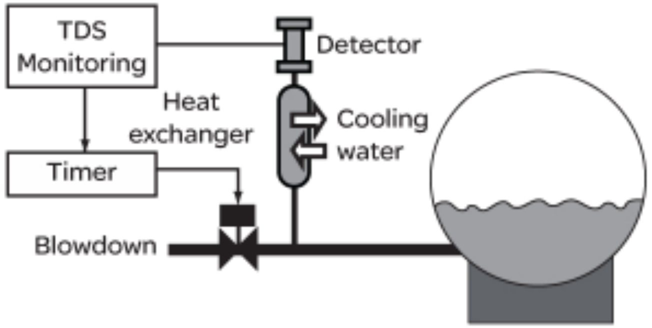
Timer is used to control blowdown according to a pre-set schedule. Load fluctuations are not considered.

Continuous Control with TDS monitoring

Monitors the variations in the TDS level and will override the timer in the event of variation from the desired TDS level



Timer based Controls

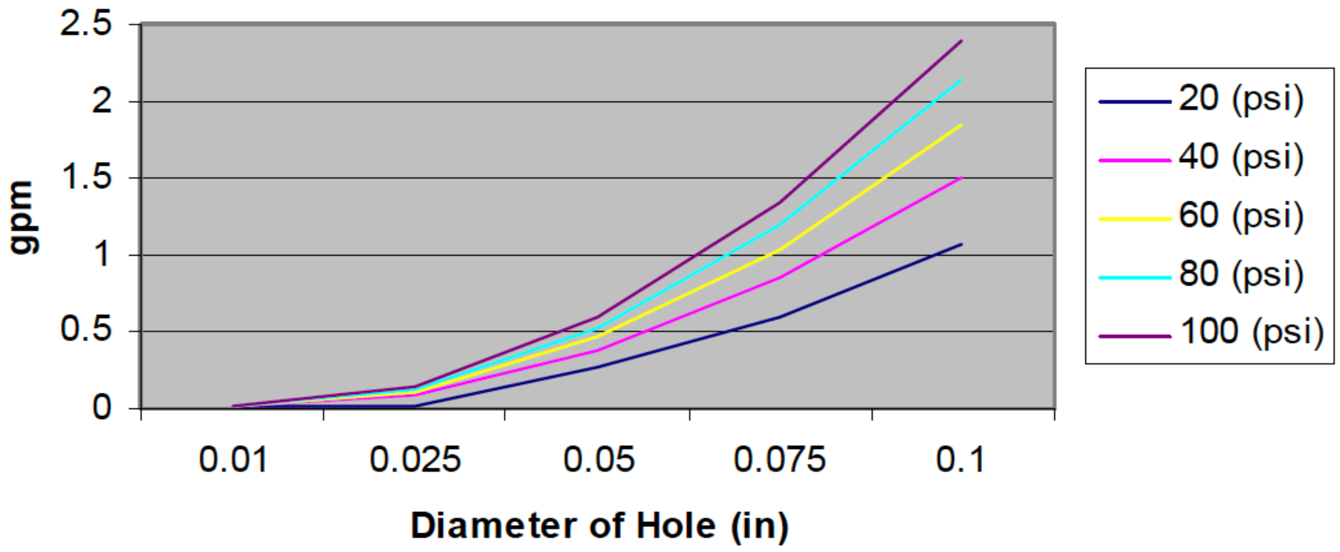


TDS based Controls

*TDS – Total Dissolved

Cooling and Condensing System – Top 5 Opportunities

2. Fix Leaks and Overflows



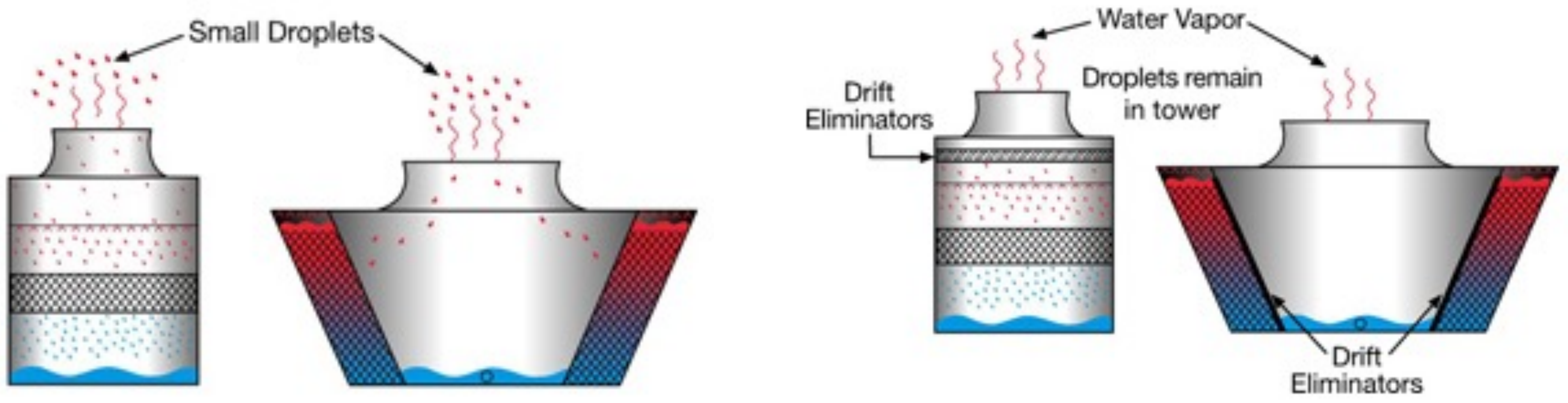
Leak Losses for Circular holes

Example of a Water Leak

- Check for **visual signs** of leaks
- Check **float control** equipment to ensure no overflows
- Check make-up water fill valve, and blowdown valve to make sure there are no unaccounted losses.
- Install flow meters on make-up and blowdown lines – ratios should match target cycles of concentration

3. Use Drift Eliminators

Designed to capture large water droplets caught in the **cooling tower** air stream. The eliminators prevent the water droplets and mist from escaping the **cooling tower**.



Cooling Towers with and without drift eliminators

4. Reuse and Recycle Cooling System Water

Reuse Opportunities (little or no pre-treatment)

- Air handler condensate
- Closed loop cooling for water used for “Once through Cooling”

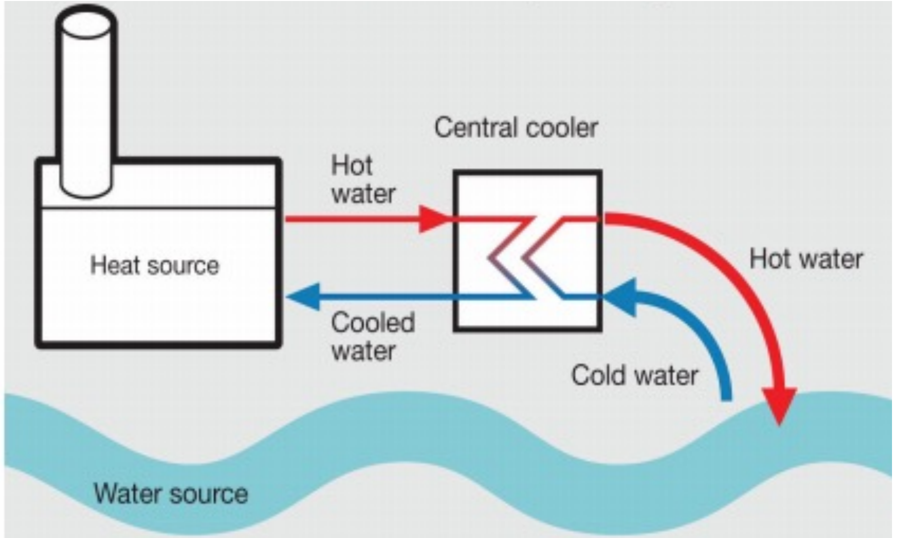
Recycling Opportunities

- Implementing a filtration system on the cooling tower blowdown and reusing the water

Water Treatment System used to recover and reuse water

Water reuse options vary depending on the nature of water uses from site to site along with a broad range of other considerations

5. Eliminate Single-Pass Cooling



Once-through cooling system

In single-pass or once-through cooling systems, water is disposed without recirculation e.g., cooling for vacuum pumps, air compressors, hydraulics etc.

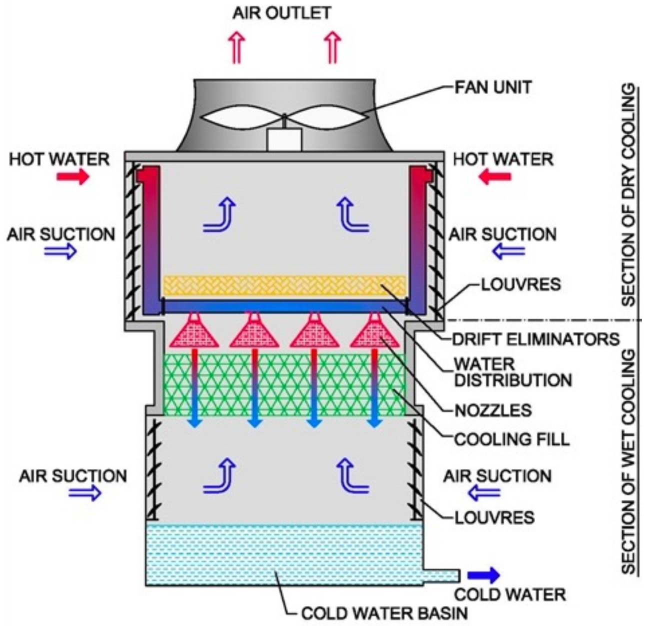
Opportunities for Water Savings

- Modify the equipment to operate on a closed loop that recirculates cooling water.
- Consider replacing water-cooled equipment with air cooled equipment.
- Reuse the once-through cooling water for other facility water requirements.
- Add an automatic control to shut off the entire system during nonproduction hours.

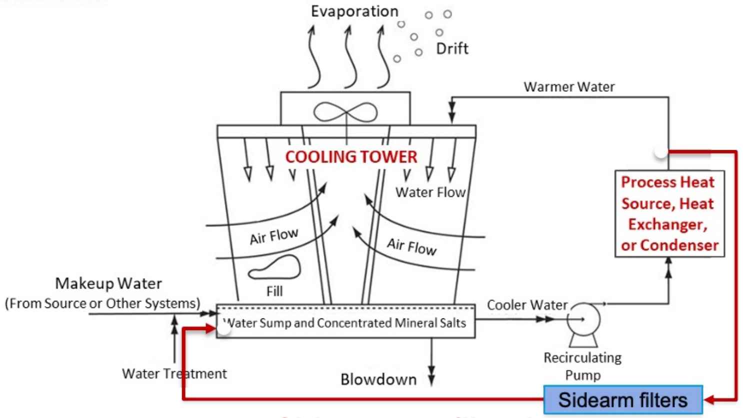
Cooling and Condensing System – Other Opportunities

- Install flow meters for makeup water and blowdown
- Install anti-splash louvers
- Install automatic shutdown unit

- Use air cooling where possible
- Consider hybrid cooling towers
- Consider **side-stream filtration** or pulse power treatment to reduce blowdown



Hybrid Cooling Towers



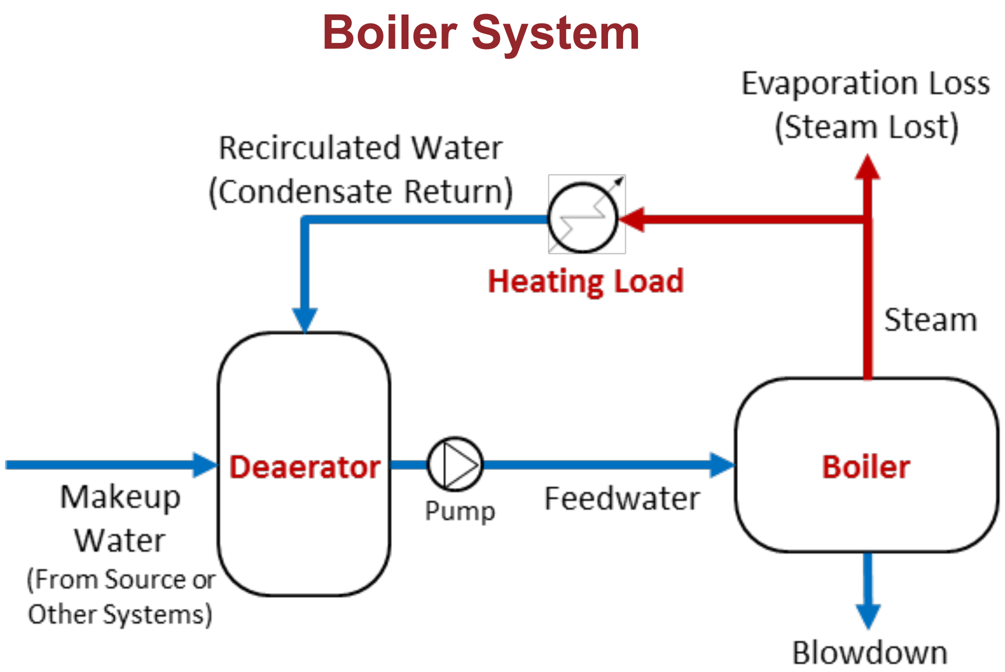
Side stream filtration

Side stream filtration

Boiler System – Overview of Water Consumption

Major Components

- Boiler
- Deaerator
- Condensate Tank
- Heating Loads
- Flash tank



Boiler

Boiler System: Top 5 Opportunities

1. Minimize blowdown
2. Increase condensate return
3. Check and replace steam traps
4. Consider a condensing economizer for flue gas
5. Reuse blowdown and condensate water

1. Minimize Blowdown

Reduces makeup water, chemical treatment costs and energy.

Blowdown Reduction, lb/hr	Annual Savings, $		
	Fuel	Water and Chemicals	Total
1,000	27,200	4,200	31,400
2,000	54,400	8,400	62,800
4,000	108,800	16,800	125,600

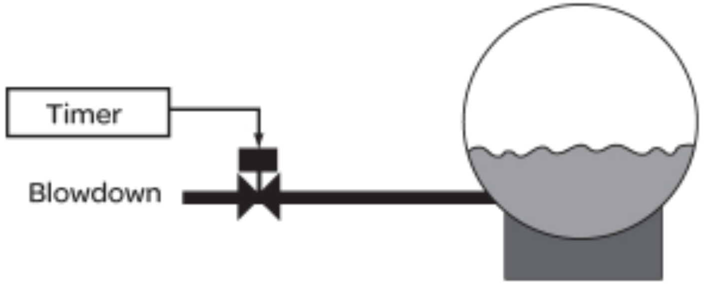
Typical Savings from Blowdown Reduction

Manual Blowdown

Blowdown Control Types

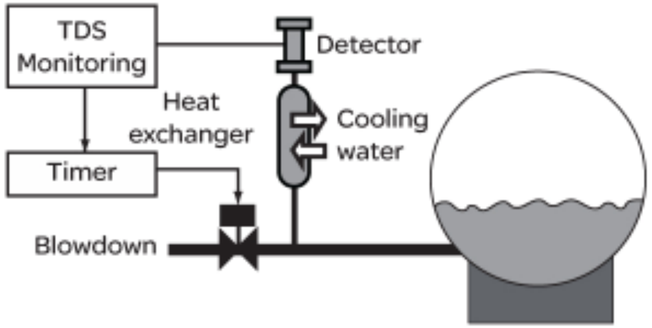
Instantaneous manual system

Manual system that is operated once per shift to reduce the boiler total dissolved solids (TDS) to a sufficient level well below the boiler specified maximum limit.



Automatically Timed Control

Timer is used to control blowdown according to a pre-set schedule. Load fluctuations are not considered.



Continuous Control with TDS monitoring

Monitors the variations in the TDS level and will override the timer in the event of variation from the desired TDS level

Boiler System: Top 5 Opportunities

Steps to Minimize Blowdown

1. Consider an automatic blowdown control system
2. Pretreatment of makeup water
3. Review blowdown practices to identify saving opportunities.
4. Examine operating practices for boiler feedwater and blowdown rates developed by the American Society of Mechanical Engineers (ASME).

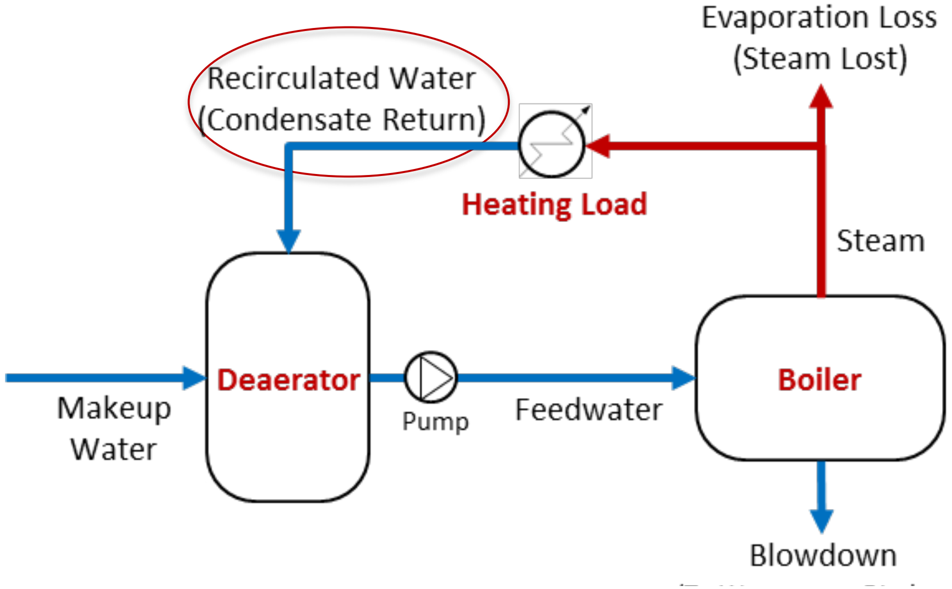
Boiler Operating Pressure (psig)	Total Dissolved Solids (ppm)	Total Alkalinity (ppm)	Total Suspended Solids (ppm)
0 - 50	2,500	500	
51 - 300	3,500	700	15
301 - 450	3,000	600	10
451 - 600	2,500	500	8
601 - 750	1,000	200	3
751 - 900	750	150	2
901 – 1,000	625	125	1

ABMA Recommended Limits for Feedwater

2. Increase Condensate Return

When steam transfers its heat at a process it reverts to a liquid phase called condensate.

Increasing the condensate being returned to the boiler saves water and energy



Boiler System Schematic

Opportunities

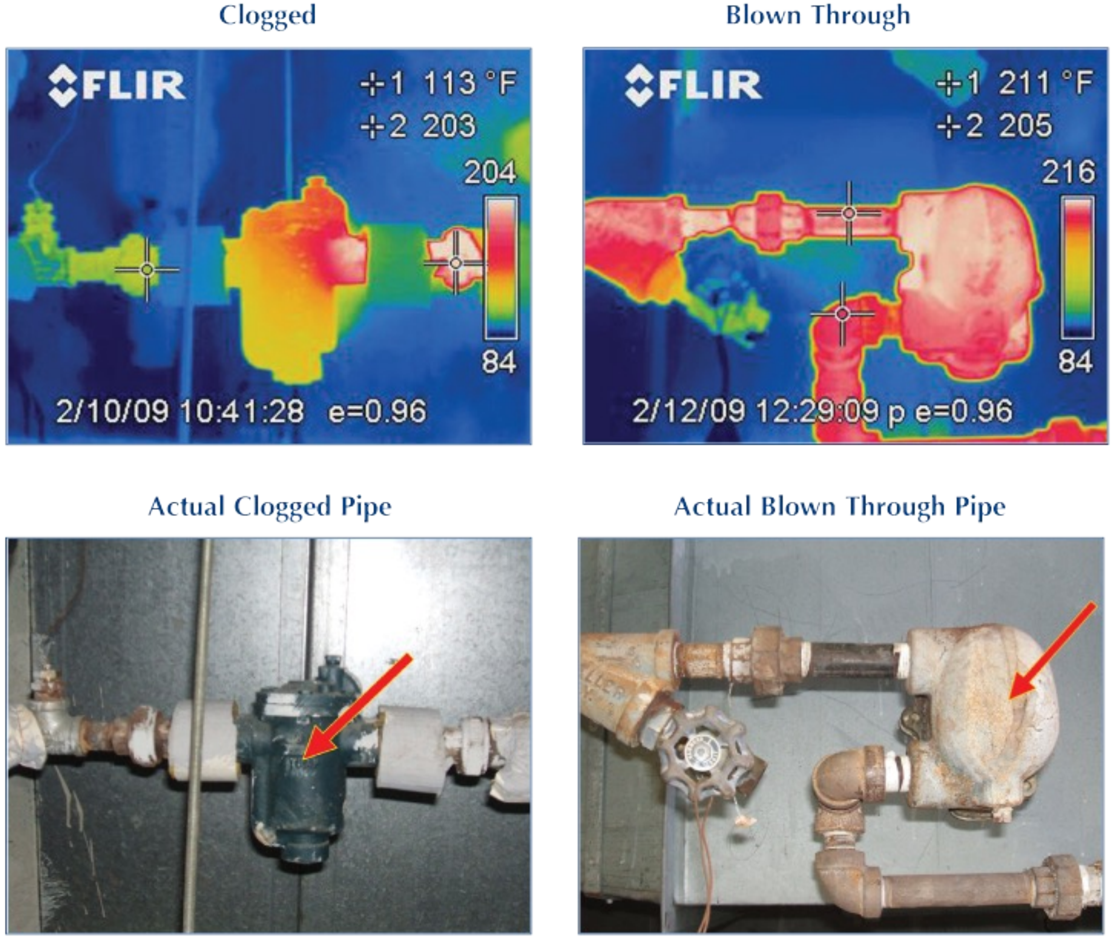
- If a condensate return system is absent, install one if economically justified.
- Monitor and repair steam distribution and condensate return system leaks
- If currently partially recovering condensate, determine how this can be increased

Boiler System: Top 5 Opportunities

3. Check and Replace Steam Traps

Properly functioning steam traps open to release condensate and automatically close when steam is present

When steam traps fail in the open or blow-through condition, they constantly lose steam



Clogged and Blown through steam straps

Identifying failed traps

- **Visual Inspection:** Live steam (flows continuously) being vented into the atmosphere from condensate collection tanks is an indicator of failed steam.
- **Temperature Difference:** If the trap is functioning properly, there is a difference in temperature between the inlet and the outlet of the trap
- **Sound Inspection:** Sound of live steam passing through the trap is an indicator

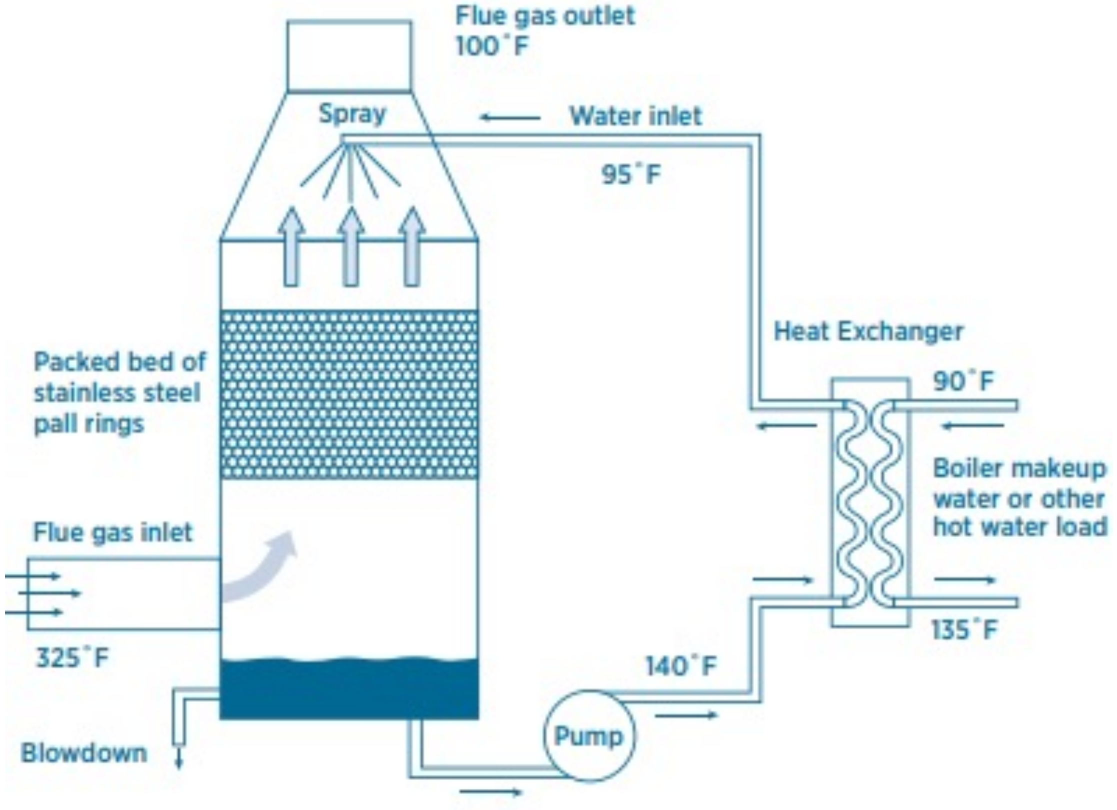
A steam systems that have not been maintained for 3 to 5 years, between 15% to 30% of the installed steam traps may have failed ; a well maintenance system should have less than 5% of the traps leaking.

4. Consider a Condensing Economizer

By installing a condensing economizer, overall steam system efficiency is increased by up to 10%.

About 12% of the total exhaust by weight is water vapor. The latent heat along with the water can be recovered with a **condensing economizer**

While primarily an energy opportunity, water treatment and reuse might be viable in sufficiently large systems.



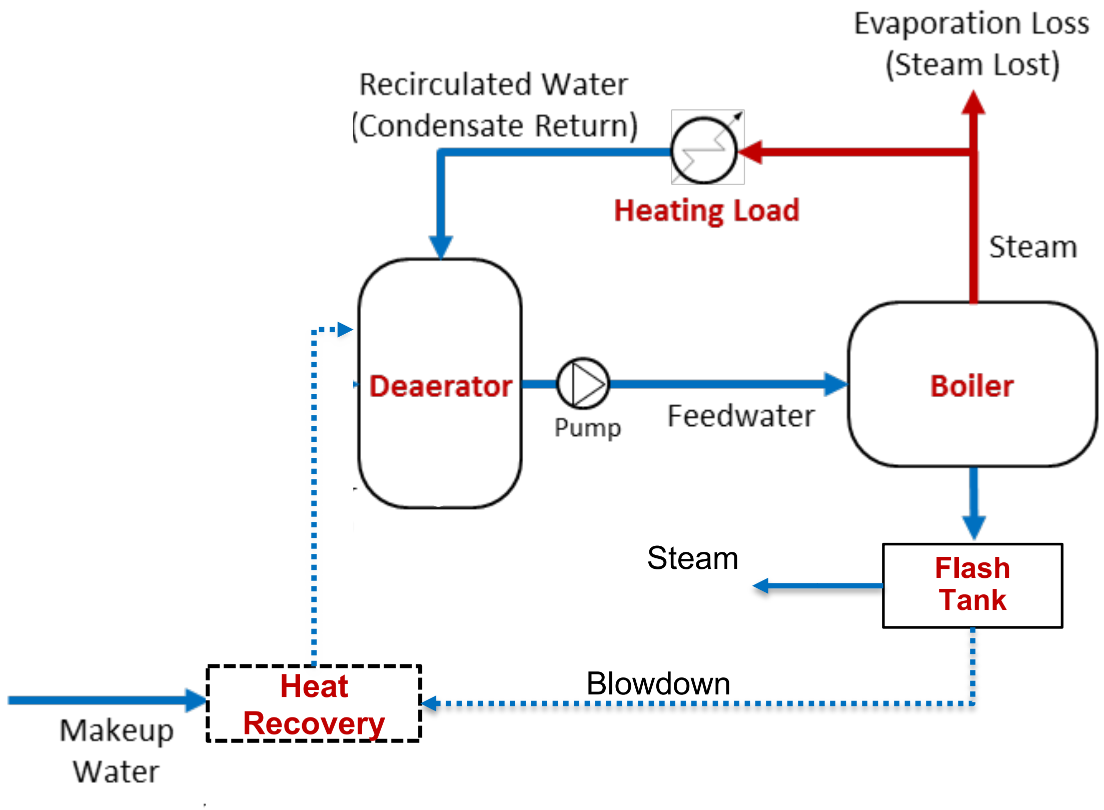
Condensing Economizer

Boiler System: Top 5 Opportunities

5. Reuse Blowdown

The blowdown water has the same temperature and pressure as the boiler water.

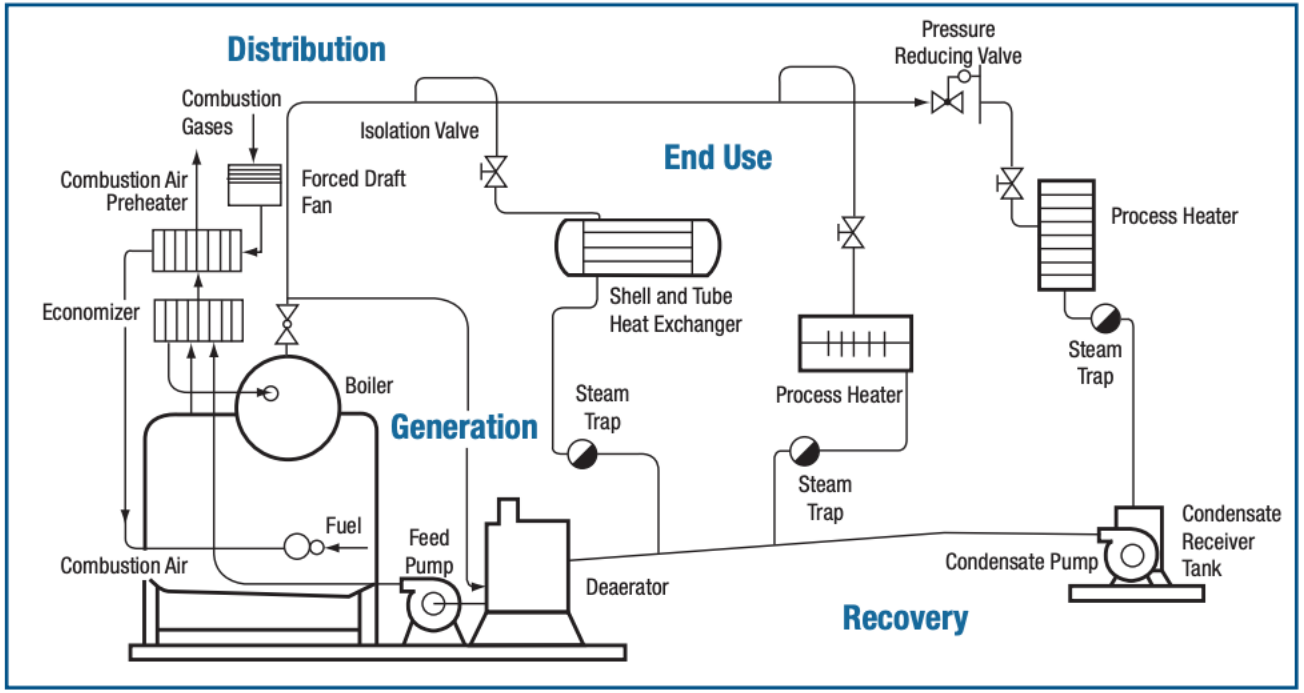
Effectively recycling and reusing it saves energy and water.



Blowdown recovery system with flash tank and heat exchanger

Boiler System: Other Opportunities

- Install flow meters for makeup water and blowdown
- Minimize/Eliminate steam end use at the facility
  - Reduce open steam sterilizers
  - Check dead legs and close off steam to unneeded distribution segments



Steam systems include generation, distribution, end use, and recovery components (Source: DOE, Improving Steam System Performance, A Sourcebook for Industries)

Process Water Use in Your Plant

Typical Process Water Use

- Cleaning/ Washing/ Rinsing
- Fabrication/processing
  - Lubrication
  - In chemical reaction
  - Sealing using water
  - Diluting
- Transportation
- Pollution control
- Inclusion in the product
- Cooling e.g. Glass
- Other process

Typical Process Water Uses

Process Equipment – Top 5 Opportunities

1. Process Equipment Modifications/ Design

2. Improved Production/ Operations Planning

3. Install Automated Control Valves

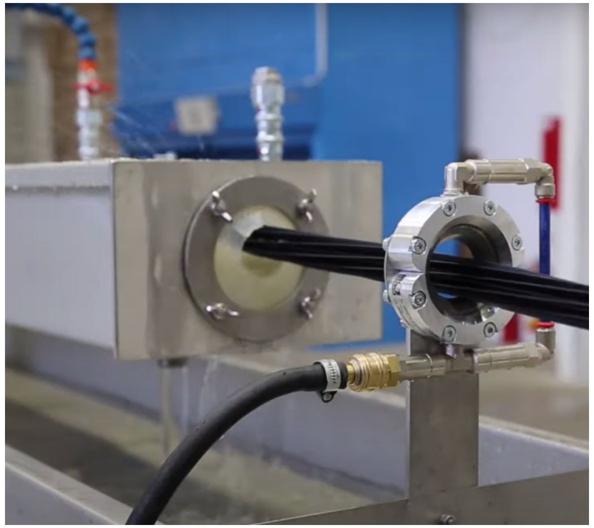
4. Optimize Washing

5. Opportunities to Reuse and Recycle

Process Equipment – Top 5 Opportunities

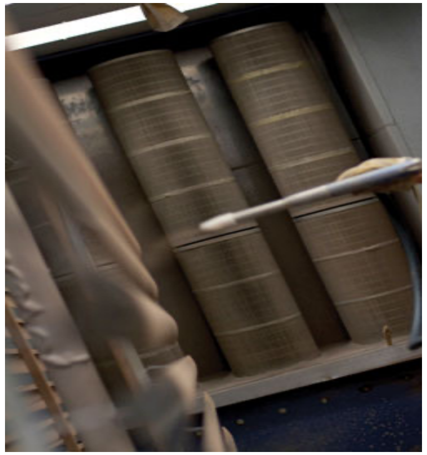
1. Process Equipment Modifications

- Check true water demand and reconfiguration equipment/controls
- Set equipment to its minimum recommended flow rates and pressure
  - Install pressure-reducing devices if necessary
- Reduce the water used by open ended cooling and heating systems (e.g. utilizing jacket and chamber setup for sterilization)



Nozzles

- Using High Pressure Low-Volume equipment
- Trigger-controlled nozzles on hoses



Trigger Controlled and Low flow Water Nozzles

Water Baths (cooling troughs, washing containers, chemical treatment)

- Reduce splash out/overflow by installing appropriately designed panels

Process Equipment – Top 5 Opportunities

2. Improved Production/ Operations Planning

- Implementing a tight equipment shutdown schedule

- Introducing water savings routines in operations
  - Avoiding spillage by minimizing transport
  - Performing mechanical cleaning before washing with water

- Readjust the production plans with a focus on water savings
  - Reducing cleaning needs by minimizing product changes
  - Sequence operations to maximize water savings

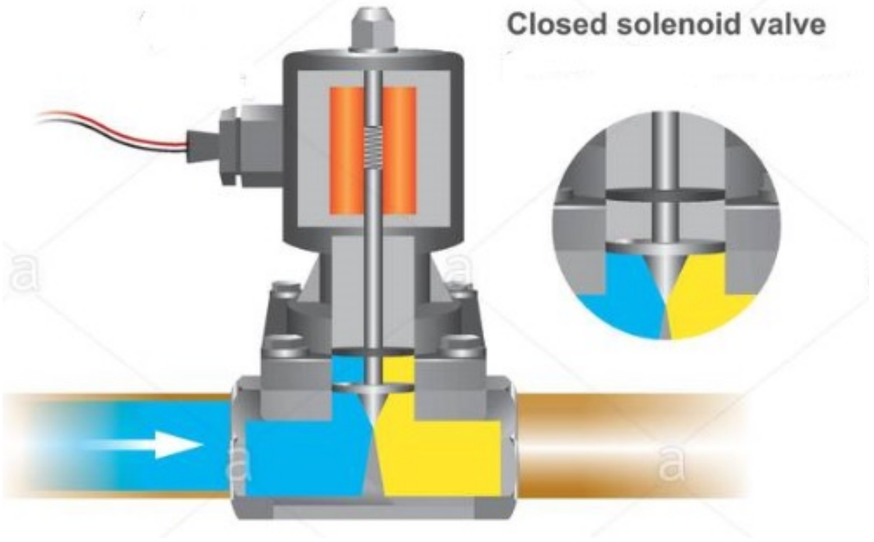
- Using alternate less water intensive feedstocks
  - Using water-based paints
  - Using Reactive dyes in dyeing
  - Switching to disposable containers in beverage industry

Increasing levels of efforts and cooperation from management

Process Equipment – Top 5 Opportunities

3. Install Automated Control Valves

- Timers, solenoids to automatically shut off water flow when water is not required
- Level/pressure switches to shut off water flow to avoid overflows
  - Provide surge tanks for each system to avoid overflow
- Equipping hoses with an automatic shutoff nozzle
- Float-controlled valve on the make-up line to control for flows from recirculation systems



Automated Control Valves

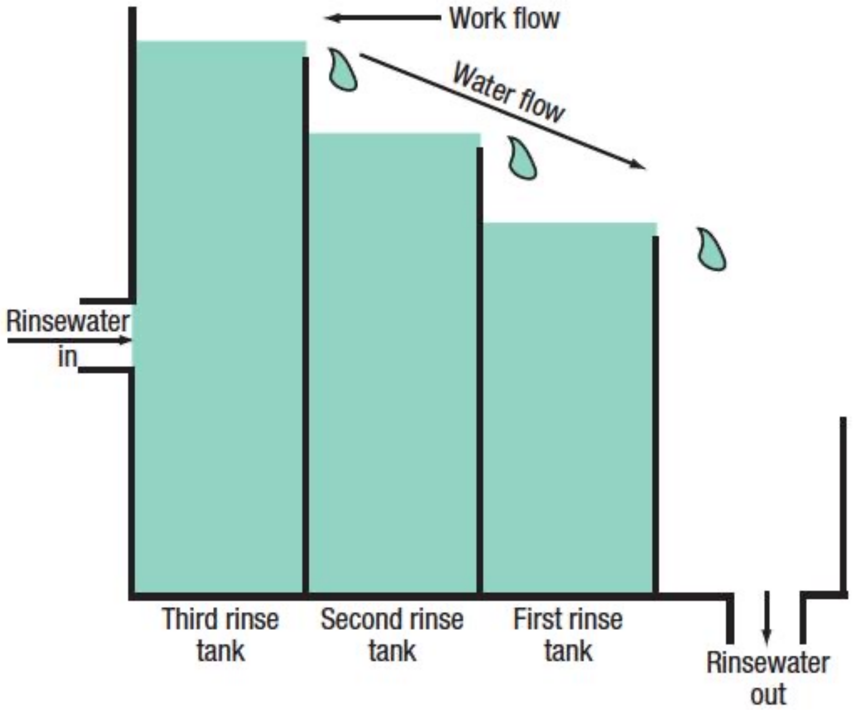
Process Equipment – Top 5 Opportunities

4. Optimize Washing/Rinsing

- Use improved rinsing techniques
  - Counter-current systems
  - Agitation
  - Spray/ Pressure rinsing
  - Static and reactive rinsing

- Sequential use of water based on quality needs

- Using booster pumps with low-pressure water instead of high-pressure water.



Counter Current Rinsing Setup to reduce water consumption

5. Opportunities for Reuse and Recycle

Reuse - no treatment is needed

Some discharges with potential for re-use:

- Final rinses from cleaning
- Bottle soak water
- Water used in equipment sterilizing
- Single pass cooling water

- **Recycling – treated to original condition**
  - Contact water from process
  - Filter backwash

Following are some common water treatment methods:

- Dissolved Air Flotation
- Biological Treatment
- Filtration
- Granular Activated Carbon
- Disinfection
- Deionization: Ion exchange and reverse osmosis

Process Equipment – Top 5 Opportunities

- Replace water-based transportation of parts
- Using waterless techniques for process
- Using conductivity-based controllers in rinses
- Sub metering process water
- Separate Water Process Streams
- Use variable speed control on pumps to minimize water withdrawal/conveyance

Domestic Use - Overview

Major Users

- Laundry
- Restrooms
- Kitchen

Domestic Use: Top Opportunities

Restrooms

- Use Water-efficient Fixture WaterSense-labeled faucets, toilets, urinals, showerheads.
- Dual-flush toilets retrofits
- Install faucet aerators and showerheads.
- Self Closing spring-loaded faucets, or faucets with sensors

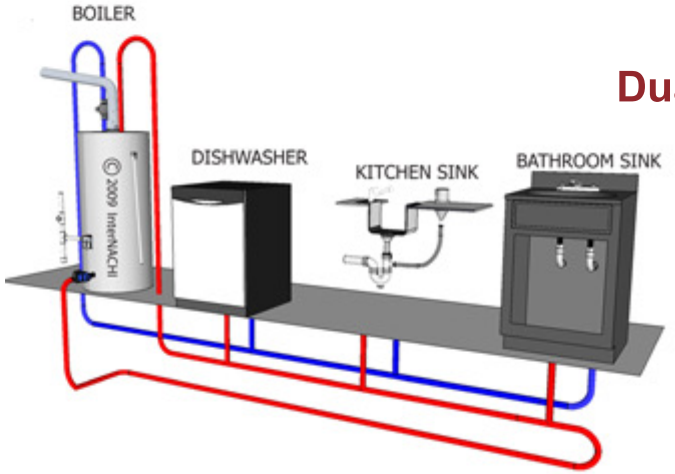
Laundry

- Recycle rinse water for laundry load
- Lower water settings for partial laundry loads.

Kitchen

- Consider a recirculation pump for domestic hot water
- Collect and Reuse Rainwater

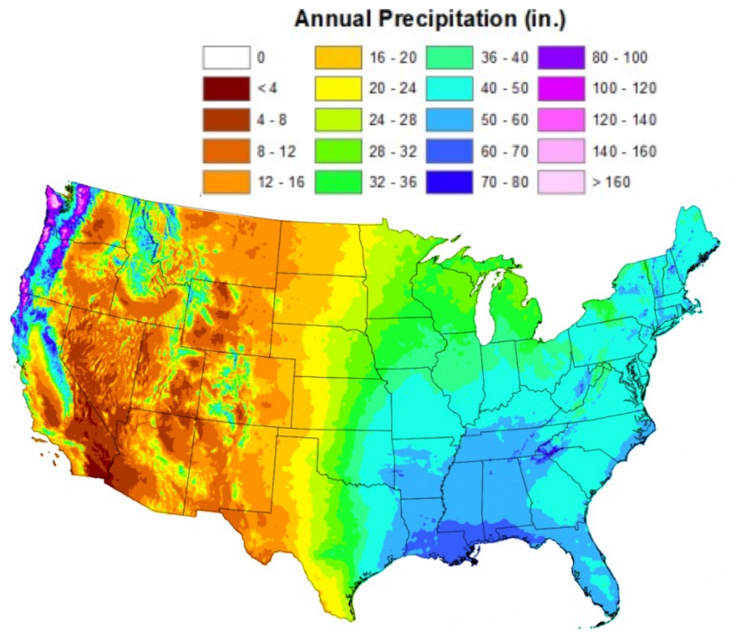
Dual Flush Retrofits



Recirculation pump for domestic hot water

Key Determinants of Water Use

- Climate/Precipitation
- Plant species
- Irrigation system



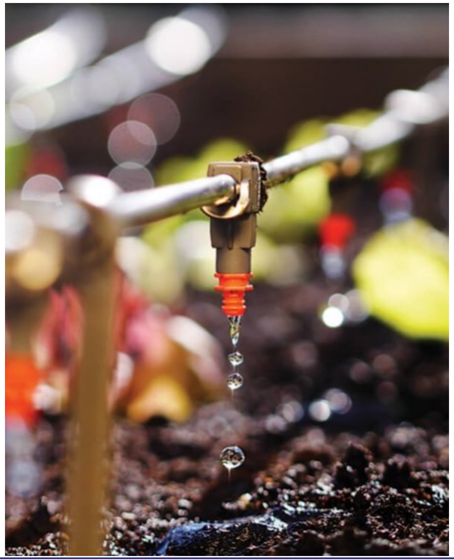
Landscape and Irrigation: Top Opportunities

Water-efficient irrigation devices

- **Adjustable sprinklers**
- **Irrigation controllers, sprinkler timers**
- **Drip irrigation system (**20-50% more efficient than conventional sprinkler)
- **Soil moisture sensors** help prevent overwatering
- **Smart sensors** detect local weather conditions, rainfall and soil moisture, and adjust water delivery, accordingly

Give your plants fewer, heavy soakings.

Use sprinklers only in the morning or evening



Landscape and Irrigation: Top Opportunities

- **Select plants appropriately**. Base your plant selections and locations on those that will flourish in your regional climate and microclimate.
- **Consider zoning of plants**: Always group plants with similar water needs together.
- **Add compost and mulch**. Compost helps keep the water by the plant's roots and mulch prevents evaporation.
- **Reuse greywater or capture rainwater.** Reusing grey water or capturing rainwater offers a free source for landscape irrigation.
- **Consider Permeable Pavers.** Permeable pavers allow water to percolate through the surface reducing rainwater runoff.

Rainwater Harvesting

Permeable Pavers

PWP Tool - Tab 9 & 10

Water opportunities checklist

System Water Efficiency Status	Response
Process	
Cooling/condensing for process	
Has once-through cooling water been eliminated with the use of chillers, cooling towers, or air-cooled equipment?	No
Has blow-down/bleed-off control on cooling towers been optimized?	No
Is treated wastewater (or other sources of water for cooling tower make-up) reused where possible?	No
Are cycles of concentration for cooling towers maximized through efficient water treatment?	No
Cooling/condensing for air conditioning	
Boiler for Facility	
Kitchen and Restrooms	
Landscaping	

Some Case Studies

American Linen and Denver Water

- Commercial laundry reconfigured a continual batch washer
- Decreased water consumption by 5.1 MGY
- Energy & treatment chemical savings: $32,500

Used remote sensors to find leaks
Repaired 21 large leaks
Annual water savings = 10 MGY
Water & labor savings = $27,700

Denver Zoo and Roche Diagnostics

Wastewater Treatment Pump with New Seal

- Comprehensive upgrades of piping, leak repair, flow control valves, and added water recycling systems
- Water savings: 160 MGY
- Treatment chemical savings: $19,000

- Deactivated fountain at corporate HQ, installed hydrometer linked to irrigation system, retrofitted seals on wastewater pumps
- Reduced wastewater treatment flow rate by 75%
- Water & treatment chemicals savings of 5.5 MGY and $26,500

SAE Circuits

- Installed flow restriction valves on all rinsing processes, redesigned a rack coating rinse to reuse cooling water.
- Installed a new electroplating line that used half the water and 80% of the energy of the previous equipment and switched to a resin-based system to treat wastewater.
- Water savings: 6.8 MGY & $9,700
- Water treatment chemical savings: $70,000

Visteon (Glass)

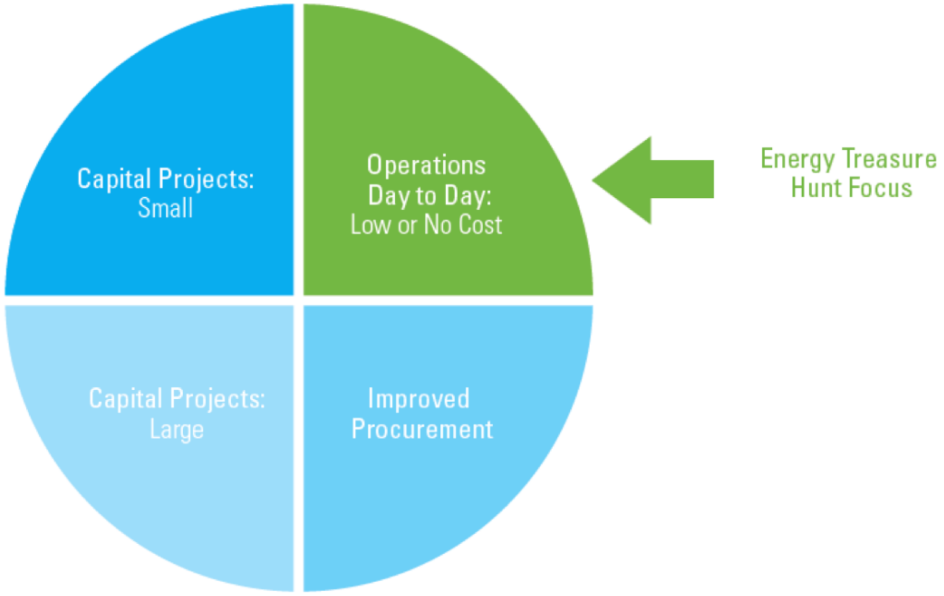
- Replaced pumps & installed VFDs on river water pumping system that drew water for cooling glass
- Reduced flowrate from 5,200 GPM to 3,125 GPM, was able to operate with one pump instead of two
- Annual water savings: 259 million gallons
- Annual energy savings: 3.2 million kWh
- Reduced purchases of treatment chemicals by $116,000/year
- Eliminated safety hazard

Preparing for Water Treasure Hunt

What is a Treasure Hunt?

- A Water or Energy Treasure Hunt is a 1 - 5 day event that focuses on identifying day-to-day operational energy efficiency improvements.

- The process involves observing the facility during idle / partially idle time periods (frequently Sunday) to identify energy waste



Areas of Water Efficiency Improvement

Operational Energy Efficiency Improvements

- Turning off equipment when not in use
- Changing set points
- Automating shutdowns
- Reducing load on the equipment
- Recover wasted water/energy

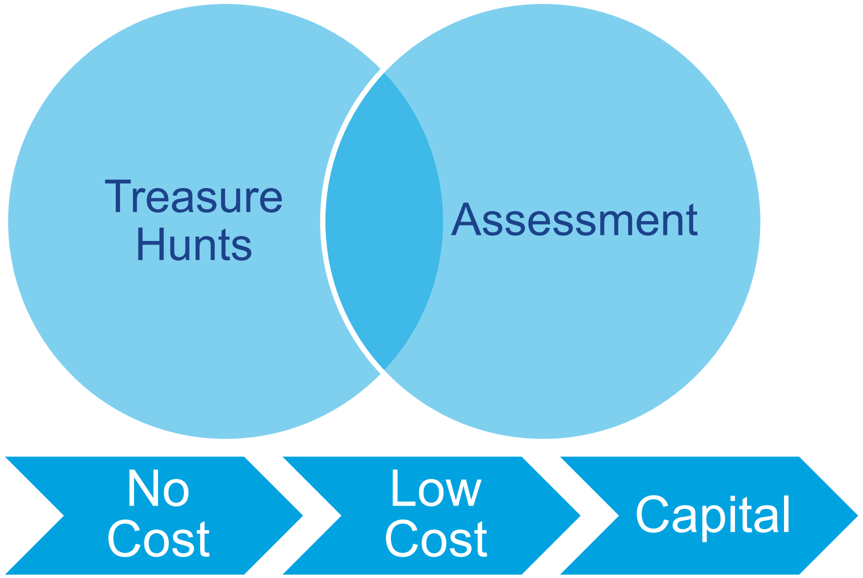
Treasure Hunt Versus Assessment

Treasure Hunt

- Continuous process (repeat annually, quarterly . . .)
- Internal resources
- Focus on operational opportunities

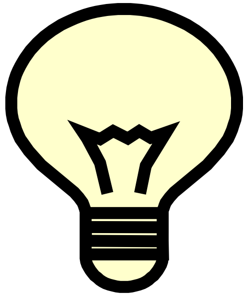
Assessment

- Standalone event (assess as needed)
- External resources
- Focus on system performance and technology



The Basic Mission

Assemble with your teams



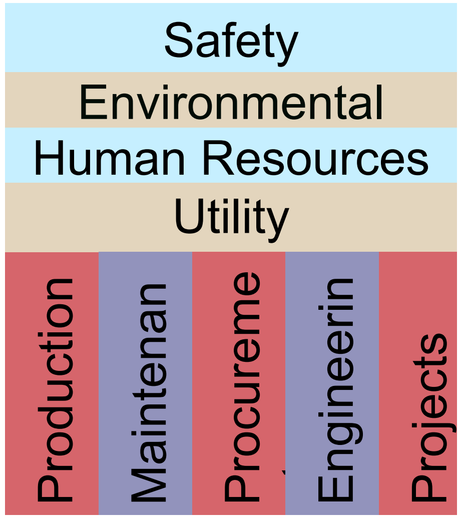
Facility walk through for each team to generate ideas

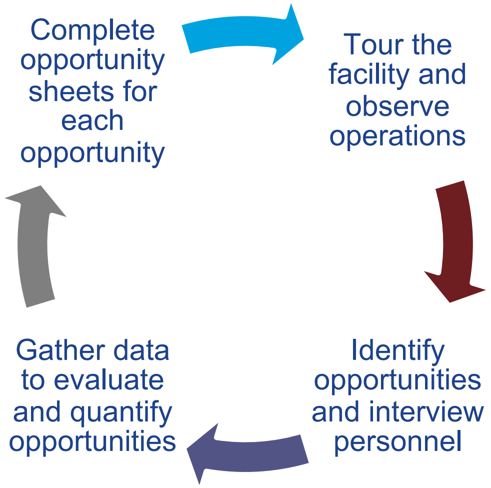
Assess idea feasibility, gather data, quantify

At the end of each day the teams brief each other on what they will pursue

Treasure Hunt – Best Practices

- Include participants from across all operations and from outside the host facility
- Operational opportunities can be ideally identified when facility is ideal. Treasure hunts should ideally start on Sundays which typically a non-production day for many facilities
- Target 3 teams of 5 participants, select focus areas based on your facility
- Energy and water treasure hunts can be done together
- Following the treasure hunt approach
    1. Walkthrough the facility and observe operations
    2. Identify opportunities
    3. Collect relevant data
    4. Quantify Savings





Advantages of a Treasure Hunt

- Can be run internally by the facility without outside expertise
- Opportunities/ideas are solicited from many disciplines and can be replicated across similar processes and businesses
- Percentage of opportunities implemented through a treasure hunt is higher than traditional assessments ; 55% of ideas generated are implemented
- At completion, the facility has sufficient information to execute identified opportunities
- Promotes a culture of efficiency within the company

Basic Daily Format –Treasure Hunt

- Sunday – 8AM – 3PM
  - Introductions, background information
  - Training on best practices and use of diagnostic equipment
  - Divide teams and assign target areas
  - Observe idle facility, generate ideas
  - Daily flip-chart notes – major opportunities

- Monday – 7AM – 5PM
  - Training on use of DOE software tools and calculation sheets
  - Observe facility under operation
  - Investigate ideas, gather information
  - Identify top 2 opportunities
  - Calculate savings for top opportunities

- Tuesday – 7AM – 4PM
  - Finalize / review all calculations
  - Summarize findings
  - Present to management

Water Treasure Hunt Agenda

- **Week 6 – Virtual Treasure Hunt**
  - **April 7th: 10am to 11am ET – Treasure Hunt Resources Overview**
  - **April 7th – April 12th : Participants run a treasure hunt walkthrough and identifies opportunities**
  - **April 8th and 12th : 1 hour Time - Reviewing Opportunities Identified**
- **Week 7 (April 14th) – 10am to 1230am ET**
  - **Estimating Water Savings Opportunities: Overview of Tools**
  - **Estimating Savings for Opportunities Identified**
- **Week 8 (April 21st) – 10am to 1230am ET**
  - **Industrial Water System Assessment Wrap-up Presentations by Participants**

Water INPLT Team is always available between the weeks for individual calls and discussions

Homework

U.S. DEPARTMENT OF ENERGY

Homework #5

- Complete PWP tool for your facility including Tab 9 and 10
- Prepare to conduct a water treasure hunt next week
  - Identify the people who will do they facility walkthrough
  - Identify the time
  - Identify the systems that you will examine

Review Water Assessment Results

Thank You all for attending today's webinar.

See you all on next Thursday – April 7th, 2022 – 10 am ET

If you have specific questions, please stay online and we will try and answer them.

Alternately, you can email questions to me at thirumarank@ornl.gov

Extra Slides

Stormwater management

Runoff can contribute to additional contaminants that facilities may need to treat before discharging or may cause non-compliance. This increases the true cost of water.

Examples of contaminants: solids from dirt, hydrocarbons from fuels used onsite, chemicals from small spills.

A photo shows excessive buildup of sediment and vegetated debris at a neglected storm drain.
Source: https://informedinfrastructure.com

Infiltration & inflow

The mixing of stormwater with process outflows can increase the volume of wastewater to be treated and adds variability to concentration of contaminants.

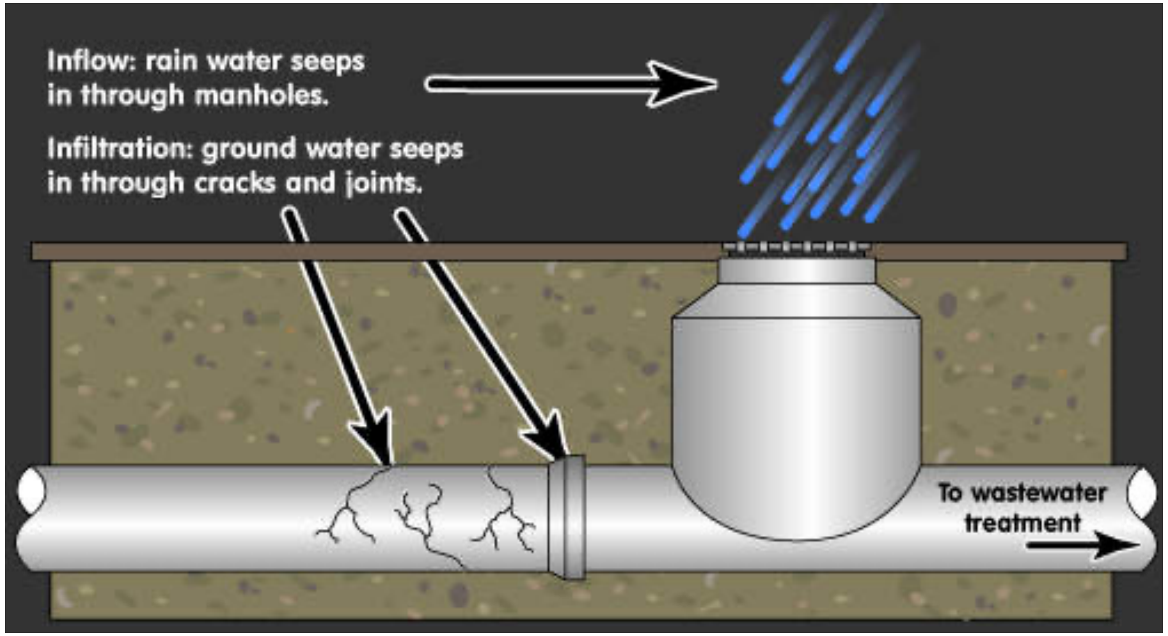
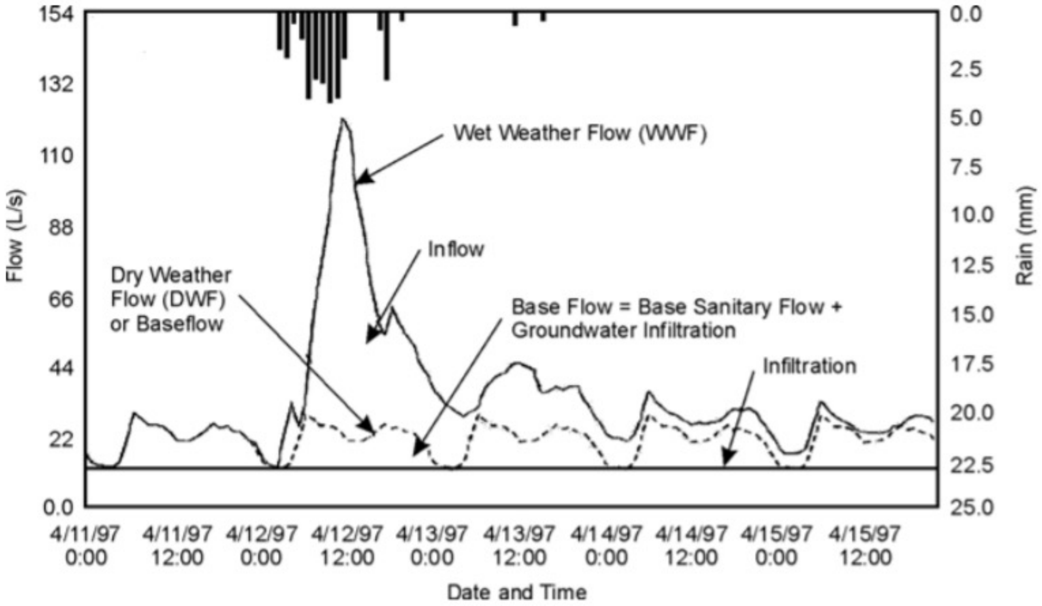


Diagram shows possible infiltration and inflow in pipes.
Source: https://www.jamestownbpu.com/

Check if the outflow has a lot of variability after storms or rainy seasons (wet weather) and compare to dry weather. The response time can vary (from minutes to days) and depends on the location of pipes, soil type, and volume of rain.



Source: www.metrovancouver.org