Innovation in Water Reuse

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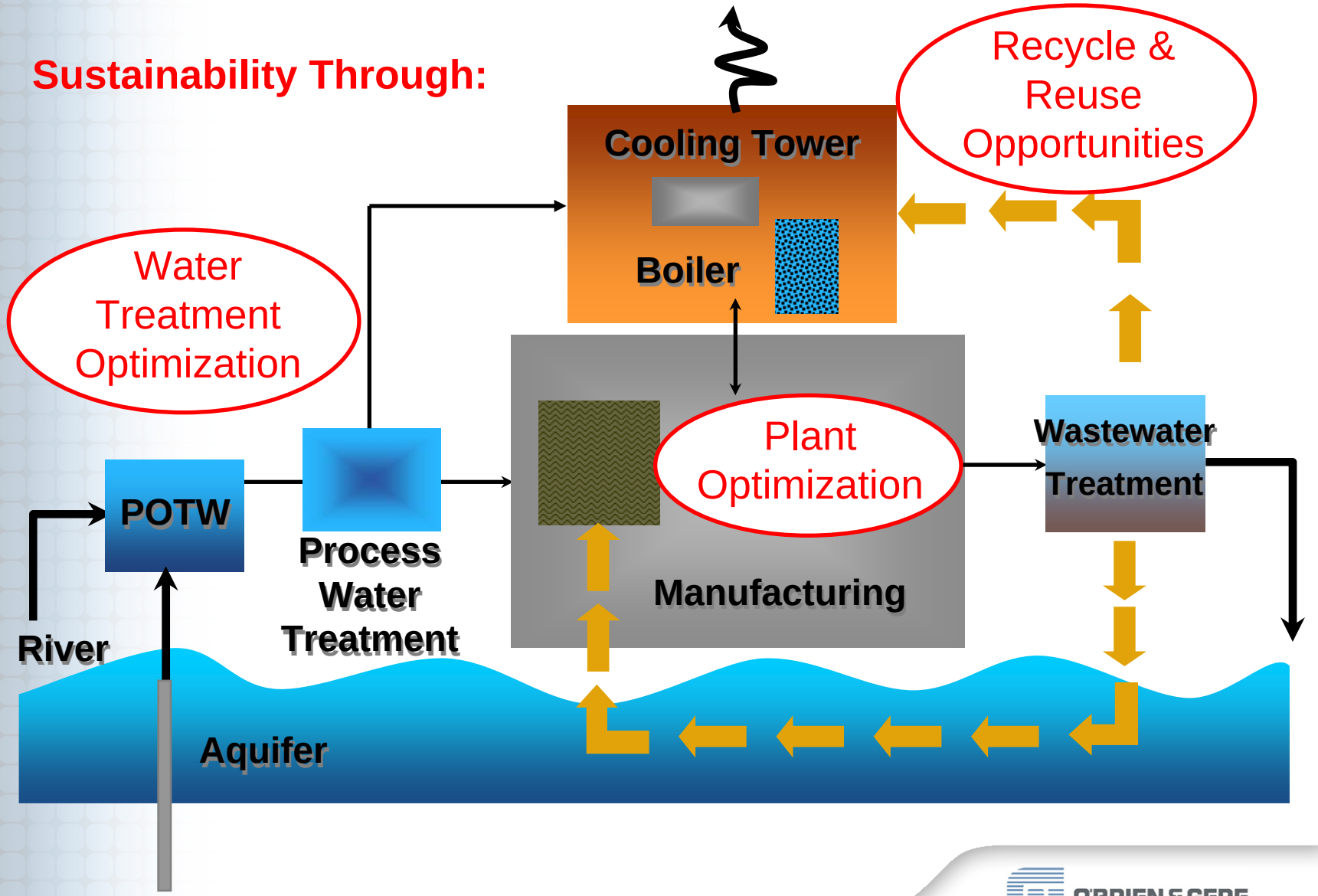
The Industrial Water Cycle



Drivers for Conservation & Reuse

- Are **Conservation & Reuse** programs classified as economically prohibitive?
- Can the capital outlay for Conservation & Reuse programs be justified in the short-term **(ROI)?**
- Have both **economic and non-economic** drivers been considered to identify Conservation & Reuse opportunities?

Economic Drivers

The most fundamental driver for recycle is availability: Supply and Demand

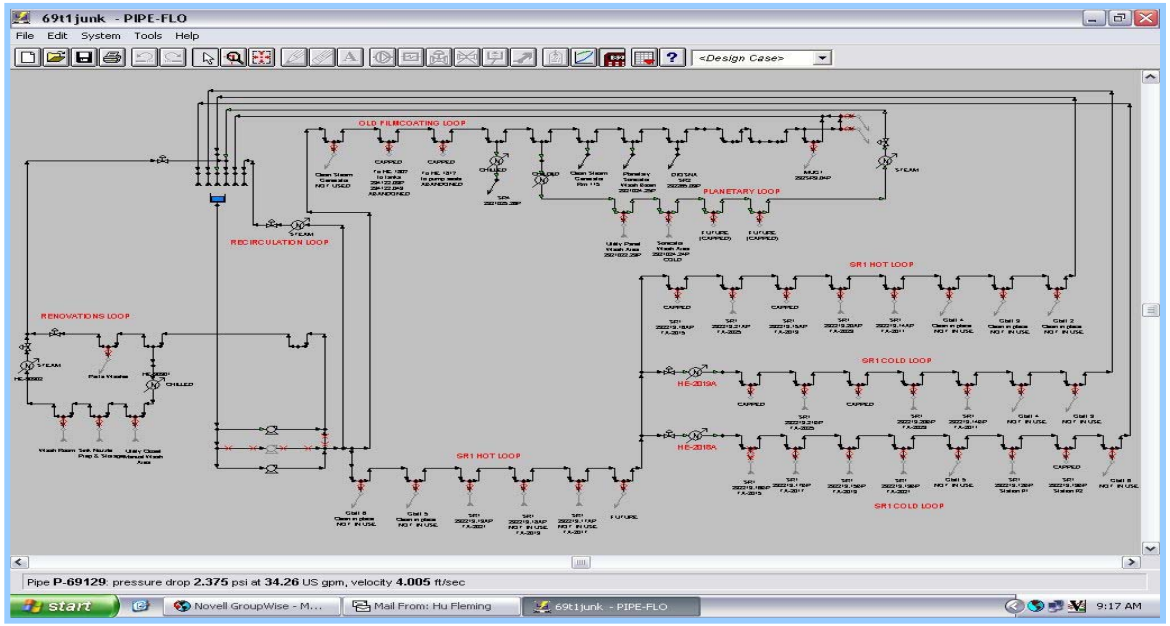
- **Water costs**
  - Infrastructure for obtaining, Unit Costs, Annual Fees
- **Water rights**
  - Limiting production or expansion
- **Wastewater discharge**
  - Capital, Fees, Surcharges
- **Total water/wastewater costs**
  - Range from <$2.00 to >$8.00 per 1000 gallons
  - Costs are on the rise

Non-Economic Drivers

- **Regulatory Impacts**
  - Total Maximum Daily Loads (TMDL)
    - Specifies the amount a water body can receive
    - EPA published changes to program - July 13, 2000
    - Impact on both direct and indirect discharges
  - ISO 14000
- **Community Relations/Environmental Stewardship**
  - Public perception / purchase patterns examples:
  - Tyson - renewable diesel from fat, oil, grease (FOG) waste
  - Sara Lee - bakery water reduction
  - Smithfield - water reduction, manure to biogas
  - Many other Fortune 100 Corporate initiatives

Measure

- **Identify all water users and wastewater generators**
- **Hydraulic Modeling**
  - Flow Meters
  - Plant Flow Diagrams
- **Water / wastewater costs**



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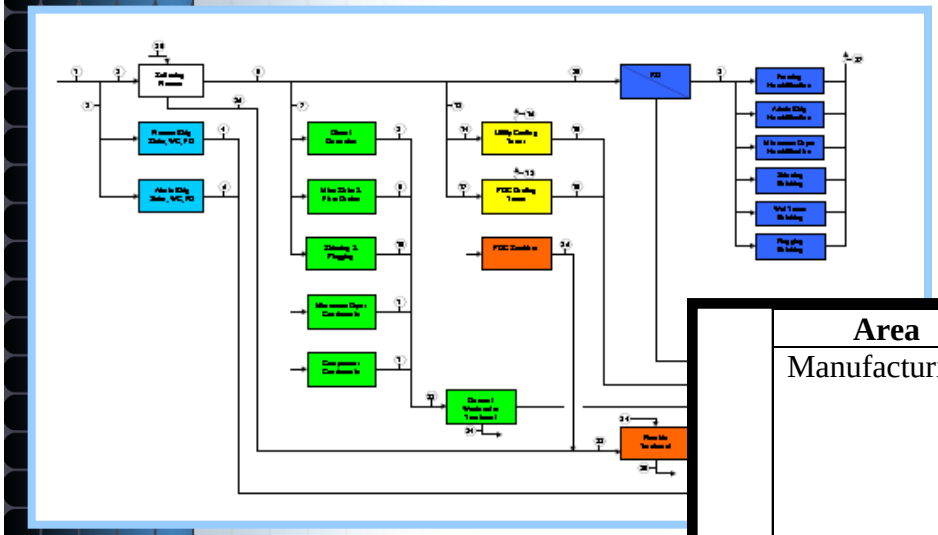
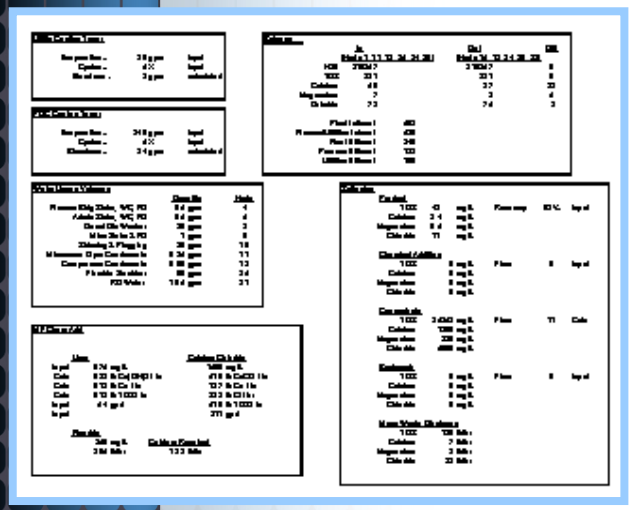
Water Audit Toolkit





Area	Inputs	Outputs
Manufacturing	Product make-up Chemical make-up Product rinsing Equipment cleaning	High purity blowdowns/rejects Product consumption Evaporation during product Drying CIP discharges Chemical bath dumps Leaks and miscellaneous losses
Utilities	Boiler make-up Cooling tower make-up Chemical make-up	Feedwater systems Blowdown/rejects Loss of steam (evaporation) Lack of condensate return Boiler blowdown Cooling tower evaporation Cooling tower blowdown
Wastewater treatment	Continuous manufacturing discharges Batch manufacturing dumps WWTP chemical additives	Effluent discharge Evaporation Sludge/filter cakes

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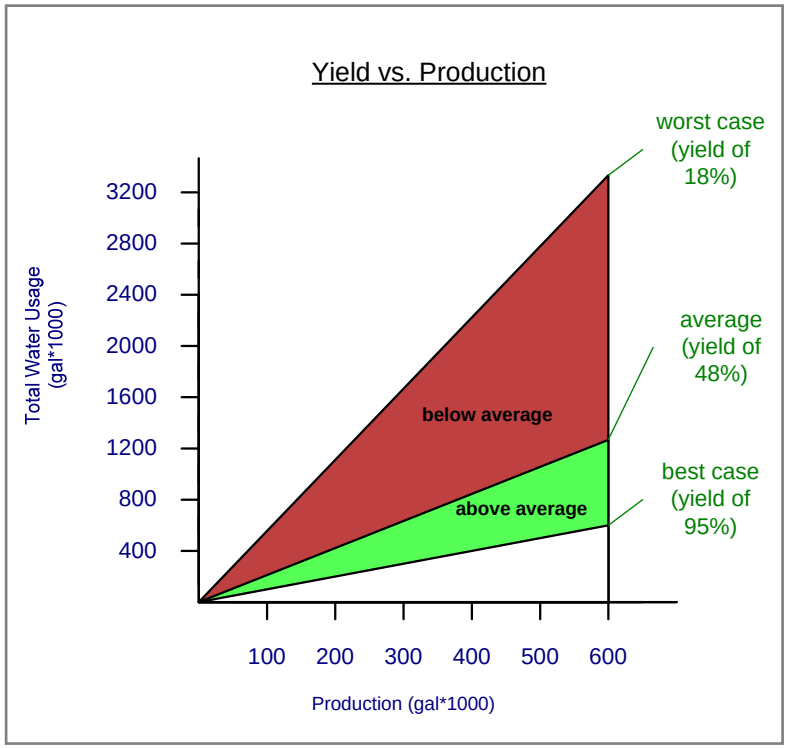
Benchmark, Evaluate, and Improve

- **Source Minimization**
- **Conservation**
- **Recycle & Reuse**
- **Improvement through**
  - Administrative
  - Operational
  - Engineering



Continuous Improvement Cycle

- Measure
- Water Audit
- Benchmark
- Evaluate
- Improve

Process Conservation

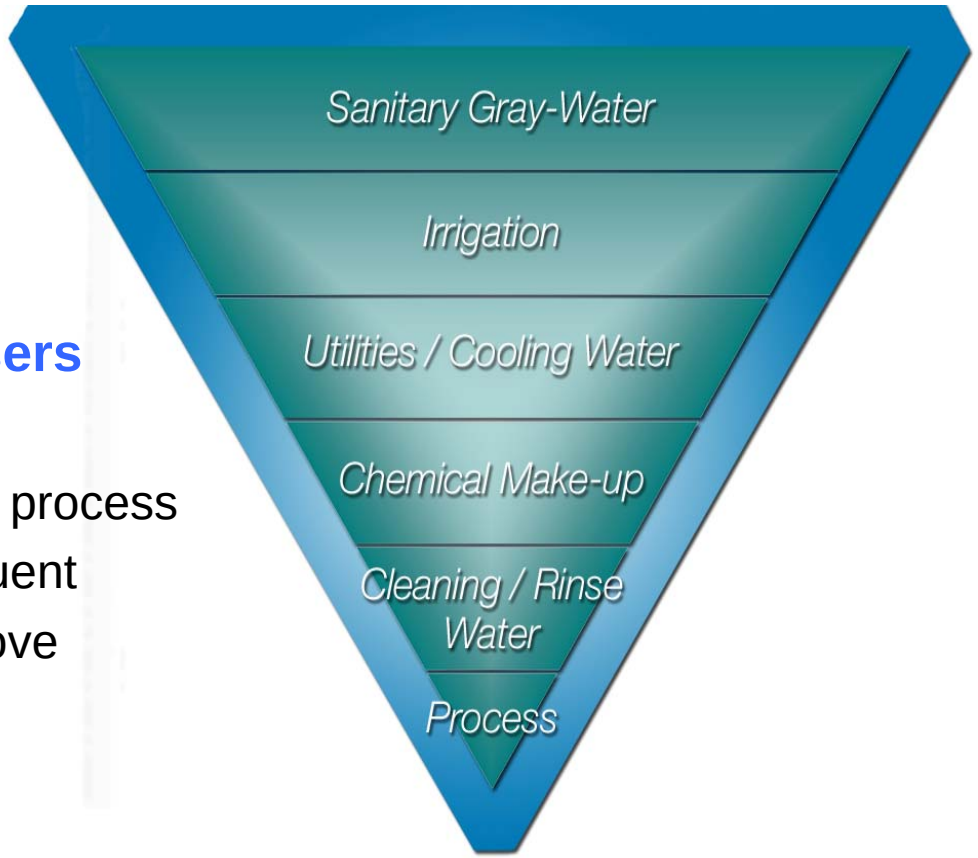
- Form conservation teams
- Select effective leaders
- Develop scorecards
- Complete audits

Key Process Recycle/Reuse Opportunities

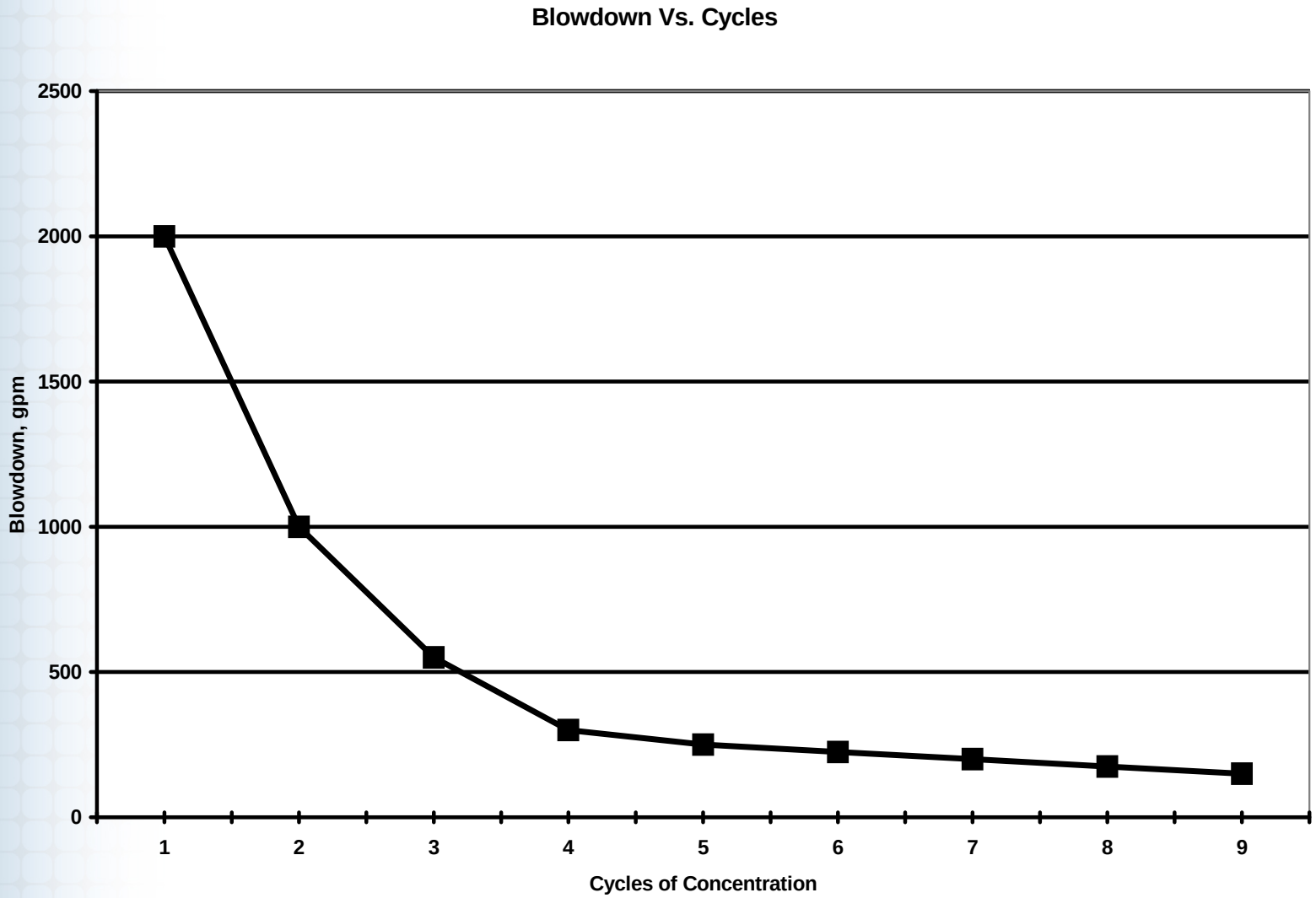
- **Cooling Tower Blowdown**
  - Typically **largest source** of wastewater to be treated
- **Existing RO Reject**
  - Potential **ARROW** opportunity
- **Boiler Make-up/Blowdown**
- **Scrubber Make-up**
- **Once-through Cooling**
- **Process/Sanitary Wastewater Effluent**

Identifying Recycle / Reuse Options

- **Match consumptive users to reuse sources**
  - Reuse water within the process
  - Reuse wastewater effluent
  - Combination of the above



Blowdown Vs. Cycles



Cooling Tower Cycles/Blowdown

- **Water quality and blowdown dependent upon operating cycles.**
  - Higher cycles = Less blowdown/less make-up
  - Lower cycles = Better quality water
  - Balance between water quality and blowdown
  - Cycles limited by water chemistry (Silica, hardness, pH,iron, biological, scaling compounds)
- **Chemicals to prevent scaling,fouling & corrosion**
  - Antiscalant,polymer & corrosion inhibitor dosage rates *based on blowdown rate*
  - Biological control (Chlorination) dosage rate *based on make-up water rate*
- **Typical blowdown range 6 to 8 cycles to maximize savings**
- **Blowdown Treated for TSS (Filtration) and TDS (membrane) removal for process and utility reuse.**

Understanding Water Quality

- **Identify water quality requirements for reuse point(s)**
- **Evaluate water treatment to meet needs**
- **Balance between water quality and user performance**
  - operating cycles
  - blowdown volume
  - scaling/chemical addition
- **Challenge Convention**
  - Historical precedence → "required" is "as received"
  - Consider the Starting-point not the End-point
  - Evaluate and redefine
- **Industry requirements**
  - FDA
  - USDA

Water Quality Parameters

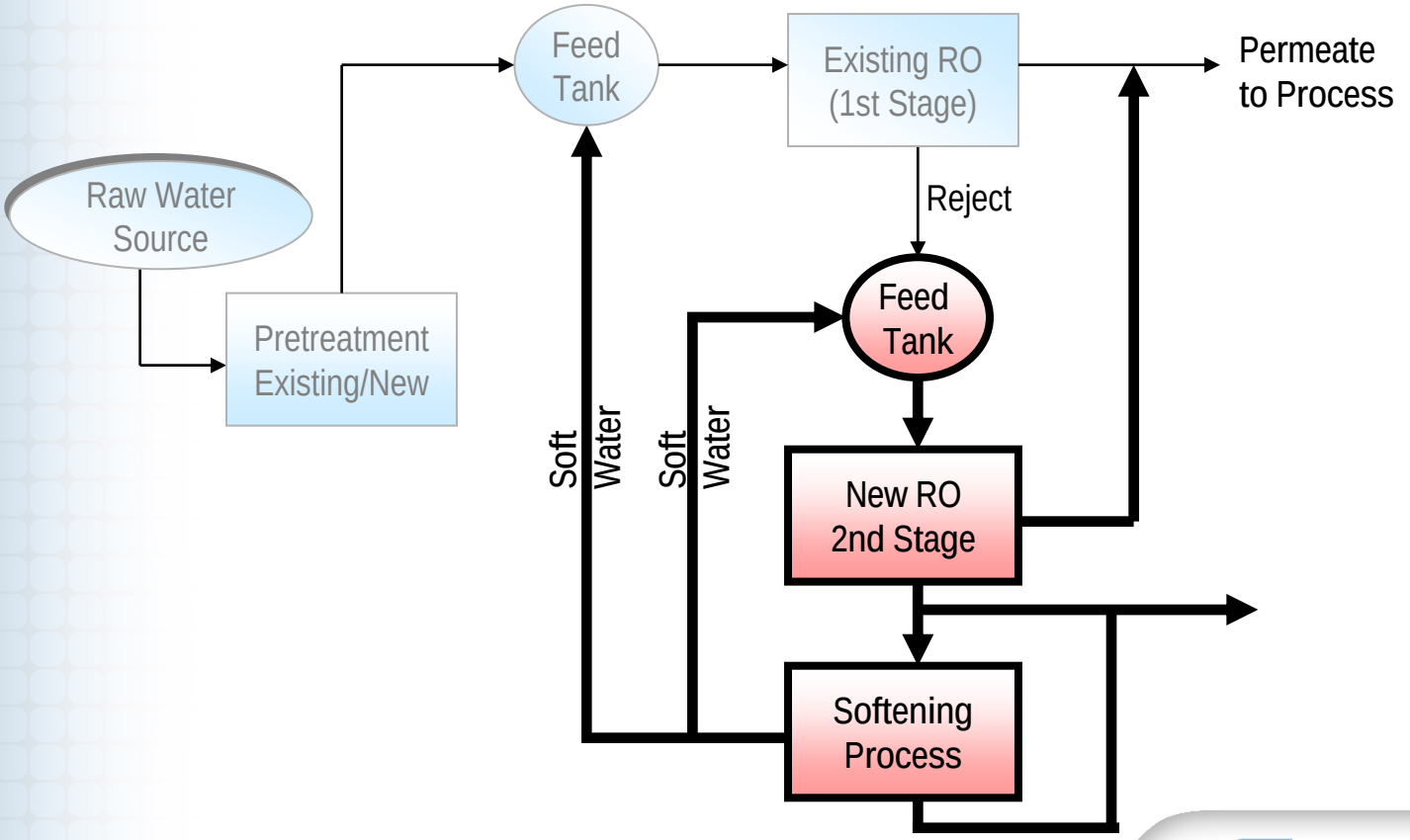
Category	Specifics	Purpose
Physical Data	pH	Alkalinity confirmation, scaling predictions.
	Specific Conductivity	Multiple purposes, overall indicator of TDS
	Turbidity, NTU	Recycle equipment impact
	TSS	Recycle equipment impact
	Oil & Grease	Recycle equipment impact
	Silt Density Index (SDI)	Membrane performance
Major Cations	Ca, Mg, Na, K	Fouling, recovery performance
Major Anions	P-Alk, M-alk, SO_4, Cl, NO_3	Fouling, recovery performance
Other Anion	Total Silica	Scaling prediction
	Filtered, Reactive Silica	Scaling prediction
	PO_4, Total	Scaling and other purposes
Biological	Ammonia, Free	Oxidant demand estimation
	TOC	Multiple purposes, chlorine demand in influent
	BOD_5	Microbe control problem
	COD	Multiple purposes, oxidant demand
Metals	Al, Ar, Ba, B, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, Ag, Sr, Th, Ti, Tn, V, Zn	Multiple purposes, waste character estimates, fouling potential

Treatment & recycle technologies

- **Do nothing → Don't overlook the simple fixes**
- **Physical / Chemical Approach**
  - Chemical Precipitation
  - UV catalyzed hydrogen peroxide reaction
  - Macrofiltration of suspended solids (>1 μM)
- **Direct Membrane Applications**
  - Microfiltration of suspended solids
  - RO to remove dissolved solids (>0.0001 to >0.001 μM)
  - Advanced Reject Recovery (ARROW)
- **Hybrid Membrane Applications**
  - Membrane Biological Reactor (MBR)
  - Combines biological reactor with Micro-filtration

ARROW™

- **Advanced Reject Recovery Of Water**
- Patented application of technologies
- Achieves **>95%** Recovery at reduced operating costs



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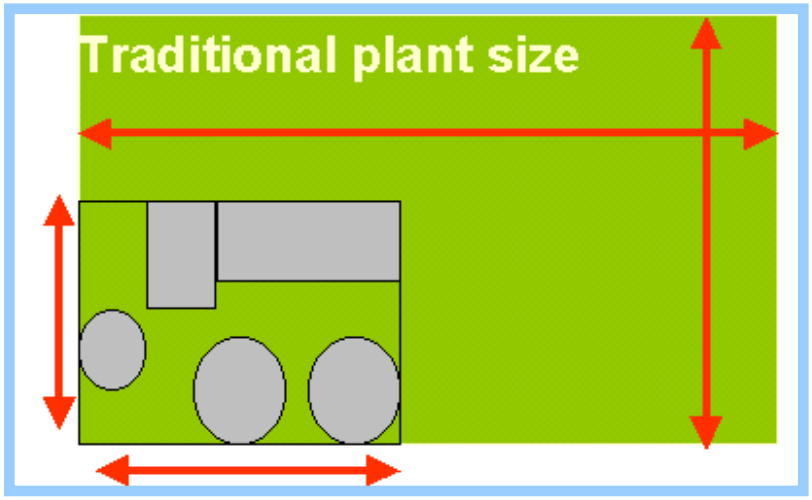
ARROW™ Case History

- **General Industry - New Jersey**
  - Maker of hand soaps - Boiler and Process Water needs
- **Problem**
  - High cost of wastewater discharge costs **($9.78/1,000 gallons)**
  - High cost of municipal water **($7.72/1,000 gallons)**
- **Design data (Bolt-on ARROW system)**
  - Additional Permeate generated: 33 gpm
  - Reject: 7 gpm (reduced discharge by 30 gpm)
  - Total **Recovery Rate: 93%**
- **Equipment - Scope of supply**
  - Bolt-on 2nd Stage RO (45% recovery) with feed/CIP and permeate tank
  - Ion exchange units with Sodium regeneration
  - Chemical feed systems
  - Automated Controls
- **Benefits**
  - Savings of **$178,000/yr** with 2.23 yr payback

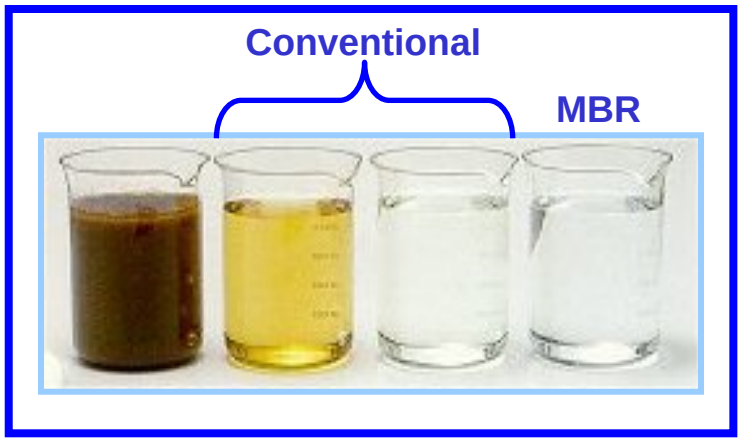
Membrane BioReactor (MBR)

- **MBR** plants are typically **1/3 to 1/4** the size of conventional activated sludge-type treatment plants
- **MBR** produce significantly **less sludge**, operate at high MLSS & long SRT.
- **MBR** technology combines the functions of a **clarifier and filter**



MBR Treatment

- **Reuse Quality Effluent**
  - Effluent BOD, TSS < 1 mg/L
  - Total Phosphorus < 0.03 mg/L
  - Total Nitrogen < 2 mg/L
  - Ammonia < 0.1 mg/L
  - Turbidity < 0.05 NTU
  - Up to 6 log removal of bacteria*
  - Up to 4 log removal of viruses*
- **Resilient** to fluctuations in loading
- Able to handle **high loadings**
- **Resistant to toxic shocks**



Multi-Cycle SBR

- Adaptation of traditional SBR cycles
  - Equalization
  - Anoxic Selector
  - Mixing
  - Aeration
  - Oxidation
  - Settling and Clarification
  - Effluent Decanting

- Multiple cycles more effective for high strength waste

Case Study - Multi-Cycle SBR

Bauru, Brazil food processor
Flow Range 223 - 715 m3/d

Parameter	Influent	Effluent
COD,mg/l	2,500–11,000	100-120
BOD,mg/l	1,500–6,550	25-35
TSS,mg/l	100-560	20-30

Case Study

- **Facility:** NJ Production & Laboratory Research
- **Water Use:** 300,000 gpd

- **Historical reduction efforts**
  - Reduced water consumption 25% over last 7 years
    - Equipment **closed loop** cooling
    - Process **optimization**
    - 225 **low-flow fixtures**

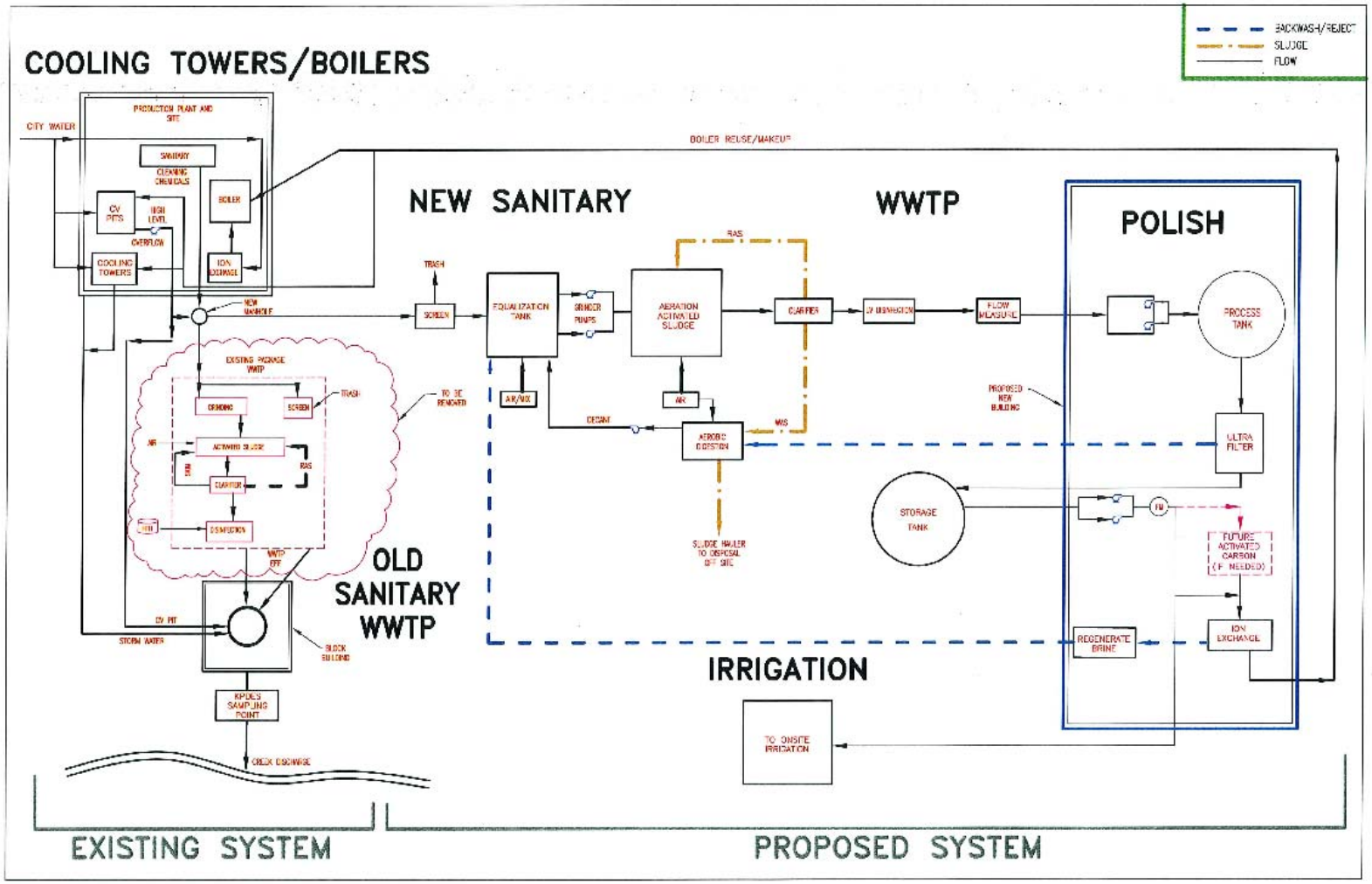
- **New alternatives identified**
  - **Upgrade** high feed water pre-treatment
  - **Reuse** off-spec / backwash from feed water system
  - **Segregate** “medium strength” wastewater for reuse
  - **Increase** cooling tower cycle operation
  - **Capture** air handler condensation for reuse

Case Study

Solutions

- **Reuse wastewater for cooling tower make-up & Replace feed water pretreatment**
  - Saves additional **22 MGY (16%)**
  - Capital: $260 K
  - Annual Operating Savings: $350 K
  - **Payback <1 year**
- **Reuse High Purity Loop reject for utilities make-up & Reuse HVAC condensate for utilities make-up**
  - Saves additional **11 MGY (8%)**
  - Capital: $200 K
  - Annual Operating Savings $55 K
  - **Payback 3.5 years**

Sanitary WW reuse for cooling towers/boilers



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New Priorities