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How to Select Industrial Water Reuse and Energy Management Solutions

AAEE Seminar at the 100th NJWEA Annual Conference

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Outline

- What are the Drivers for Reuse?
- Water Footprint and Water Ratios
- Integrated Approach and Water Balance Tools
- Reuse Considerations and Quality Issues
- Treatment Alternatives
- System Design Issues
- Examples (Pharmaceutical & Beverage)
- Summary

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What are the Drivers?

- Corporations have Sustainability Goals for Water, Energy and Greenhouse Gases
- ISO 26000 – Guidance on Social Responsibility – Public Image
- Business/Production Risks – Disruption from Droughts and Water Quality Concerns
- Water and Energy Cost Reduction
- Production Increase/New Products

Water Footprint for a Product

- The volume of fresh water used to produce the product summed over the various steps in the production chain
  - Green water footprint – rainwater
  - Blue water footprint – surface and groundwater
  - Grey water footprint - wastewater

Reference: Water Footprint Network

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Water Footprint Examples

Product	Water Used	Water Used gal/gal
Apple (One)	18 gal.	--
16 oz. Tea	18.5 gal.	148
Pint of Beer (16 oz.)	40 gal.	320
16 oz. Diet Cola	33 gal.	264
16 oz. Coffee	37 gal.	296
16 oz. Milk	106 gal.	848
16 oz. Wine	63 gal.	504
1 lb. Chicken	467 gal.	--
1 lb. Beef	1,857 gal	--

Reference: Water Footprint Network (Research by Cranfeld University in UK (2011))

Water Use Ratio (in a Facility)

$$WUR = \frac{Total\ Water\ Used}{Total\ Beverage\ Production}$$

WUR has become common expression for water efficiency

Origin:

- Adopted by United Nations Global Compact
- Global Reporting Initiative voluntary, internationally recognized framework for sustainability reporting that provides the opportunity to measure and report our performance in key sustainability areas
- 2006 – Current guidelines launched

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2012 Water Stewardship Benchmarking Results

Product	# of Facilities Surveyed	Water Use Ratio L/L	
		2009	2011
Carbonated Soft Drinks	725	2.23	2.02
Bottled Water	131	1.55	1.47
Brewing	296	4.53	4.00
Distillery	80	38.35	34.55
Winery	27	3.78	4.74

Reference: Beverage Industry Environmental Roundtable (BIER), Christianson, T. (2012)

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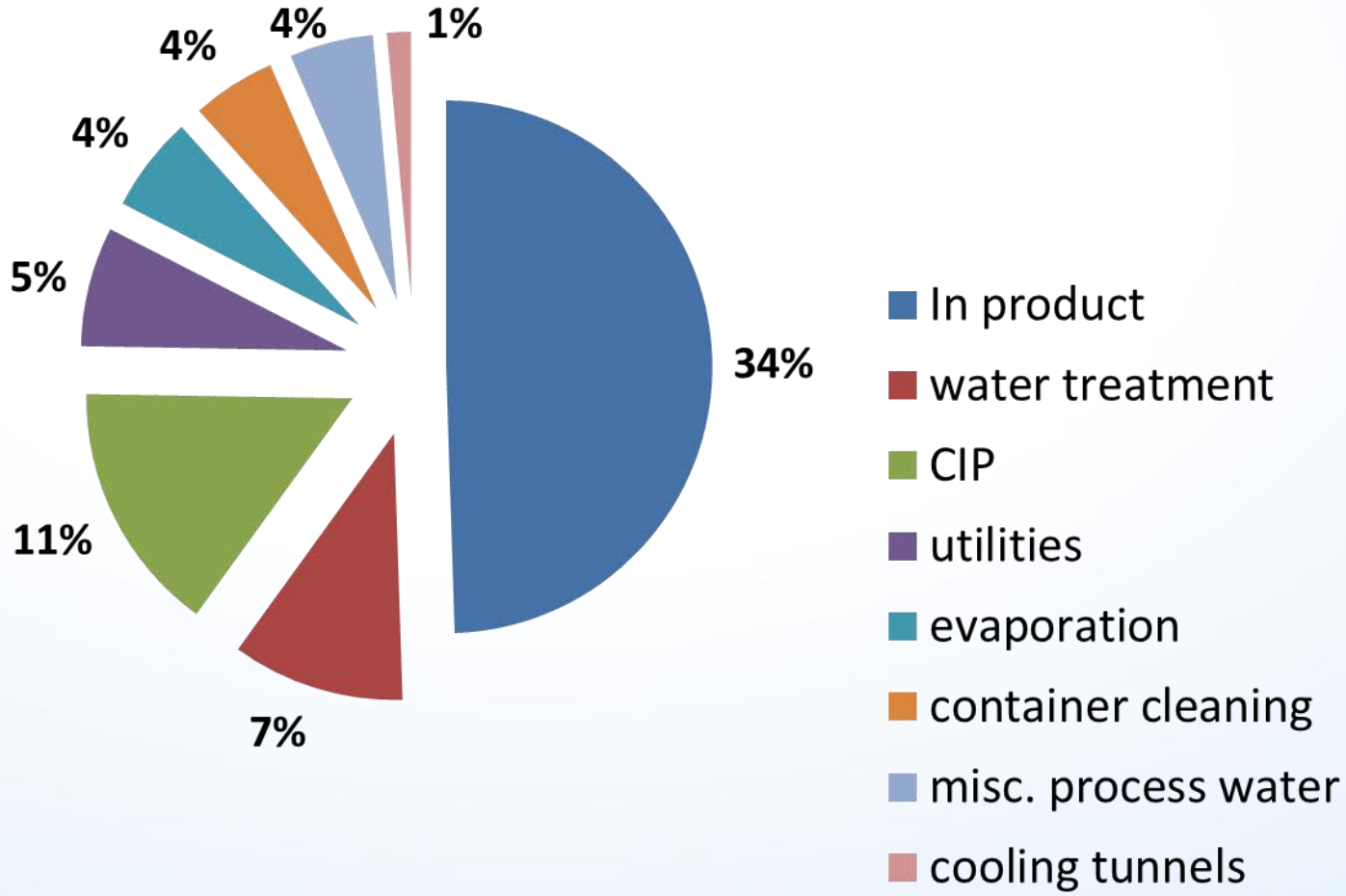
Water Use Breakdown



Reference: Beverage Industry Environmental Roundtable (BIER), Christianson, T. (2012)

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Water Footprint and Water Use Ratio
Coca-Cola Example

- 83 billion gallons water used at 900 bottling plants worldwide – equivalent to double the City of Chicago
- Water use ratio at plants average about 2.4 gallons used per gallon of product
- Water footprint is 70 gallons per gallon of product with most of this water needed to grow the sugar
- Goal is 20 % reduction in water ratio from 2004 to 2012 – they are on target now
- What is next generation of technologies ?

Source: Paul Bowen of Coca-Cola – NJWEA Industrial Seminar (2011)

Comparison Pharmaceutical & Food & Beverage

Similarities

- Drivers
- Regulatory (e.g., EPA, FDA)
- Contact or use of treated water with product is not acceptable
- Water users in facility (e.g., utilities)

Differences

- Active Pharmaceutical Ingredients (APIs) Concerns
- More solvents used in pharmaceutical industry
- High strength wastewaters for energy recovery in food and beverage – more use of anaerobic digestion

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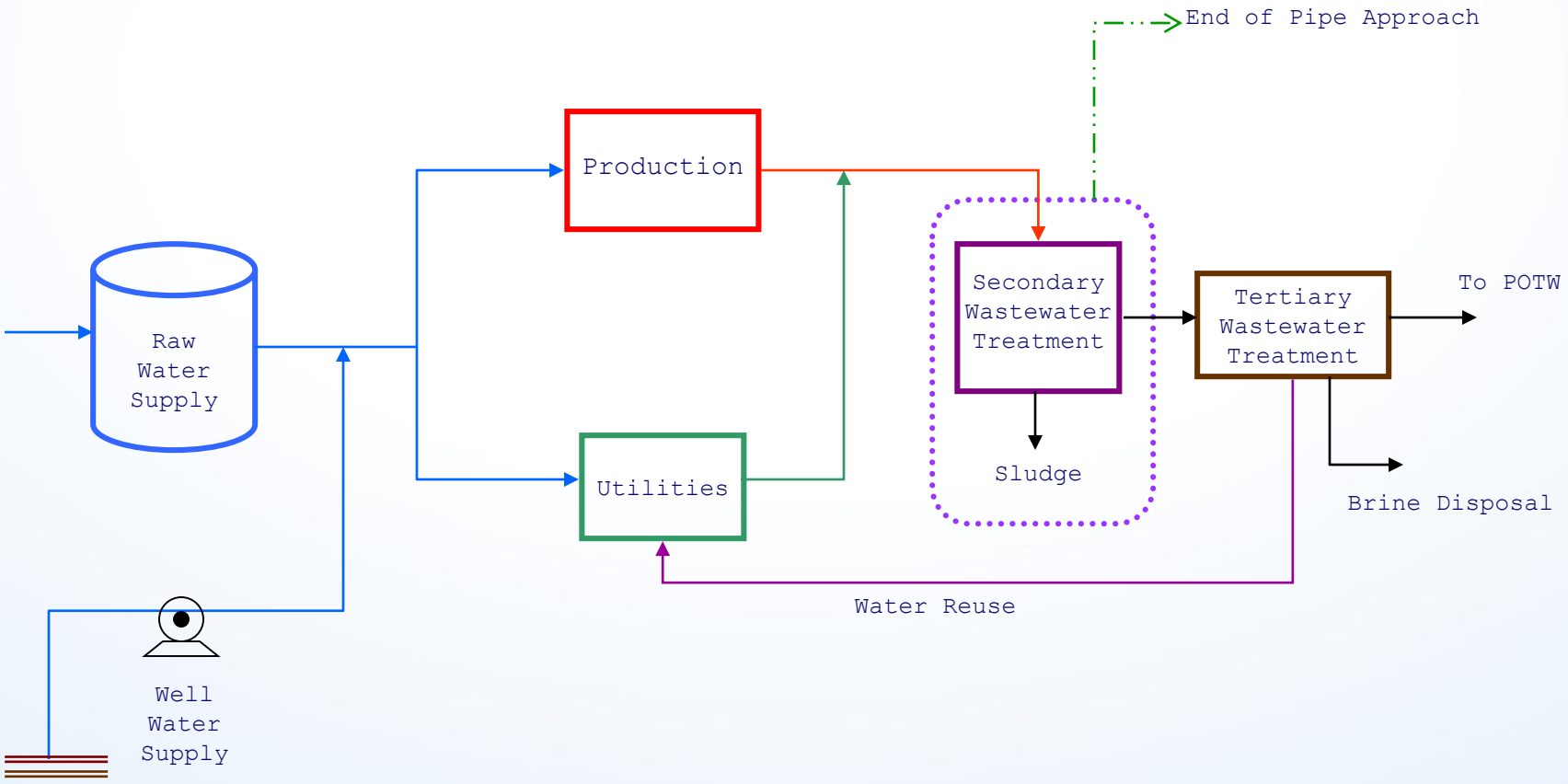
Use An Integrated or Holistic Approach at a Facility



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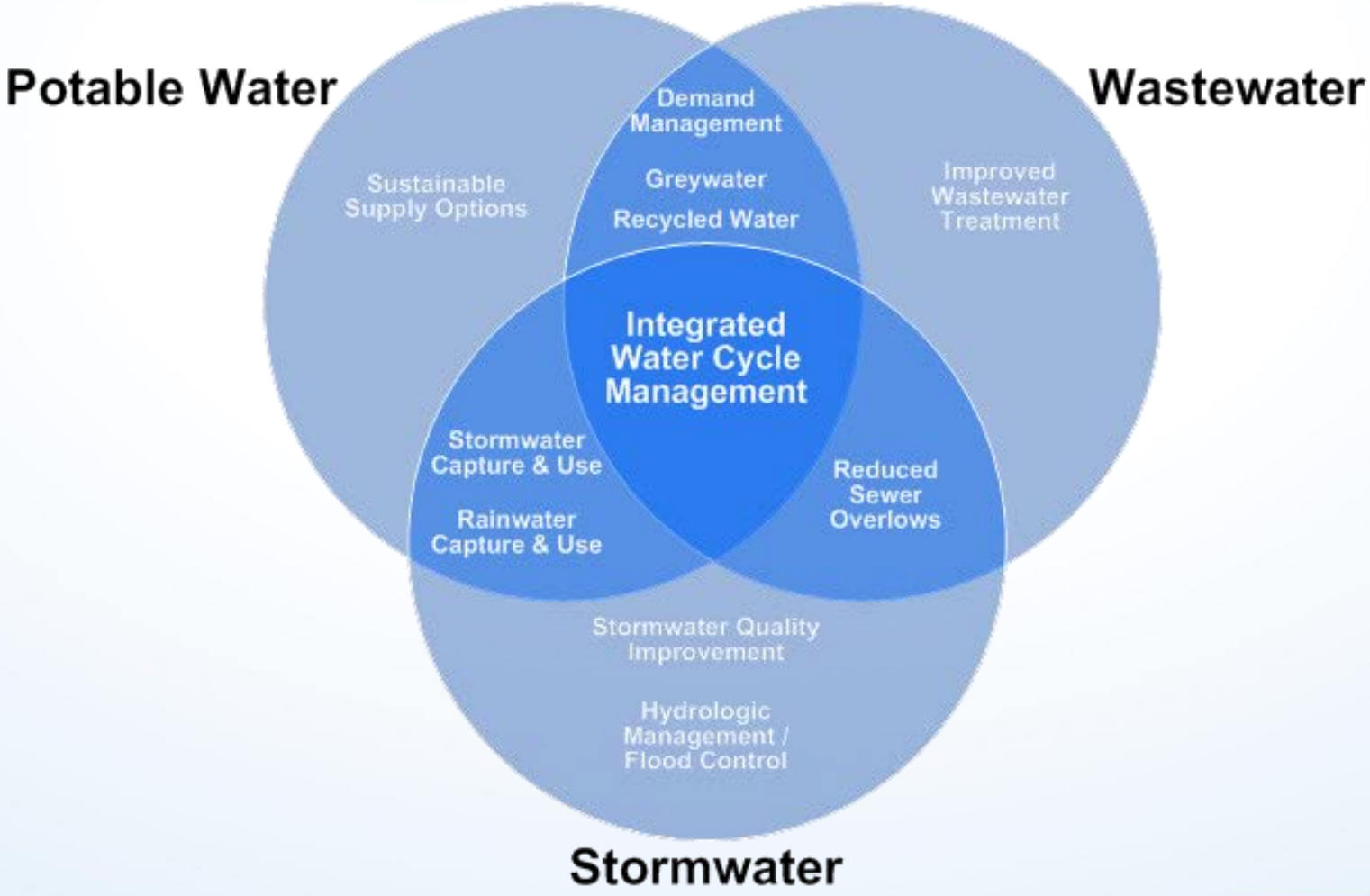
Use An Integrated Approach to Water Treatment & Reuse



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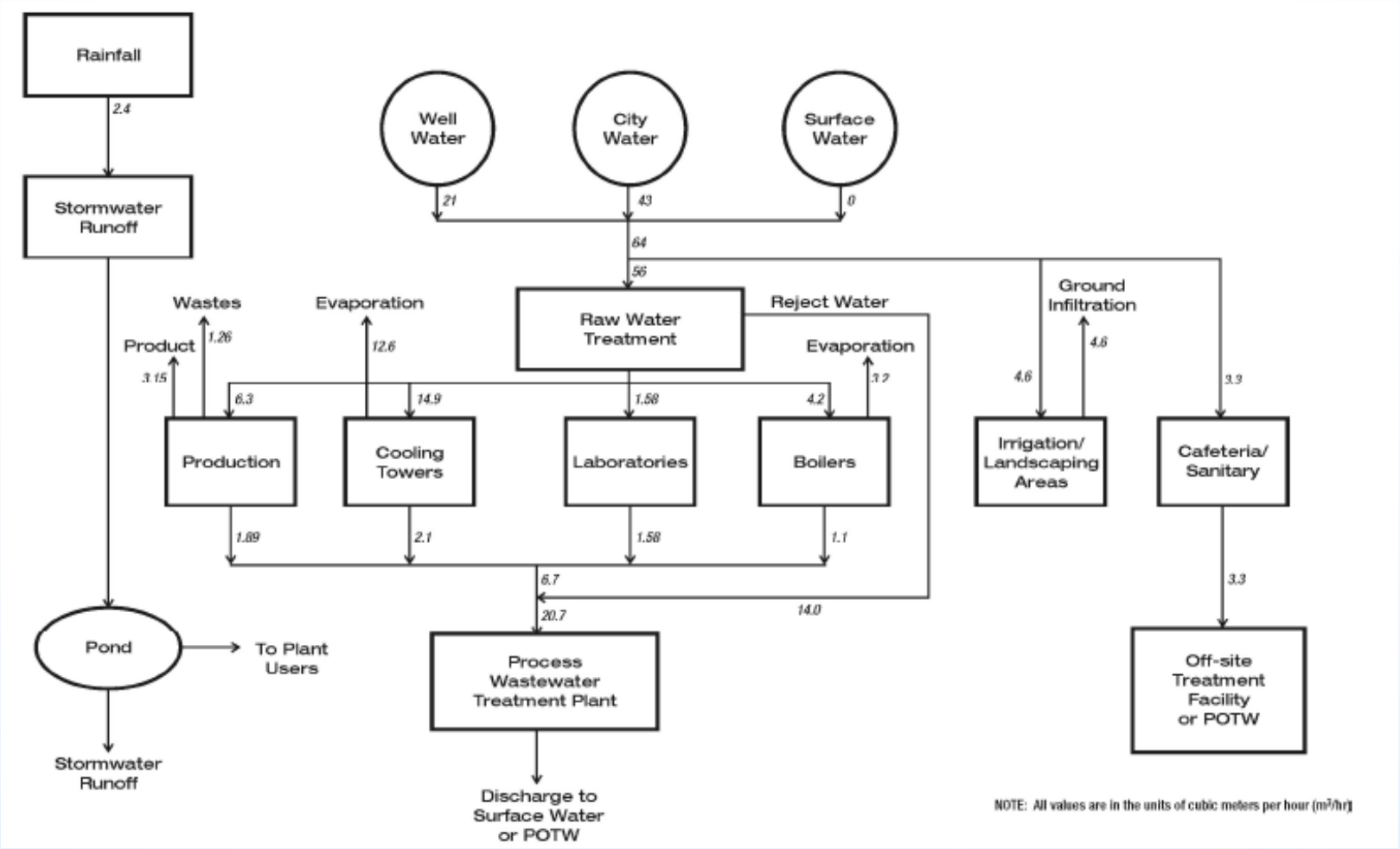
Use Collaborative Team Approach

- Mobilize a Team – include those closest to the problems
- Include production, water utilities, wastewater operators, EHS compliance etc.
- Outside consultant to facilitate and bring broad background at other facilities
- Management and team commitment
- Frequent communications and training

Develop "Representative" Water Balance Diagram



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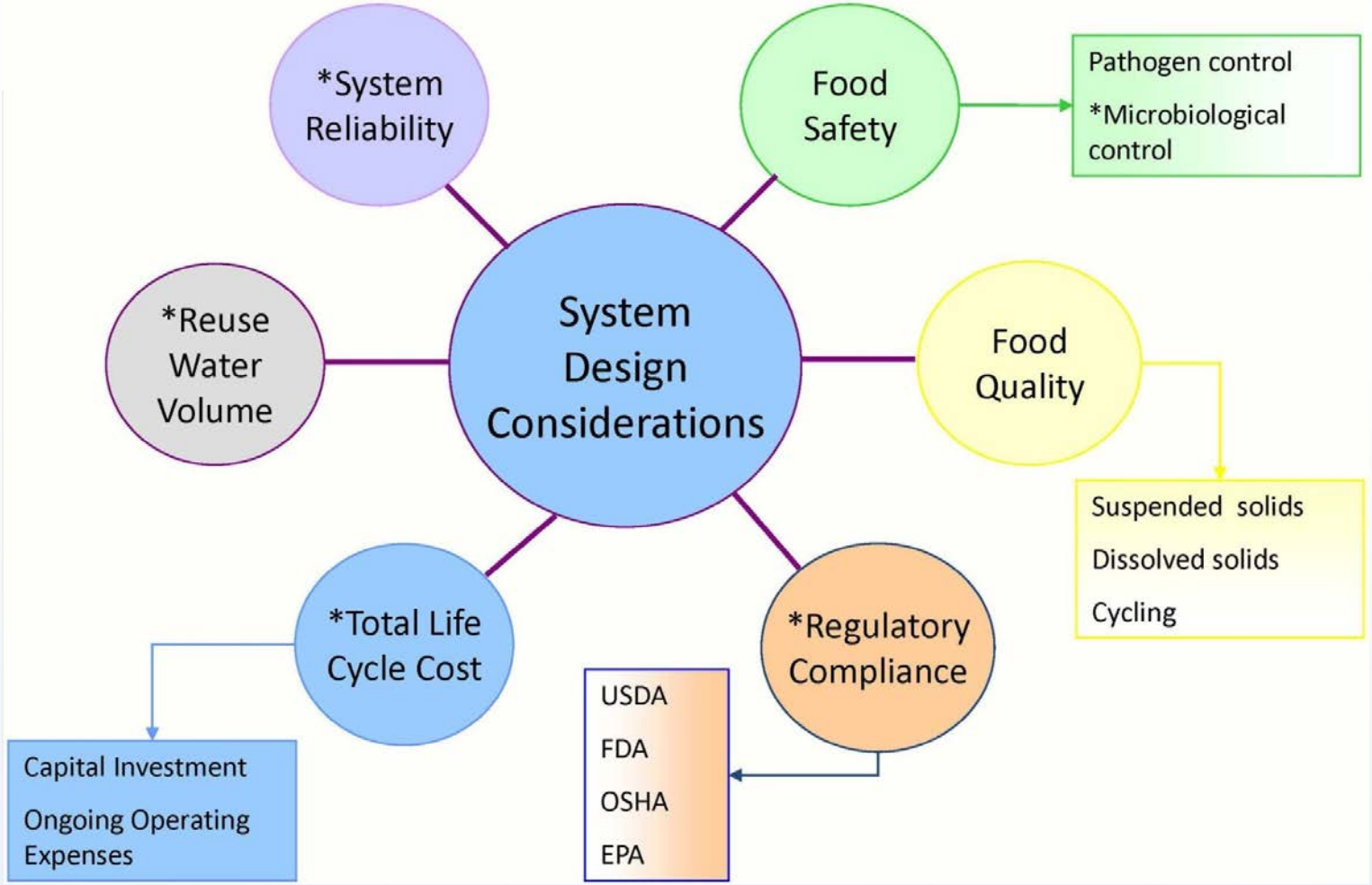
Reuse System Considerations



Reference: U.S. Water Services – Gary Engstrom (September 2013)

Key Target Water Users at Plants

- **Pharmaceutical & Food & Beverage**
- **Cooling Towers**
- **Scrubbers for Air Pollution Control**
- **Chillers, Boilers and HVAC (Air Handling Condensates)**
- **Lawn Sprinklers/Irrigation**
- **Cleaning Water for Clean-in-Place Systems, etc. (e.g., tanks, bottle washing)**
- **Cafeteria**
- **Washrooms and showers**
- **Other Water Users – Laboratories etc.**

- **Food**
- **Fluming or transport (e.g., tomatoes & beans)**
- **Pork (e.g., spraying & cooling of livestock, scalding tubs & washing of animals)**

Reuse Water Considerations

- Fouling – Heat Transfer Loss, Plugging
  - Iron (Fe)
  - Silica
  - Organics
  - Dirt, Dust, TSS
  - Extracellular Polysaccharides (EPS)

- Microbiological – Fouling
  - Potential Pathogens (LP)
  - Nutrients – NH_3, P
  - TOC/BOD – Food

Reuse Water Considerations

- **Scale – Heat Transfer Loss, Plugging**
  - Calcium (Ca)
  - Magnesium (Mg)
  - Barium (Ba)
  - Strontium (Sr)
  - Carbonate ($CO_3^{=}$)
  - Phosphate (PO_4^{-3})
  - Sulfate ($SO_4^{=}$)
  - Silicate ($SiO_2^{=}$)

- **Corrosion – Equipment Life (Metallurgy)**
  - Total Hardness (Ca, Mg)
  - Manganese (Mn) – Mild & Stainless Steel
  - M-Alkalinity
  - Fouling
  - pH
  - Chloride (Cl^-) – Stainless Steel
  - Ammonia (NH_3) – Copper (Cu), Admiralty Brass

Treatment Alternatives

- Flow Equalization
- pH Control
- Screening
- Oil and Grease (D.A.F.)
- Primary Clarification
- Anaerobic Treatment
- Activated Sludge and MBRs
- UF and RO
- UV Disinfection

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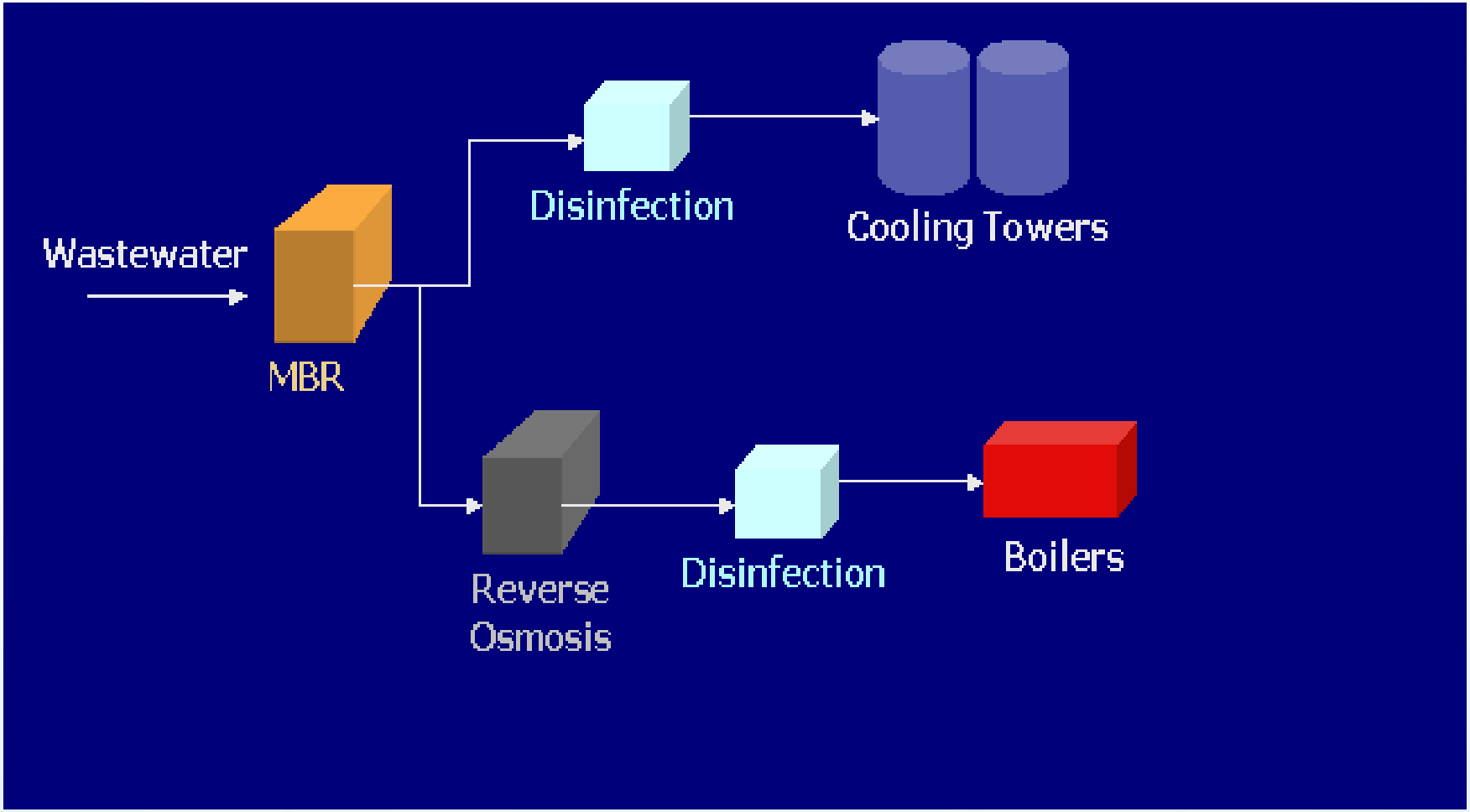
Non-Potable Reuse: Industrial Reuse



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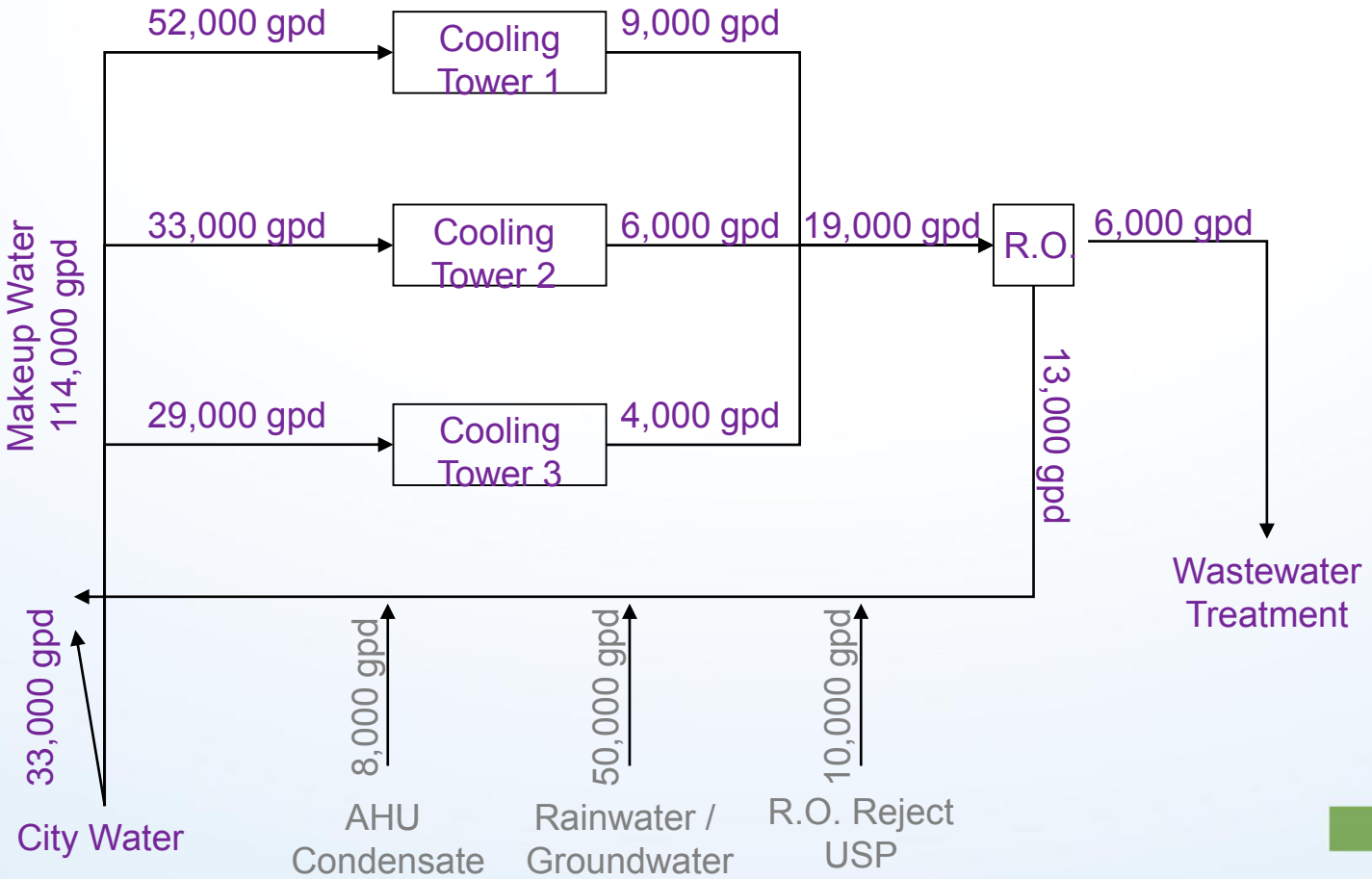
Pharmaceutical Plant Rainwater Harvesting

60% Reduction in City Water Use
Business Risk Driver on Water Supply Available



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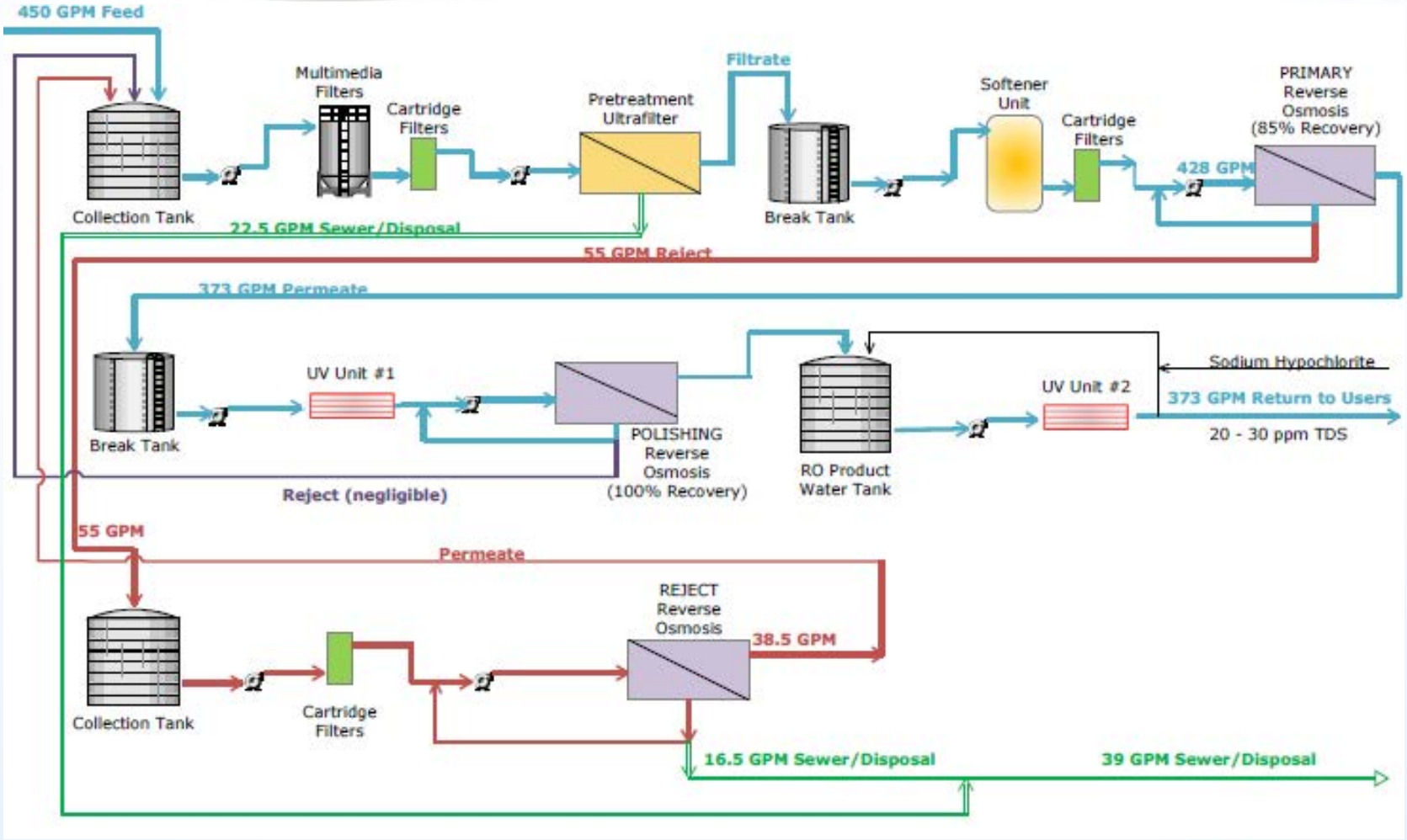
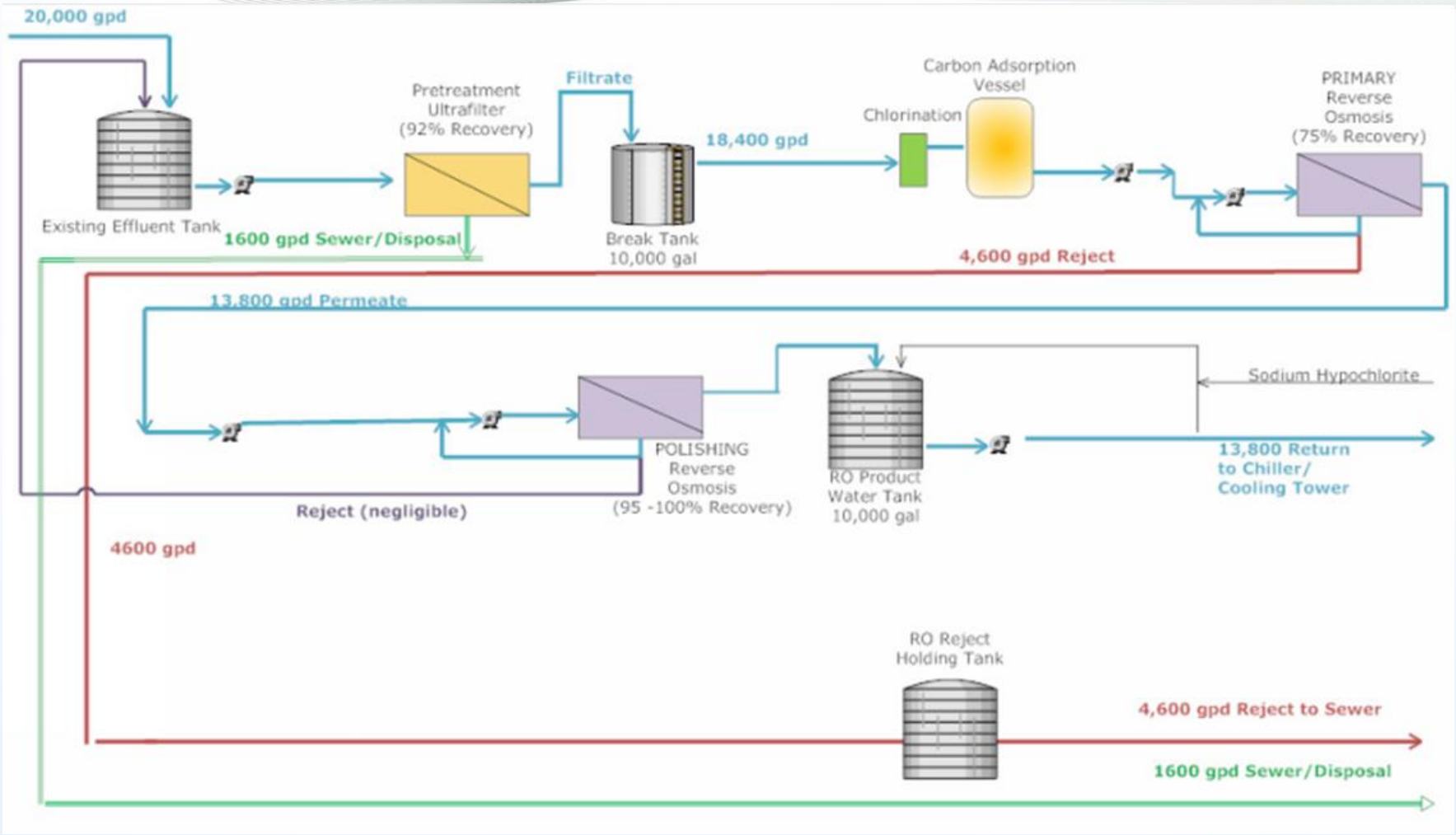
Beverage Plant Water Reuse Zero Liquid Discharge (ZLD)



Pharmaceutical – Recommended System – Membrane Filtration (MF or UF) + RO



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Pharmaceutical Plant Recycle/Reuse Treatment System-Required Effluent Concentrations

Parameter	Unit	Evapco/Carrier Water Quality Guidelines	Required Makeup Water Quality (at CoC=3) with safety factor = 20%
pH	su	7 - 9	**7 - 9**
TSS	mg/L	< 25	**6.7**
Conductivity	umhos/cm	< 4,000	**1067**
Alkalinity as $CaCO_3$	mg/L	< 350	**93**
Chlorides	mg/L	< 500	**133**
Silica	mg/L	< 150	**40**
Total Bacteria	cfu/ml	< 10,000	**2667**
Iron Oxides	mg/L	< 1.0	**0.27**
Ammonia	mg/L	< 0.5	**0.13**

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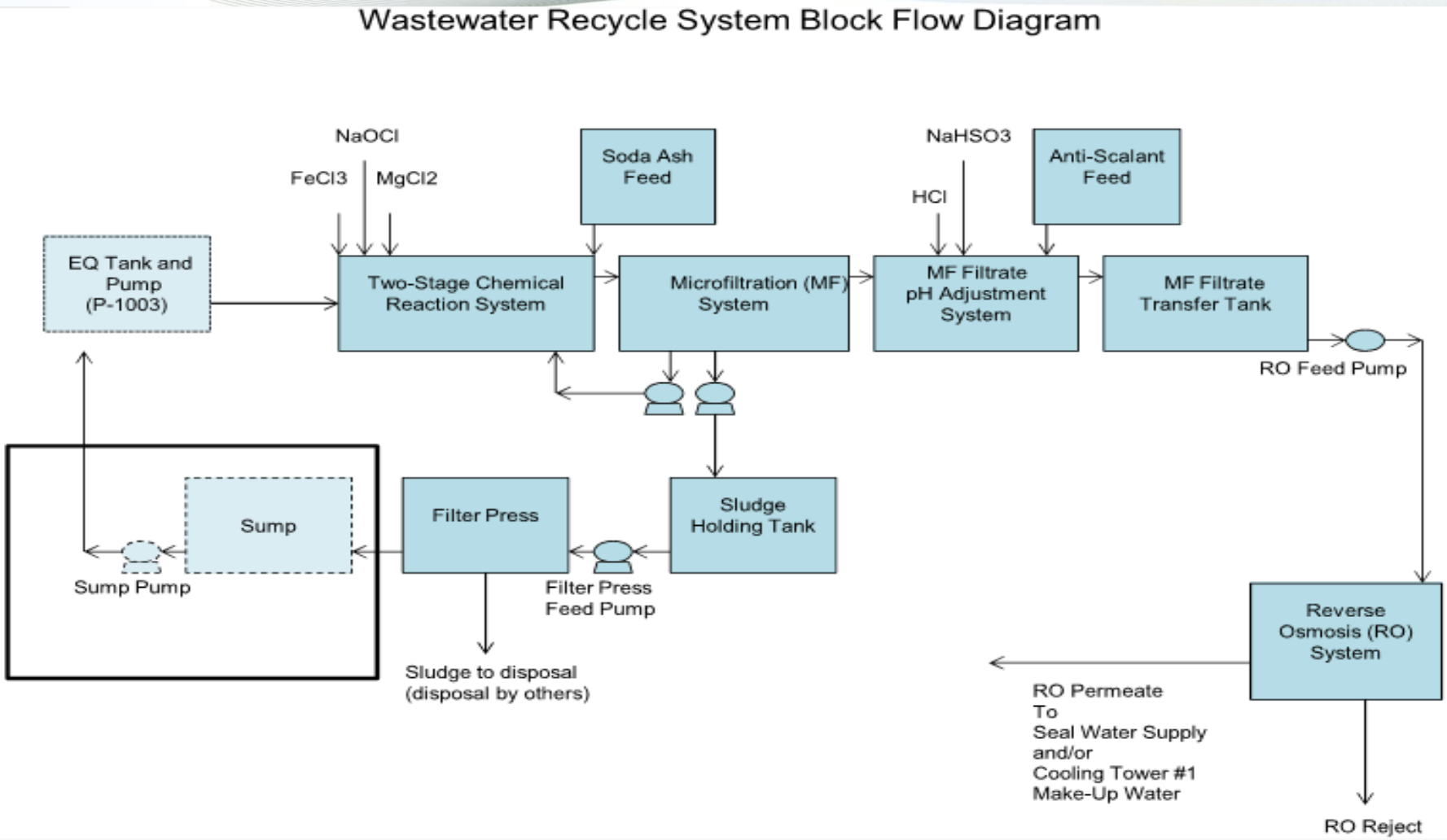
Pharmaceutical – Comparison of Costs (20,000 gpd system)

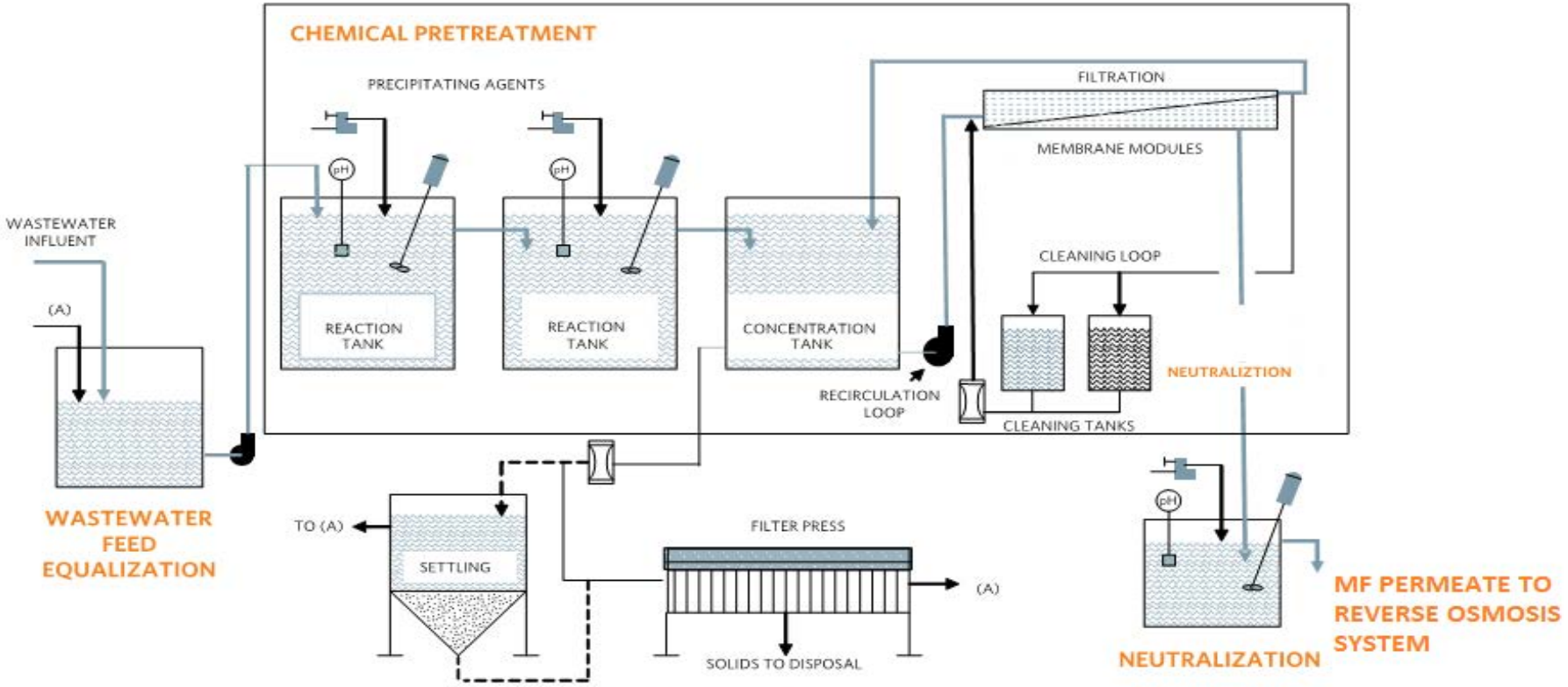
Alternative	Description	Total Capital ($ Millions)	Total Annual O&M ($ Millions)	Total Present Worth[1] ($ Millions)
1	UF/MF + RO (Two-Pass)	1.33	0.23	2.95
2	Disk + Cartridge Filters + RO	0.95	0.12	1.82
3	Filtration/Softening	0.39	0.23	2.01

[1] Based on 7%, 10 years

Distillery - Non-Process Control Strategies



Distillery - Non-Process Control Strategies



NPWW Reuse Treatment System

Alternative 1b - EQ + Chemical Pretreatment + MF + RO + UV (Divert MF Peremeate to Seal Water System, RO only for CT Make-Up Water)

Reuse System Influent*	
86,000	gpd
59	mg/L TSS
1,517	mmhos
0.5	mg/L Phosphate
0.6	mg/L Ammonia
76	mg/L silica, as SiO2
332	mg/L Chloride
1.7	Iron, as Fe
8	SU (pH)

% Removal**	MF PERMEATE	
99.5%	85,570	gpd
99.0%	1	mg/L TSS
5%	1,442	mmhos
5%	0.48	mg/L Phosphate
5%	0.60	mg/L Ammonia
99%	1.14	mg/L silica, as SiO2
5%	315	mg/L Chloride
99%	0.02	Iron, as Fe
-	8	SU (pH)

% Removal**	RO PERMEATE	
75%	15,428	gpd
75%	0.15	mg/L TSS
75%	360.4	mmhos
75%	0.12	mg/L Phosphate
75%	0.15	mg/L Ammonia
75%	0.28	mg/L silica, as SiO2
75%	79	mg/L Chloride
75%	0.00425	Iron, as Fe
-	8	SU (pH)

MF Chemicals
RO Cleaning

MF Permeate Chemicals
HCl
NaHSO3
Anti-Scalant

RO Chemicals
RO CIP

Chemicals (RXN System)
FeCl3
NaOCl
MgCl2
Soda Ash

Equalization Tank

Chemical Reaction System

Microfilter (MF)

MF Permeate

Reverse Osmosis (RO)

RO Permeate 15428 gpd

REJECT 5,143

65000

SLUDGE	
430	gpd
11,632	mg/L TSS
16,616	mmhos
5.5	mg/L Phosphate
6.97	mg/L Ammonia
14,914	mg/L silica
3,635	mg/L Chloride
337	Iron, as Fe
-	SU (pH)

Seal Water Reuse Tank

RO REJECT	
5,143	gpd
9.3	mg/L TSS
22907	mmhos
7.55	mg/L Phosphate
9.61	mg/L Ammonia
18	mg/L silica, as SiO2
5012	mg/L Chloride
0.27012603	Iron, as Fe
-	SU (pH)

UV

Water Reuse Tank

REUSE

Reject Holding Tank

OFF-SITE 5,143

Sludge Press

FILTRATE RETURN TO EQ

Roll-off

DRY CAKE

OFF-SITE

** COD/BOD Removed Prior to UF/RO (< 5 ppm)*

** O&G Removed Prior to UF (< 2 ppm), prior to RO (<0.2 ppm)*

** Silica Softening Prior to UF/RO (< 1 ppm)*

** Chlorine for Iron Oxidation prior to RO (Iron < 0.4 ppm)*

*** Estimated removals - pilot testing required to confirm removals*

Pork Manufacturing Plant Water Reuse

- 3.5 MGD water usage – 33 % reused for non-potable uses including: livestock spraying/cooling, inedible rendering, utilities, carcass washing, scald tubs and cooling water
- Approval for water reuse – USDA, EPA and FDA
- Reconditioned process water criteria was established: pH, turbidity, fecal coliform, total coliform, total plate count, chlorine residual and TOC
- Process wastewater plant – activated sludge
- Advanced or reconditioned water plant – conventional water treatment processes including UV disinfection

Summary

- Use the Integrated and Collaborative Team Approach
- Serious droughts in CA, AZ, Texas and Georgia and are not going away
- Corporations benefit from social, economic and environmental (triple bottom line) evaluations
- Industries have different issues but similar water reuse approaches and technologies
- Technologies are proven and available – the Time is Now!

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Questions?