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CHEESE MAKERS
ASSOCIATION

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Optimizing Water Quality in Dairy Processing

July 10, 2025

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APPLIED SCIENCE
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Agenda

- Dean Sommer, Center for Dairy Research
- Scott Fisher, The Kurita Group
- Aaron Shaver, Advanced Process Technologies
- Rachel Kloos, ISG
- Q&A

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CENTER FOR DAIRY RESEARCH

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Dairy Wastewater Fundamentals

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Course Date: August 26, 2025 | Registration closes: August 12, 2025 | Course Fee: $129

Location: McMahon Associates, Inc. (McMahon Associates, Inc., 1445 McMahon Drive, Neenah, WI 54956) & **Agropur Little Chute** (3805 N Freedom Rd, Appleton, WI 54913)

Scott Fisher
The Kurita Group

COW and Polished Water Reuse

Wisconsin Cheese Makers Association

July 10, 2025

Kurita

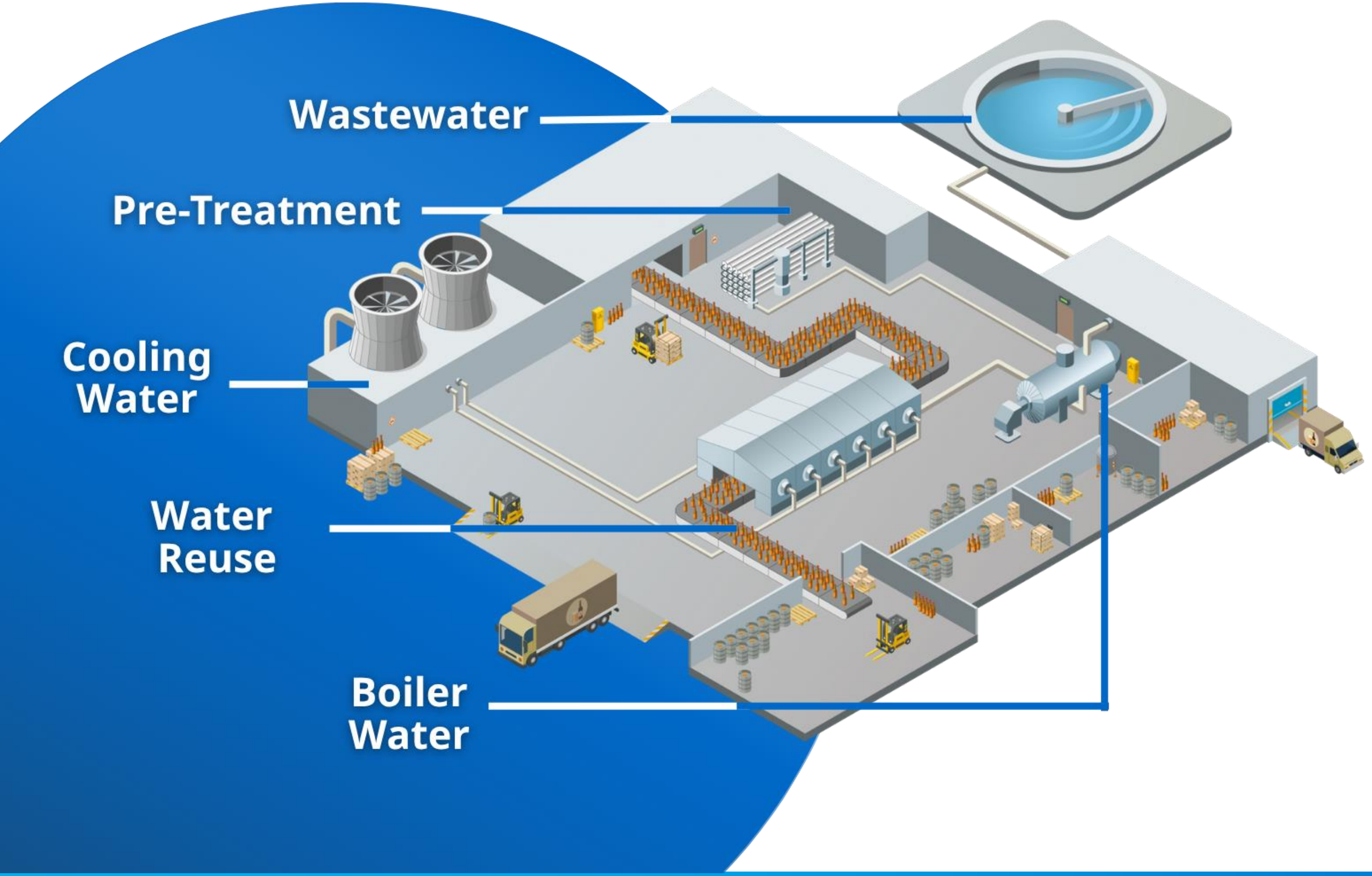
Scott Fisher

Director of F&B – West Division

- 25 years in the water treatment industry
- Oversees sales and marketing efforts into F&B market for North America, South America and EMEA
- Active participant in WCMA for over 10 years

- Interesting Fact:
  - Grandfather was a dairy farm inspector for back in the 50’s and 60’s

Kurita America – Dairy Water Expertise



Water In.
Water Out.

Download your guide to optimize your water treatment at your food & beverage facility!

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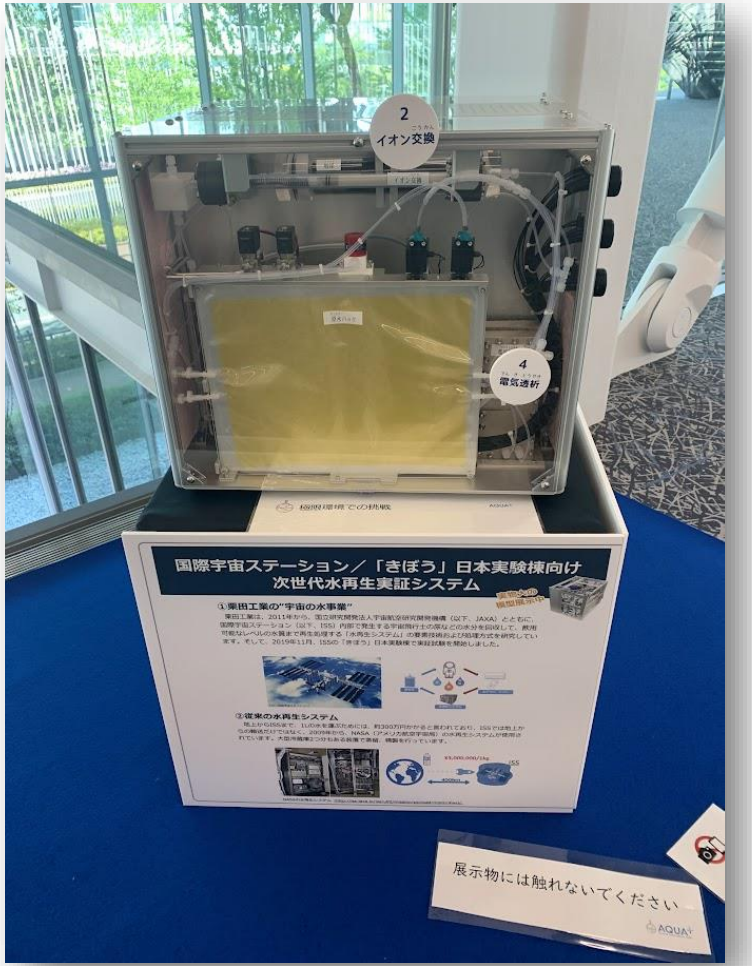
“Out of this World“ Water Reuse

- Kurita Innovation on the International Space Station
  - Water recycling technology was utilized on the ISS
  - Module “Kibo” recycles urine to generate potable water
  - More recently, Kurita is collaborating with the Japan Aerospace Exploration Agency (JAXA) for water recycling efforts on future Lunar and Mars exploration



“Kibo” water recycling system replica

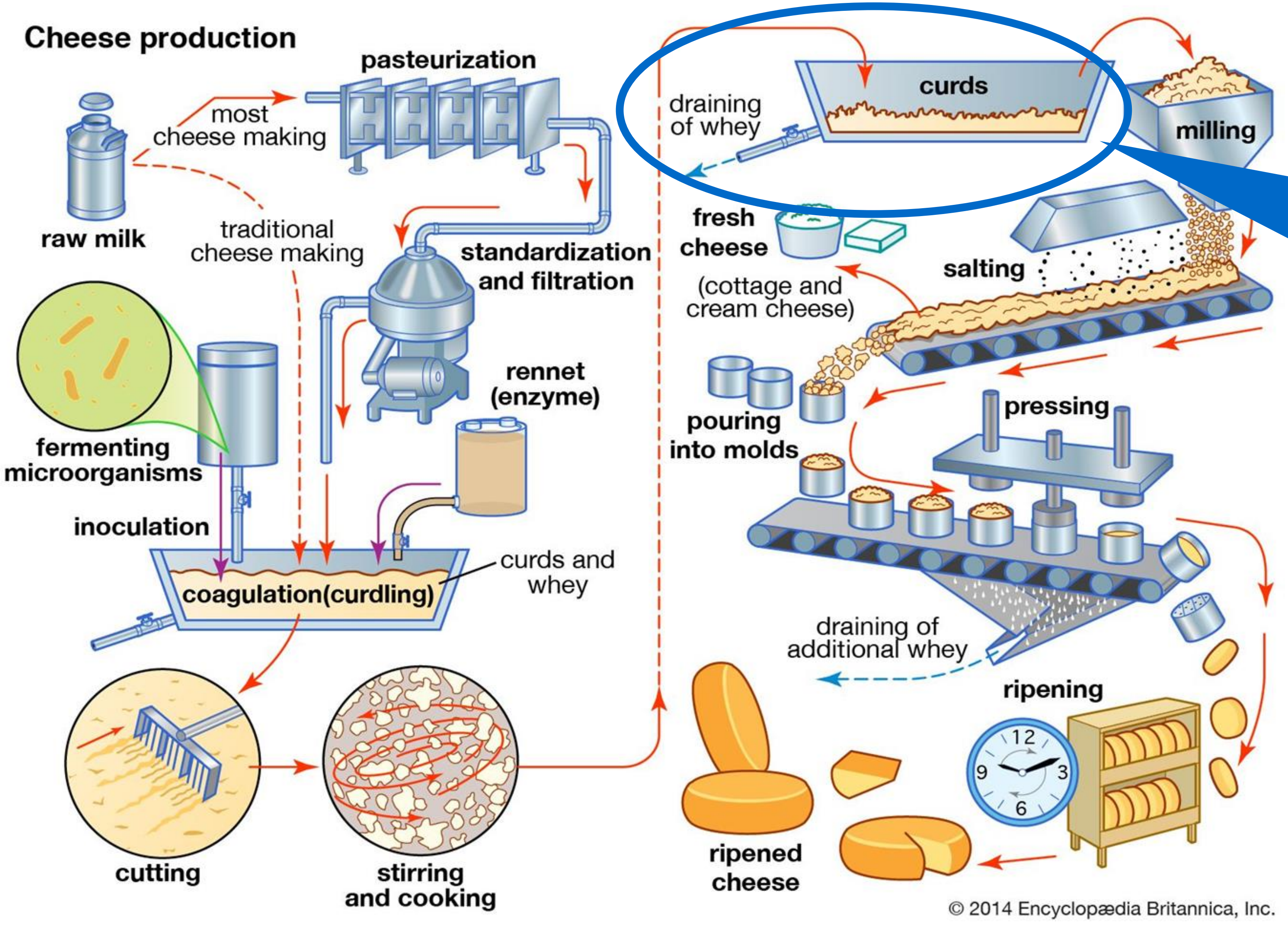
Cheese & Whey Production

Cheese Production

Whey Production

Water Generated from Process

Cheese & Whey Production



Cheese solids and whey liquid

Condensate of Whey

Example 1

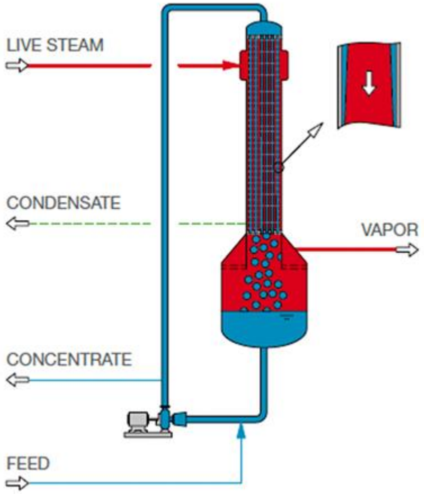
Whey

Process RO

Permeate (COW Water)

Whey Concentrate

Example 2



Whey Concentrated

Whey

Process Condensate (COW Water)

Evaporator

COW & Polished Water Reuse

- The FDA 2023 Pasteurized Milk Ordinance (PMO) details how this water can be reclaimed and reused in Appendix D
- Category 1 – Best Water Quality, Potable Equivalent Water
  - Most stringent requirements for water and verification methods
  - Uses: final rinses, CIP, utilities – not approved for sinks, toilets and domestic waters
- Category 2 – Less Stringent Requirements, still high quality
  - Uses: pre-rinses, utilities, cleaning solutions make-up
- Category 3 – Least Stringent Requirements
  - Uses: boilers of non-culinary steam production, floor rinses in non-production areas

Category 1 Water Reuse

- Shall not exceed a total plate count of 500 per milliliter
- Samples shall be collected daily for two (2) weeks following initial approval of the installation and at least once every six (6) month period thereafter. Provided, that daily tests shall be conducted for one (1) week following any repairs or alteration to the system.
- Standard turbidity of less than five (5) units (FAU/NTU)
- An electrical conductivity (EC) maintained in correlation with an organic content of less than 12 mg/L, as measured by the chemical oxygen demand (COD)
- Automatic fail-safe monitoring devices, located at any point in the reclaimed water line prior to the storage vessel, shall be used to monitor and automatically divert, to the sewer, any water that exceeds the standard.
- The water shall be of satisfactory organoleptic quality and shall have no off-flavors, odors or slime formations.
- Approved chemicals, approved for potable water use, may be used to suppress the development of bacterial growth and prevent the development of tastes and odors.

Benefits of Water Reuse

- Reduction in Inlet Water Demand
  - Water Cost Reduction
- Reduction in Wastewater Volume
  - Waste and sewer cost reductions
- Sustainability Improvement

Considerations for Dairy Water Reuse

- Water Quality
  - Need to understand the quality of water produced in the process
    - Impurities and organics
    - Generally, this water is of good quality if processes are operating properly
- Water Quantity
  - Plant and Production Demand
  - Storage capacity

Kurita

Aaron Shaver
Advanced Process Technologies

Aaron Shaver

Senior Technical Advisor Project Development, Process Engineering, Project Management, and Support

B.S. Chemical Engineer, University of Minnesota

With APT since 2010

30 Years Experience in Food, Dairy, and Pharmaceutical

APT Overview

- Advanced Process Technologies, Inc. was founded in the year 2000
- APT today employs over 150 employees
- Specializing in cheese components: cheese vats, dosing systems, enclosed finishing vats, cheese towers, belts and bulk cheese packaging
- Project offerings include plant design, process, mechanical, and electrical engineering, process automation, equipment fabrication, complete site installation, integration, and supervision
- Serving customers in Dairy, Egg, Beverage, and Processed Foods industries
- An Employee-Owned company

Water Uses in a Cheese Plant

Product / Product Contact

- Water Addition to Products, Powder Reconstitution
- Diafiltration
- Product Flushing and Displacing
- CIP Final Rinses
- Sanitation hoses that may directly contact product

Sanitation /CIP

- CIP Solution Makeup and Pre/Intermediate Rinses
- General Sanitation Hoses that do not reach product

Process Heat Transfer

- HTST Hot Water Sets, Intermediate Heat Recovery Loops
- Chilled Water and Glycol Systems
- Non-Contact Cooling Water (e.g. single use vs. product)

Industrial Uses & Indirect Heat Transfer

- Steam and Condensate,
- Evaporative Cooling – Tower Water Make-up
- Seal Water, Separator Operating Water, etc.

Domestic

- Drinking Water, Personal Hygiene, Eye Wash Stations, etc.

Water Types in a Cheese Plant (naming conventions will vary)

Potable Water

- Well Water and/or Municipal Water (Quality Regulated)
- Typically treated by plant or supplier (Chlorinated, etc.)
- Suitable for product or product contact unless minor constituents pose a concern (PEW for Grade A Pasteurized)
- Chlorine exposure to RO/NF membranes is problematic
- Mineral content can foul heat transfer equipment

Soft Water

- Softened by Ion Exchange (NaCl) or Reverse Osmosis
- Frequently best choice for heat transfer equipment
- High purity (RO) water can negatively affect aluminium, iron equipment, e.g. vacuum pumps, cooling towers, etc.

COW Water

- Condensate Of (evaporated) Whey – Water **recovered** from product evaporator systems
- High purity, but risk of carryover and production upsets can limit direct re-use in plants

Polished Water

- Water **recovered** from milk or whey products
- Purified by Reverse Osmosis for re-use in the plant
- Typically the highest purity water in the facility

Domestic (Typically a subset of Potable)

- Systems Isolated for Drinking Water, Personal Hygiene, Eye Wash Stations, etc.

Cheese Plants use how much water?!?

Water Consumption

- Total water consumption in cheese plants varies from 80% to over 200% of the milk processed on a daily basis, depending on plant scale, throughput, processes, and products.
- Complex whey processing can consume a great deal of water, but can also provide much or all of the water it needs via polished water re-use in production/CIP.
- Some water used in a cheese plant ends up in product, and some ends up as water vapor, but most of the water (that isn't recycled) winds up in a waste treatment plant.
- Some cheese plants are able to direct discharge some of their used water when the water is of suitable quality, and they can obtain or maintain the necessary permits.
- Some plants are able to operate nearly water neutral, by using water reclaimed from incoming milk for almost every plant need.

Example:

A theoretical plant that consumes 3 MM lbs. of milk a day might consume the following water on a daily basis:

Product & Product Flushes	50,000 Gallons
CIP Rinses & Solution Makeup	300,000 Gallons
Steam, Refrigeration Makeup, etc.	50,000 Gallons
Misc. Sanitation & Hygiene	25,000 Gallons
Total Water Consumed:	**425,000 Gallons**

Water Balance: What goes in must come out…

Water Balance:

- Knowing how much water you are using in all the different phases of your operation is the first step in optimizing your net water usage.
- If you are recovering water, you will need to store it for some period of time before using it, and you will need an independent distribution system to deliver it where you need it.
- Knowing when in your production day you are using that water is the second step in optimizing your net water usage.
- When discussing water, it is easy to miscommunicate. E.g. does the example plant shown consume 175K, or 350K, or 425K gallons of water?

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A theoretical plant that consumes 3 MM lbs. of milk a day might consume the following water on a daily basis:

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Steam, Refrigeration Makeup, etc.	50,000 Gallons
Misc. Sanitation & Hygiene	25,000 Gallons
Total Water Consumed:	**425,000 Gallons**
Water recovered from whey by RO	250,000 Gallons
Water from Well/City	175,000 Gallons
Water shipped out in Product	25,000 Gallons
Water lost to Evaporation	50,000 Gallons
Water to Waste Treatment	350,000 Gallons

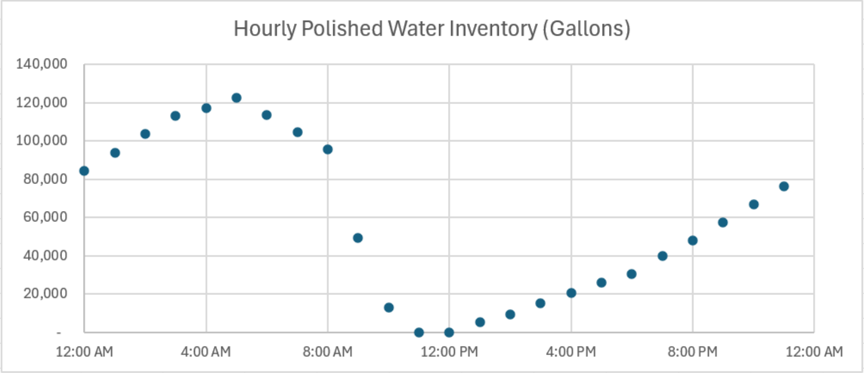
Scheduled Water Balance: Timing Is Everything

Scheduled Water Balance:

- CIP timing creates significant surges in reclaimed water inventory, even when water is used in all areas of the plant.
- Knowing when the different phases of your operation are consuming water will help define inventory needs.
- Understanding peak demands by area can guide the design of an efficient and cost-effective distribution system.
- Most plants will keep their reclaimed water distribution on 24 hours/day except when CIPing the distribution itself.

Example:

The chart and table below show hourly plant operations and water production and consumption for our theoretical plant.



Daily Operating Schedule																								
	12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM	6:00 PM	7:00 PM	8:00 PM	9:00 PM	10:00 PM	11:00 PM
Milk Receiving	Silo CIP				Milk Receiving, Truck CIP														Line CIP		Silo CIP			
CIP Water Usage	1,500				5,500	4,000	6,000	6,000	6,000	6,000	4,000	4,000	4,000	4,000	5,500	4,000	4,000	4,000	5,000		1,500			
Cheese Production							HTST, Milk UF, and other CIP				Production, with regular vat CIP and other periodic CIP													
CIP Water Usage	2,500	2,500	2,500	2,500	2,500	2,500	15,000	15,000	15,000	15,000	7,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500	2,500
Whey Operations										Membrane Systems in CIP				Membrane Systems in Production, Misc. CIP Support for pretreat, swing tanks, loadout, etc.										
CIP Water Usage	500	500	500	500	500	500	500	500	500	25,000	25,000	25,000	25,000	500	500	500	500	500	500	500	500	500	500	500
Polished Water Recovery	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	-	-	-	-	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500	12,500
Net Polished Water Inventory	84,500	94,000	103,500	113,000	117,000	122,500	113,500	104,500	95,500	49,500	13,000	-	-	5,500	9,500	15,000	20,500	26,000	30,500	40,000	48,000	57,500	67,000	76,500
											50,000 gallons of non-polished water required to make up difference.													

Storage and Distribution Considerations for Reclaimed Water

Reclaimed Water Storage:

- Storage vessels must be cleanable. Generally, this is taken to be CIPable, as the downtime for more manual cleaning isn't practical or reliably available.
- Ideally, storage systems should be sized large enough to utilize all the water produced while accommodating typical variations in production and CIP schedules.
- Systems with multiple storage tanks allow for continuous supply of reclaimed water, while allowing tanks to be cycled for regular cleaning.
- Differentiation of storage vessels can lend itself to utilizing water at different temperatures for different purposes, including heat recovery prior to secondary uses.
- Mixproof valve technology can be used to provide rapid CIP capability if desired.

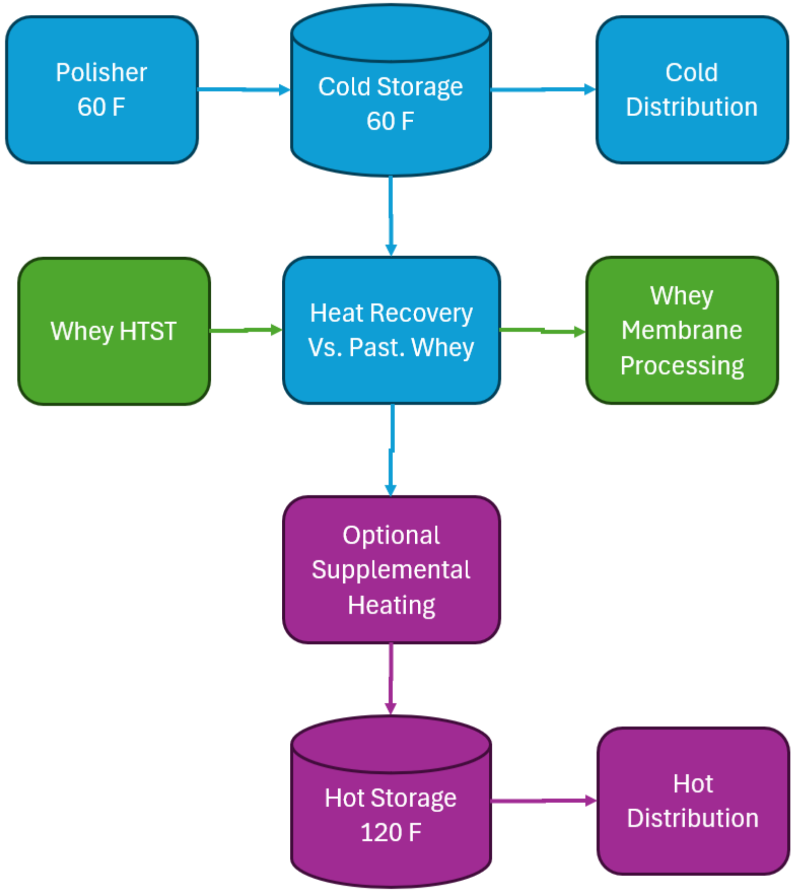
Reclaimed Water Distribution:

- Reclaimed water distribution systems cannot cross connect with traditional potable water systems, even if the reclaimed water is usable as potable water (Category 1).
- Systems must be capable of being sanitized, although this doesn't have to be automatic or efficient.
- Systems should be sized to comfortably deliver all the water produced to suitable destinations.
- Redundancy of water supplies to processes is recommended, to avoid becoming stuck if a reclaimed water system runs out of water or an operational problem requires a downgrade or disposal of the reclaimed water.
- APT suggests new distribution installations be installed in such a way as to be CIPable. The extent of automation and ease of cleaning are financial considerations for each given installation.
- Consider designing for easy transition from Category 1 to Category 2 distribution, to allow for limited use while testing, etc.

Heat Recovery Considerations for Reclaimed Water

Reclaimed Water Energy Efficiency and Heat Recovery:

- Different sources of reclaimed water can be significantly different temperatures depending on the process.
- Cold polished water from cold membrane operations can be used as a cooling source against warm whey or other streams requiring cooling.
- Cold Category 1 polished water is frequently a suitable temperature for diafiltration in membrane plants.
- Regeneration can be used to allow polisher processing of otherwise too-hot COW water, and for better mineral rejection.
- Reclaimed water used for membrane CIP can shorten cycle times if it is delivered at target CIP temperature.
- Variable flow heat recovery can greatly reduce peak utility loads.



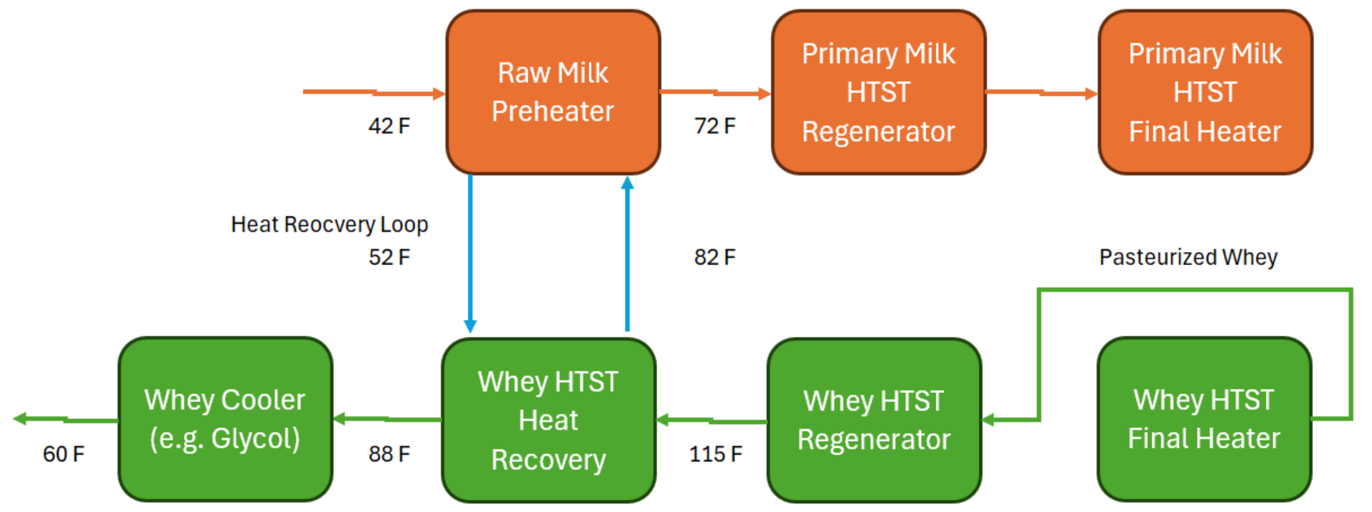
Energy Savings Through Regeneration

Heat Recovery Between Milk and Whey

- **HTSTs:**
- A water loop between cold milk and warm whey might save 25-30 degrees F heating and cooling on the milk and whey respectively.

  In our example, this might save 3,600 lbs/hr of steam, and 275 Tons of refrigeration hourly, 17 hours each day. This equates to over $400,000 in annual energy savings for a 24/7 ope

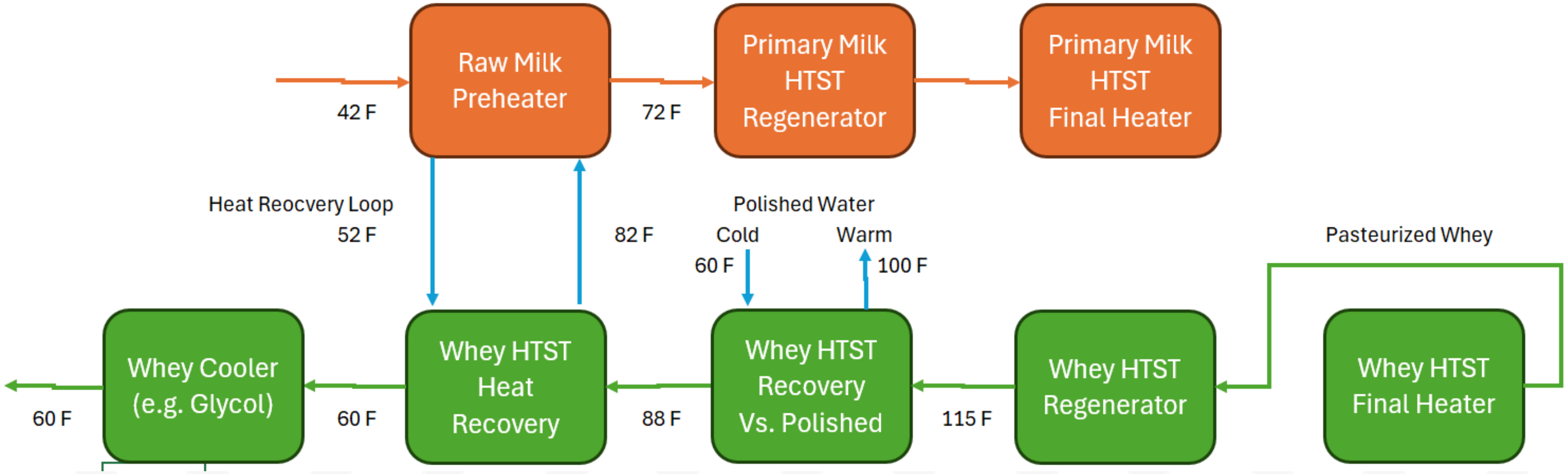
- When regenerating between raw and pasteurized products, legal pressure differential is required, (detailed in the PMO).
- Direct and indirect heat recovery between processes is limited by the concurrent operating times of the processes.
- Some plants will utilize hot and cold water surge capacity to accommodate process timing differences. This can be a significant capital expense.



Energy Savings Through Regeneration

Heat Recovery Between Polished Water and Whey HTSTs:

- Utilization of cold polished water to cool whey prior to further heat recovery vs. raw milk can provide enough cooling to feed whey membrane plants at 55-60 F without refrigeration load.
- Operating whey heat recovery against higher flow cold polished water when milk heat recovery is unavailable can significantly reduce peak refrigeration loading
- In our example, this might save another 275 Tons of refrigeration hourly, 17 hours each day, and 400 Tons when Milk Heat Recovery is not available. This equates to another $200,000 in annual energy savings for a 24/7 operation.
- When compared to direct cooling, this will also save 400 Tons of peak refrigeration capacity for a facility, potentially saving or avoiding significant capital investment.



Economic Considerations

Economics of Reclaiming Water:

- The capital costs of water reclaim, storage, distribution, and heat transfer can be significant, and do not scale linearly with capacity.
- Water, wastewater treatment, and energy costs vary substantially by region, and all play a part in determining payback on reclaimed water investments.
- Operational requirements for managing water systems are significant and shouldn't be overlooked when considering investment.
- Existing equipment in facilities can sometimes be repurposed to reclaimed water and heat recovery functions to save capital.

Low Hanging Fruit:

- Rinse recovery tanks on CIP systems are typically the most economical investment for water reuse in a dairy plant, and are quite common, especially in larger operations.
- Careful management and tuning of product displacement and CIP system flushes can save significant quantities of water.
- Evaluation and monitoring of utility single-pass water users can avoid excess waste. (e.g. seal water, vacuum pump cooling, blow down cooling/dilution.)
- Automated monitoring of water usage can help plant management be aware of changing conditions or operations in their facilities to minimize waste.
- Turbidity sensors can be used to optimize flush length, minimizing product loss and water use.

25th ANNIVERSARY
2000-2025

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Rachel Kloos
ISG

Dairy Processing Wastewater: Water Recovery

Rachel Kloos

Firm Overview

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- Water/Wastewater
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- Geographic Information Systems
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- Testing

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- Healthcare
- Housing
- Mining
- Public Works
- Sports + Recreation
- Transportation
- Water

Industrial Water and Wastewater Solutions

- Sustainability
- Robust Solutions

Rachel Kloos

Water/Wastewater Group Leader

Rachel.Kloos@isginc.com

Can you imagine a day without water?

Essential Ingredient – Can you make product without it?

- Resiliency
- Limited Resource
- Prioritization to protect and restore
- Responsibility

Water Positivity

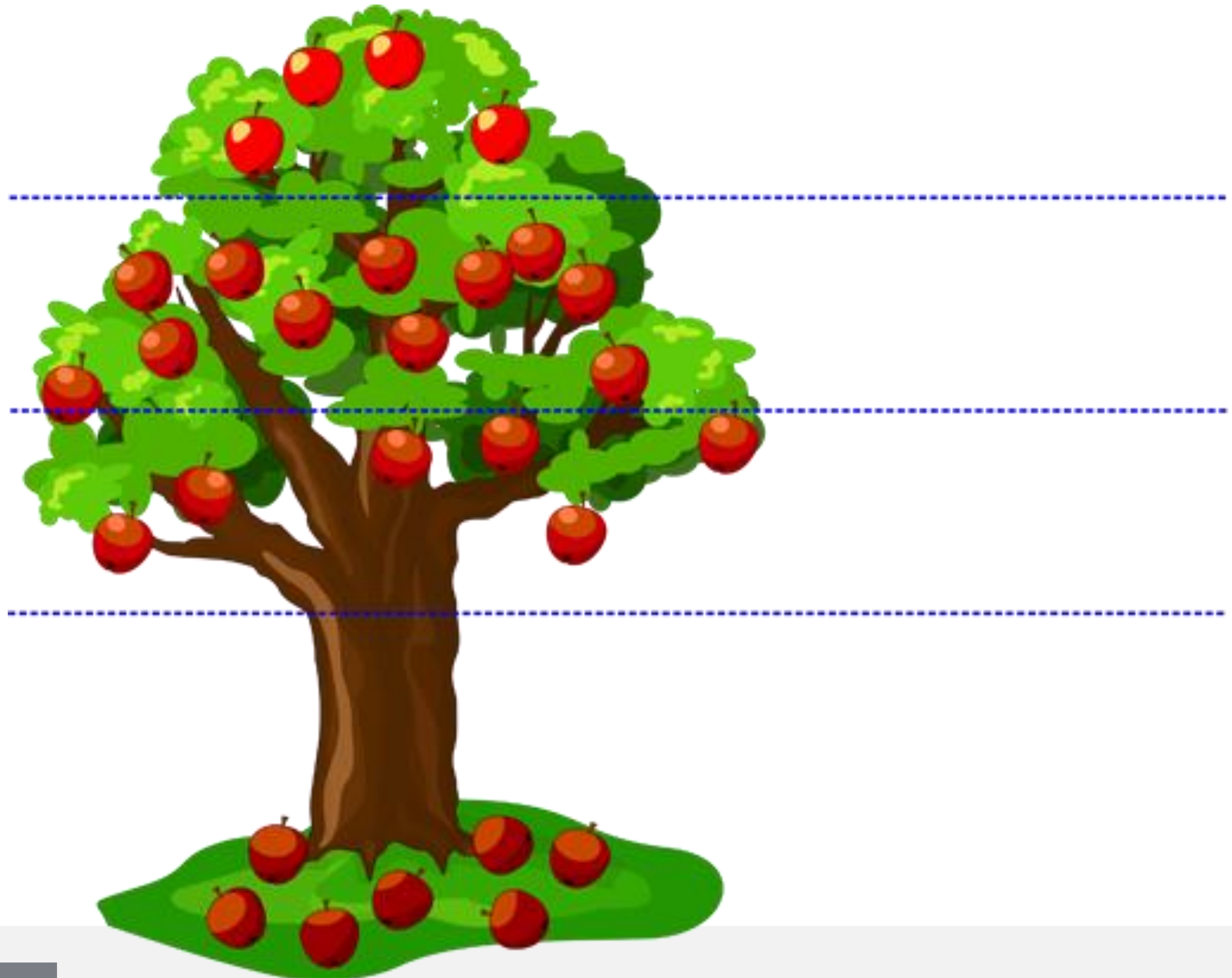
(def) Water positivity is the process of enhancing the regeneration of water resources beyond what is consumed.

- Water Efficiency
- Water Recycling
- Sustainable water management

Amazon Web Services (AWS) committed to being water positive by 2030. Returning more water to communities than what is used in data center operations.

Coca Cola has committed to a reduction in fresh water/liter of Coke by 20% by 2025 (from 2019).

Coca-Cola and Low Hanging Fruit



2030 Goal: 1.00 gallons/gallon of Coca Cola

2024: 1.79 gallons/gallon of Coca Cola

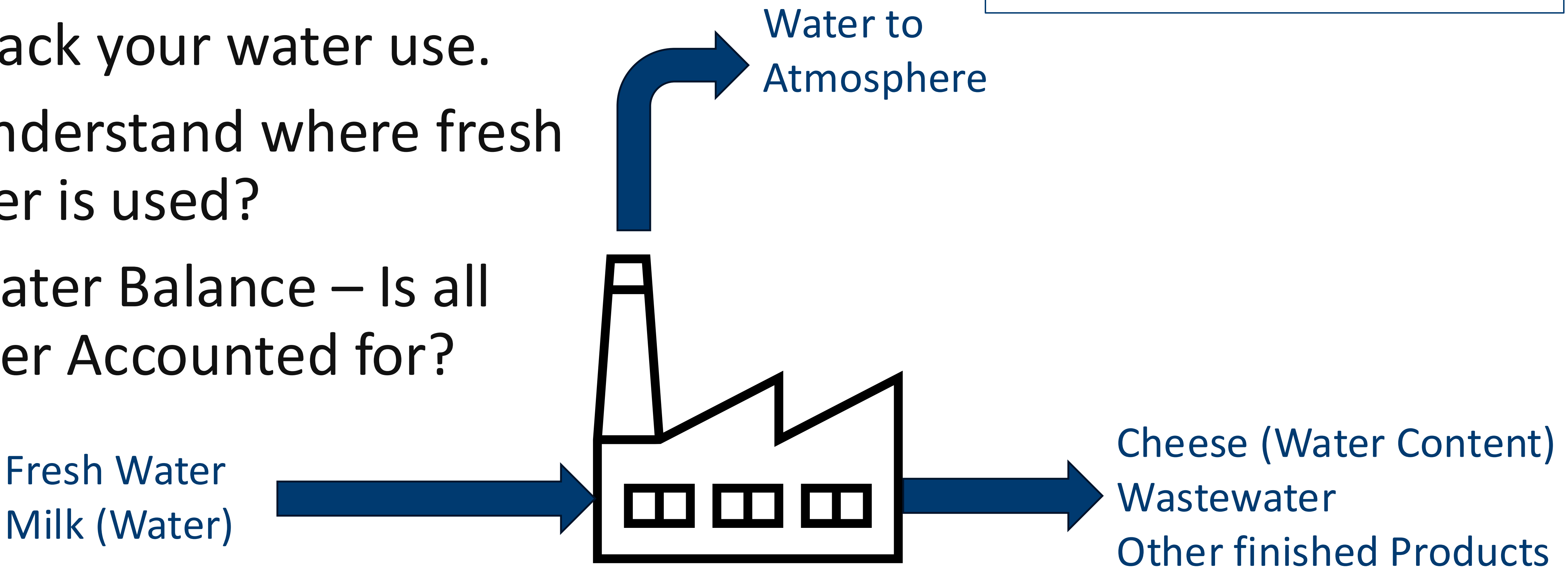
2020: 3.00 gallons/gallon of Coca Cola

Step 1: Efficiency

Metric:

Gallon of Water/pounds of Milk processed

- Track your water use.
- Understand where fresh water is used?
- Water Balance – Is all Water Accounted for?



Step 1: Efficiency

Water Balance

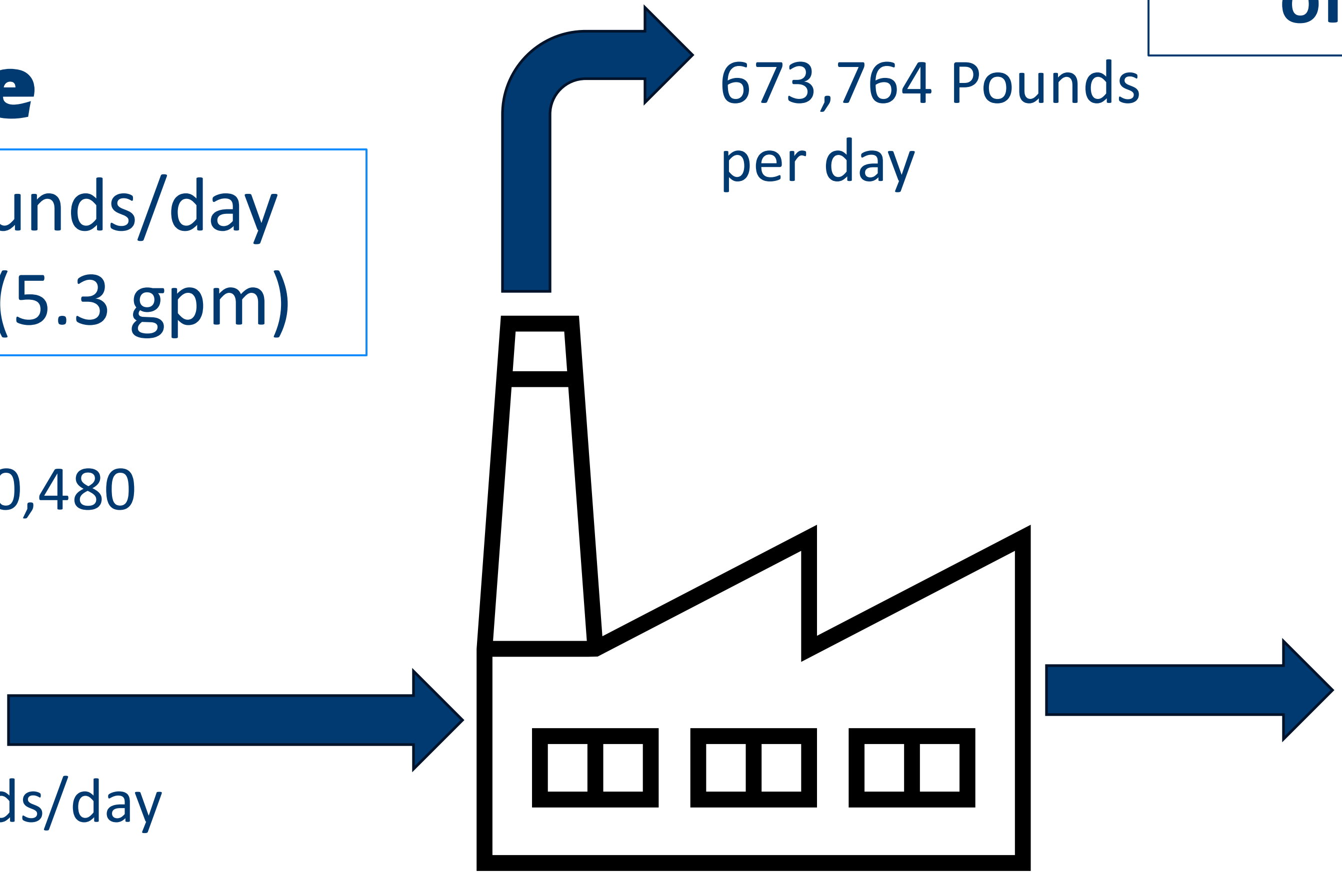
+64,017 Pounds/day
~7,676 gpd (5.3 gpm)

Metric:

Gallon of Water/pounds of Milk processed

Fresh Water: 600,480 pounds per day

Milk:
3,454,000 Pounds/day

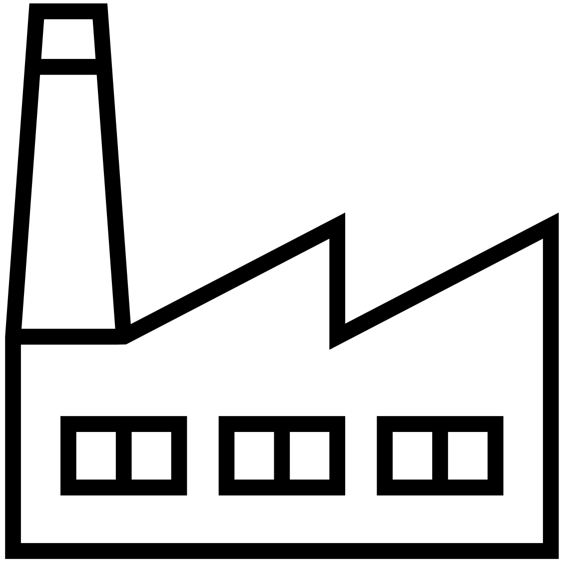


673,764 Pounds per day

Finished Product:
278,815 Pounds per day
Wastewater:
3,037,884 Pounds per day

Step 2: Reduce by Recycling

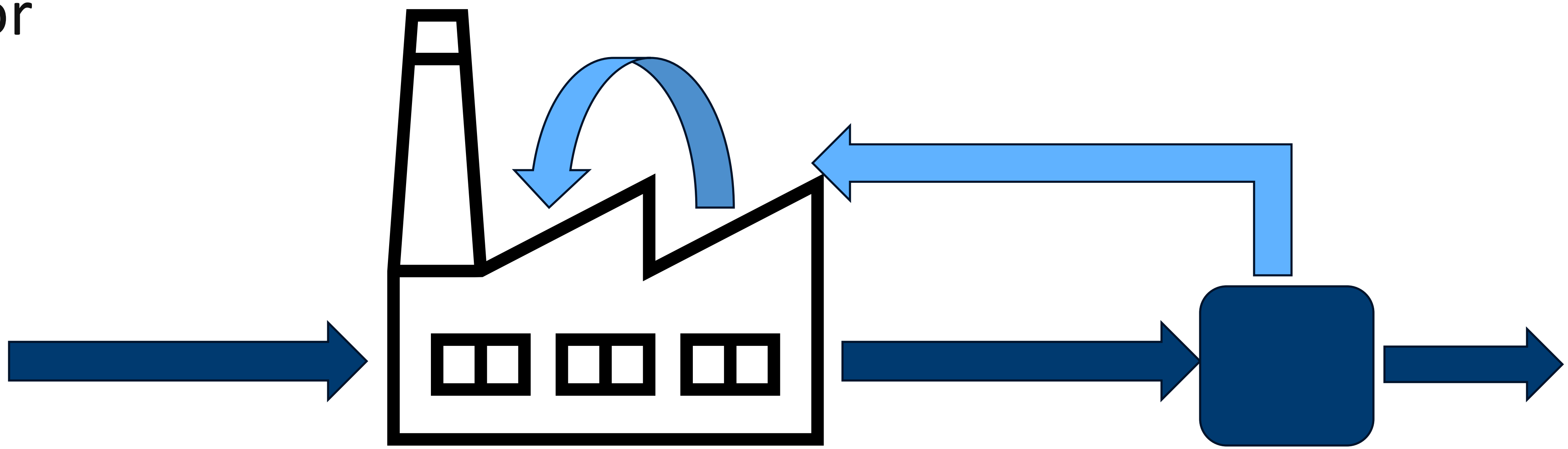
- Optimization of COW and Polish water?
  - Is there excess COW or Polish water to Wastewater?
  - Why can't it be used?



	Example 1	Example 2
Incoming Water, Pounds/day	2,268,480	600,480
Excess Polish Water, Pounds/day	228,474	68,724
Wastewater, pounds/day	2,799,260	2,465,686

Step 3: Reuse

- Wastewater as a resource
- Water Quality must be reviewed; often tertiary treatment is required.
- TDS, Chlorides and Temperature are common components to watch for



Wastewater as a Resource

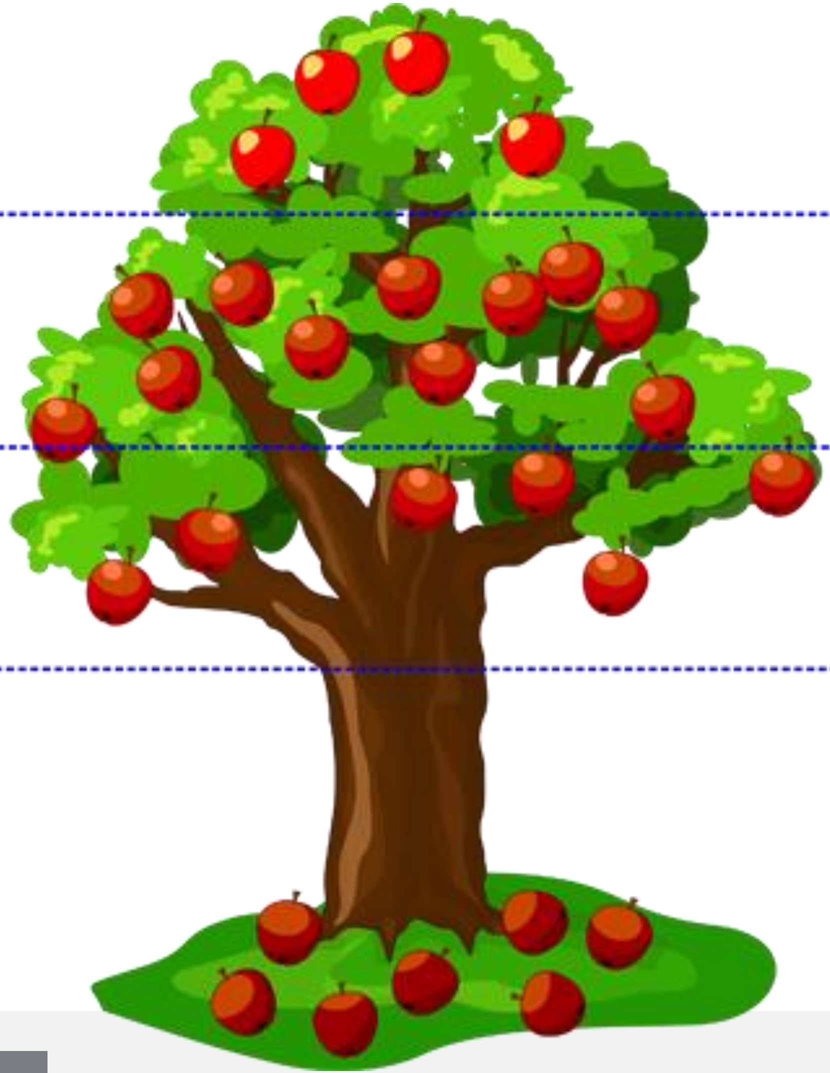
- **We always have wastewater.**
- **Can we use it?**
  - Regulatory - PMO and Reuse Standards
  - Quality
- **Should we reuse it?**
  - Risk Factor
  - Can someone else use it to offset fresh water?

Water Quality

Not all water is Equal – Water Quality must meet the finished use requirements.

- **Variables:**
  - Temperature
  - Total Dissolved Solids
  - Hardness
  - Chlorides
  - Suspended Solids
  - BOD and Organic Loading

Dairy Processing



Wastewater Reuse

Efficiency

COW and Polish Water Utilization

Rachel Kloos

Water/Wastewater Group Leader

Thank You!

Share your water stories!!

Rachel.Kloos@isginc.com

Questions and Answers

Q&A

How does polished RO permeate from whey processing vary from condensate from evaporators of the same material? (e.g., RO permeate vs. evaporator condensate)

Q&A

What is best practice for quantifying the water reused? (i.e., getting a data point you'd be comfortable sharing publicly.)

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