Reuse of Alternative Water Sources for Cooling Tower Systems—Two Case Studies Using Non-Traditional Water Sources

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Operational Priorities and Challenges for Cooling Tower Systems

- Water supply
- Water quality
- Discharge options
- Air permitting contraints
- Energy supply
- Energy Efficiency
- Performance
- Reliability

Resource Recovery Priorities

- Conserve limited fresh water supplies
- Avert discharge that contaminates fresh water
- Increase recovery and utilization of waste water or grey water sources
- <u>Cost feasible</u> technology to enable expanded use of recovered waste water
- <u>Cost feasible</u> use of impaired or alternative water sources
- Avoid bad tradeoffs that consume other limited resources to recover water (energy-water nexus)

Water-Energy Nexus

- 47% of US water used in producing energy
- Then we consume energy to manage water …
  - Purify and transport water
  - Supply water to cooling towers
  - More water to replace wasted tower water
  - Treatment of the wasted water

Cooling Tower Water-Wastage Nexus

- 410 billion gallons of water consumed daily
- 80% used for irrigation and power generation
- Power plants use the most in their towers
- Then supply over 400,000 cooling towers in US
- That typically waste 20-40% of the water
- **“Cooling towers – a herd of fresh water wasting 800 pound gorillas that we have ignored”**

How Natural Chemistry Works

- The major surface water minerals are Ca, Mg, Na, Cl, SO4, alkalinity and silica
- HES softening replaces hardness with high solubility sodium salts that do not form scale
- Evaporation of tower water saturates silica, TDS salts and alkalinity that cause silica to form silicates
- The silicates are outstanding corrosion inhibitors, and do not form scale or deposits

Case Study: Southeast Air Separation Unit

- Facility Description
  - 250 ton liquid oxygen/nitrogen plant with a single cooling tower system for air/nitrogen compressor cooling and bearing oil cooling.
  - Site is ZLD, requiring the reprocessing of source water and cooling tower filter backwash water. Regenerate waste collected and hauled off-site. System volume roughly 150,000 gallons
  - Make-up water is extracted from a swamp located next to the facility, with the following water characteristics:

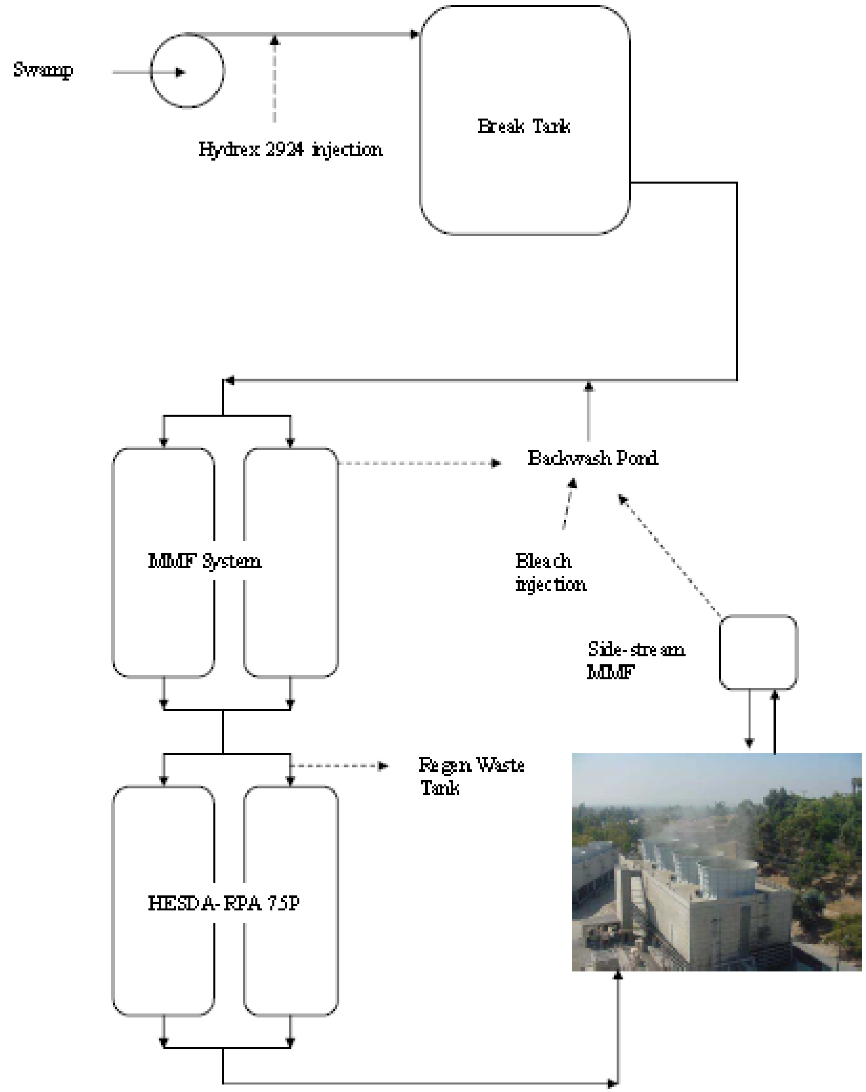
Parameter:	Range:
pH	7.4 – 8.5 s.u.
M- alkalinity	30 – 200 ppm
Silica	1.3 – 9.8 ppm as SiO_2
Chlorides	30 – 100 ppm
Total Hardness	40 – 150 ppm
Total Dissolved Solids	70 – 440 ppm

Case Study: Southeast Air Separation Unit

- Treatment Options
  - Acid, Biocides, Scale/Corrosion inhibitors including make-up water and side-stream softening. Haul off brine waste
  - Reverse osmosis with clarification or filtration pretreatment on make-up water with evaporation/crystallizer for waste streams or haul off
  - ZLB technology with filtration as pretreatment with waste haul-off or small evaporator/crystallizer system
  - ***Option chosen needed to be plug-and-play with minimal capital investment***

Case Study: Southeast Air Separation Unit

Cooling Tower & Swamp



Case Study: Southeast Air Separation Unit

- Approximate water savings of **3,000 GPD**.
- Current water chemistry for the recirculating cooling system:

Parameter	ZLB Operating Range	Expected Traditional Operating Range
TDS	50,000 – 80,000 ppm	< 3,000 ppm
Total Hardness	< 30 ppm	Up to 1,200 ppm w/ acid
pH	≈ 10.0 s.u.	7.0 – 7.5 (stabilized PO4 w/ acid) 8.7 s.u. alkaline
Silica	> 400 ppm	< 150 ppm
Cycles of Concentration	> 300	3 – 8
Corrosion Rates	Mild Steel: 0.50 to 1.50 mpy Copper: 0.01 – 0.10 mpy	2.0 – 5.0 mpy 0.10 – 0.60 mpy
Chlorides	> 5,000 ppm	< 500 ppm

Case Study: Northeast Pharmaceutical Plant

- Facility Description
  - Pharmaceutical R&D facility and data center
  - Three separate cooling tower systems (2 HVAC, 1 data center); 7,600 tons of installed mechanical refrigeration capacity
  - Make-up water a combination of well water, city water, and industrial wastewater
- Challenges for site:
  - Limitations of well water extraction from water table (local township authority)
  - Elevated costs for city water make-up (new pipeline had to be installed)
  - Limitations on both quality and quantity of water to NPDES discharge point (no connection to municipal sanitation system)
  - Industrial WW comprised of cooling tower and boiler blowdown streams, acidic and caustic lab waste, pharmaceutical compounds

Case Study: Northeast Pharmaceutical Plant

- Previous Treatment Program and Issues
  - 4 to 5 cycles of concentration with biocides and scale/corrosion inhibitor addition
  - Significant scaling and fouling issues in tower fill, piping, and heat transfer surfaces
  - Traditional water treatment option placed constraints on plant's ability to handle high-water demand situations
- Zero Liquid Blowdown Implementation
  - Installation of high efficiency softening system to process all make-up water sources through a common system
  - Softened make-up water distributed to three systems
  - Design allowed for flexibility when going between water sources
  - Adjustments made only to HES system (throughput settings), simplifying water chemistry

Case Study: Northeast Pharmaceutical Plant

- Results
  - Projected water savings of **3.6 million** gallons per year
  - Ability to switch seamlessly between water sources without significant O&M involvement (HES system throughput settings)
  - Significant clean up of mineral scale/foulants from cooling tower fill, piping and heat transfer surfaces (6 month transition period)
  - Provides buffer capacity in WWT system to discharge water at leisure versus detention and discharge
- High Level Impact
  - Success at this site allows client to implement strategy across several sites across the country
  - Flexibility in source water make-up options (Industrial WW, storm water, HVAC condensate, grey water, well water)
  - Will help meet client’s 5% per year, 5-year fresh water reduction strategy

Case Study: West Coast University Chiller Plant

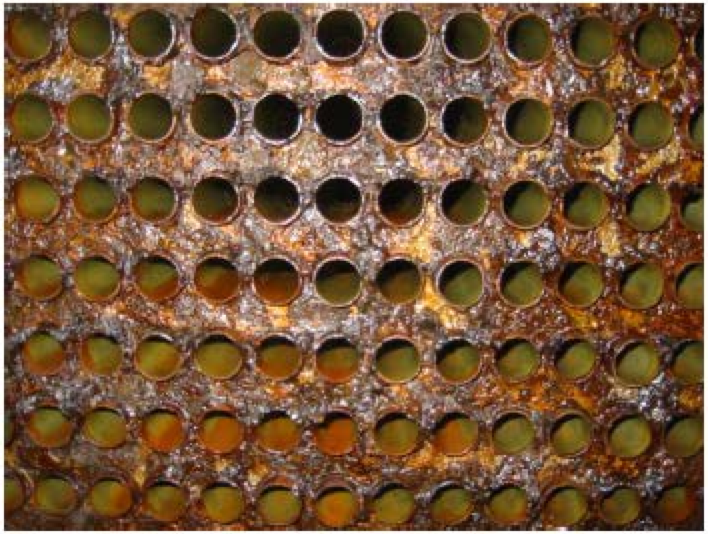
- Facility Description
  - Centralized chiller plant with two, 1,250-ton absorption chillers
  - Previous water source was city water, with variable water quality
  - Issues included: tube sheet degradation, heat transfer surface fouling, and concrete sump deterioration
  - Water treatment program included the use of acid, oxidizing biocides and corrosion/scale inhibitors

Case Study: West Coast University Chiller Plant

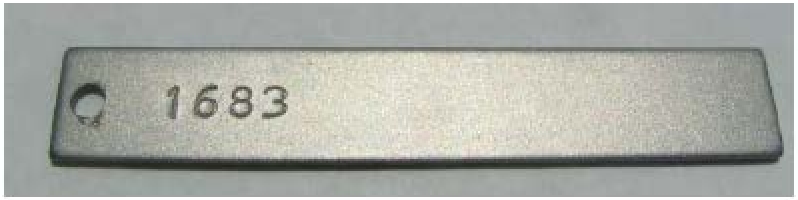
- An alternative program was selected that provided the following benefits:
  - Switch from city water to municipal wastewater
  - An increase in cycles of concentration from 3 to 5 to over **100 COC**
  - A significant improvement in waterside conditions, including mild steel corrosion control, an elimination of heat transfer mineral scale, and a reduction in concrete degradation
- Water Quality & Challenges
  - 800 to 1,500 TDS
  - 30-50 ammonia

Case Study: West Coast University Chiller Plant

Concrete Tower Basin



Prior Absorber Corrosion



Current Steel Corrosion Rates < 0.1 MPY

Case Study: West Coast University Chiller Plant

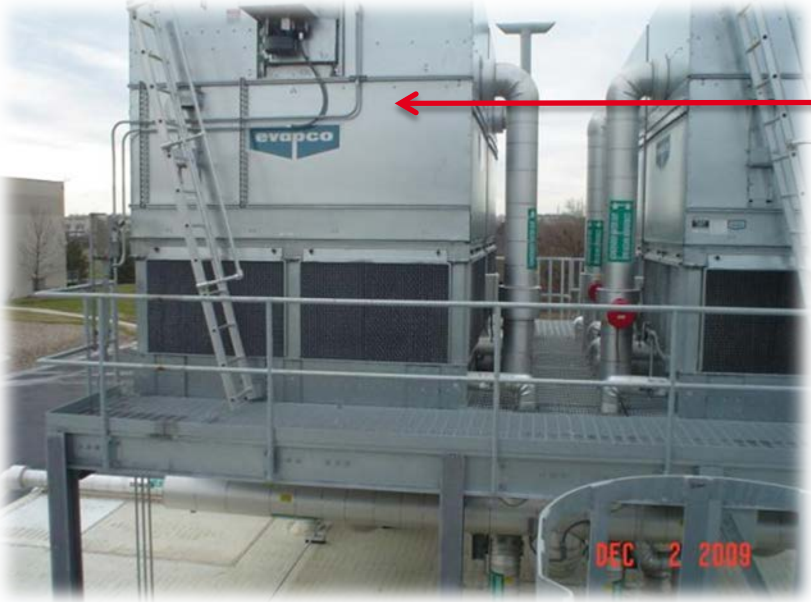
Tons Tower Capacity	Peak Flow GPM	Installed $ Cost Estimate	MGY Water Saved *	$ /yr Water Cost Saved*	ROI Months
250	7	6000	1.2	7200	**10**
500	13	12000	2.4	14000	**10**
1000	25	18000	4.8	28800	**8**
1500	38	24000	7.8	46800	**6**
2000	50	30000	10	61200	**6**
3000	75	35000	15	90000	**5**
4000	100	50000	20	122400	**5**
5000	125	60000	24	144000	**5**
10000	250	175000**	49	288000	**7**
20000	500	300000**	99	576000	**6**

*60% of design average load ** Includes bulk salt handling system

Case Study: Midwest Mission Critical Data Center

- Facility Description
  - This is a mission critical data center, requiring 100% uptime
  - Three centrifugal chillers, each approximately 600 tons for a combined capacity of 1800 tons
  - Source water is onsite well water, with the following water characteristics:

Parameter:	Range:
pH	**8.2 – 8.5 s.u.**
M- alkalinity	**250 - 350 ppm**
Silica	**25 – 30 ppm as SiO_2**
Iron	**<0.1 ppm**
Total Hardness	**350 – 400 ppm**



Cooling Towers

Chillers

High Efficiency Softening System

Case Study: Midwest Mission Critical Data Center

- Current water chemistry for the recirculating cooling system:

Parameter	ZLB Operating Range	Expected Traditional Operating Range
TDS	80,000 ppm	< 2,000 ppm
Total Hardness	< 20 ppm	Up to 1,200 ppm w/ acid
pH	≈ 10.0 s.u.	7.0 – 7.5 (stabilized PO4 w/ acid) 8.7 s.u. alkaline
Silica	> 400 ppm	< 150 ppm
Cycles of Concentration	> 200	2.5 – 4.0
Corrosion Rates	Mild Steel < 0.04 mpy	0.5 – 5.0 mpy
Corrosion Rates	Copper < 0.01 mpy	0.1 – 0.5 mpy

Case Study: Midwest Mission Critical Data Center

- Satisfied Client
- All of the program goals have been met or exceeded
- Cooling tower treatment program is 100% chemical free with the exception of sodium chloride salt
- This client will be mandating ZLB technology at all data centers
- Approximately **4.5 million gallons** per year of water reduction

Opportunities

- There are significant opportunities for water use or reuse from a variety of alternative sources for cooling towers:
  - Rainwater, condensate from HVAC systems, municipal wastewater, storm water, reverse osmosis reject, boiler blowdown, etc.
- … Using available commercial technologies that are:
  - Easy to operate
  - Maximizing water conservation
  - Energy responsible
  - Cost feasible
- … And that
  - Minimize risk from a safety and asset standpoint
  - Positively impact water and carbon footprints

Thank You!

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