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Water Resources Management in the US Southwest

**“Green” Chemistry Uses Natural Water Minerals to
Treat Cooling Towers, Reduce Water Use and
Eliminate Toxic Discharge to Support
Water Resources Management**

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Presentation Outline

- Water Sustainability & Cooling Towers
- New Corrosion & Scale Control Chemistry
- Fresh Water Case History
- Recycled Water Case History
- Power & Industrial ZLD
- WRM – New Opportunities
- WRM Incentives / Regional Support

Water Sustainability

- Fresh water supply is diminishing for nature, irrigation, population, industry
- Discharge of organics / toxicants into ecological resources must be eliminated
- Limited water supply, discharge regulations, and cost will restrict use

Why Cooling Towers?

- They consume second largest quantity (~5%) of fresh water use, following irrigation
- Their primary purpose is to reduce water use
- They evaporate pure water to biosphere
- They concentrate minerals in source water, typically discharging 20-40% of water to sewer
- They discharge organic chemicals and biocides used to control scale, corrosion and bio growth

Tower Blowdown is Required with Limitations of Chemical Treatment

<u><i>Limit</i></u>	<u><i>Impact</i></u>	<u><i>Control Mechanisms</i></u>
1. Ca/Mg	Scale	<u>Blowdown</u> / Inhibitor / Acid
2. Silica	Deposits	<u>Blowdown</u> / Inhibitor
3. TDS	Corrosion	<u>Blowdown</u> / Inhibitor
4. pH	Corrosion & Scale	<u>Blowdown</u> / Acid

Cooling Tower Chemicals Discharged with Blowdown & Drift

- 70 million pounds annual discharge of non-oxidizing organic biocides in US
- Most also use halogen biocides, source of AOX (absorbable organic halogens)
- Even greater quantities of organic scale and corrosion inhibitors discharged

What If

- You could replace 20 to 40% of the fuel in your vehicle tank with water ...
- get the same gas mileage ...
- and eliminate toxic exhaust emissions!

Cooling Towers .. can use .. Natural Water Chemistry process to ...

- Evaporate over 98% of water used
- Reduce water use by 20-40% (*9-24,000 GPD per 1000 tons cooling load*)
- Use recycled water rather than fresh water
- Save energy used to treat and pump water
- Eliminate biocide and inhibitor discharge
- Mitigate scale, corrosion or bio fouling

New Corrosion & Scale Control Chemistry

Four US Patents; # 6,929,749;
6,949,193; # 6,998,092; # 7,122,148
Further US & Foreign Patents Pending

How The Chemistry Works

- Low solubility ions (Ca/Mg) removed from water
- Remaining TDS in water are very soluble
- Scale limitations eliminated (< 100,000 TDS)
- Soluble silica polymerizes at > 200 mg/L
- Polymerized silica protects metals from TDS
- Excess silica forms non-scaling colloids
- High TDS/pH prohibits bio & pathogen growth

Natural Water Chemistry

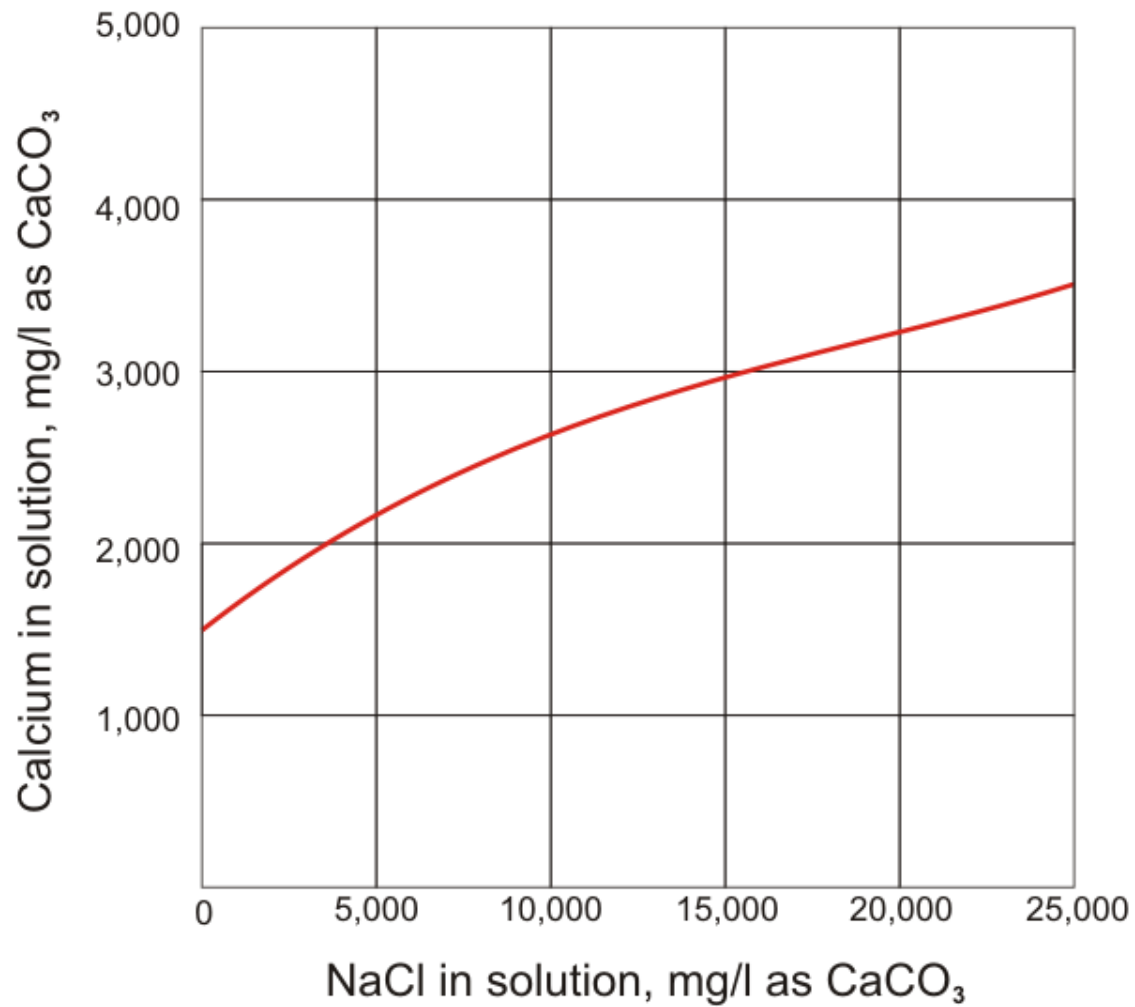
- The major surface water minerals are Ca, Mg, Na, Cl, SO_4 , carbonate alkalinity and silica
- Ion exchange of Ca & Mg with Na eliminates low solubility salts that scale
- Evaporation of water saturates silica, TDS, and alkalinity (pH) which catalyze polymerization of silica to form amorphous silicates or colloids
- Natural Zeolite exchange and silica colloids occur in nature (geothermal process)

Highly Soluble Sodium Salts Eliminate Scale Limitations

(Solubility of Ion pairs as sodium salts @ 30° C)

- Sodium Chloride (36% ~ 360,000 mg/L)
 - Sodium Carbonate (16% ~ 160,000 mg/L)
 - Sodium Sulfate (48% ~ 480,000 mg/L)
 - Sodium Ortho-Phosphate (26% ~ 260,000 mg/L)
- Non-common ion effect also increases solubility
(increased calcium solubility in seawater)

Calcium sulfate (gypsum) solubility increases with increasing sodium chloride.



Corrosion Control

- Outstanding corrosion protection for mild steel, copper, aluminum, stainless, galvanized metals
- New standard for mild steel; less than 0.1 mpy versus 1-5 mpy for traditional chemical treatment
- Performance vetted by independent corrosion evaluation studies (Dr. Lietai Yang, Corr Instruments, NACE papers 07626 & 88372)

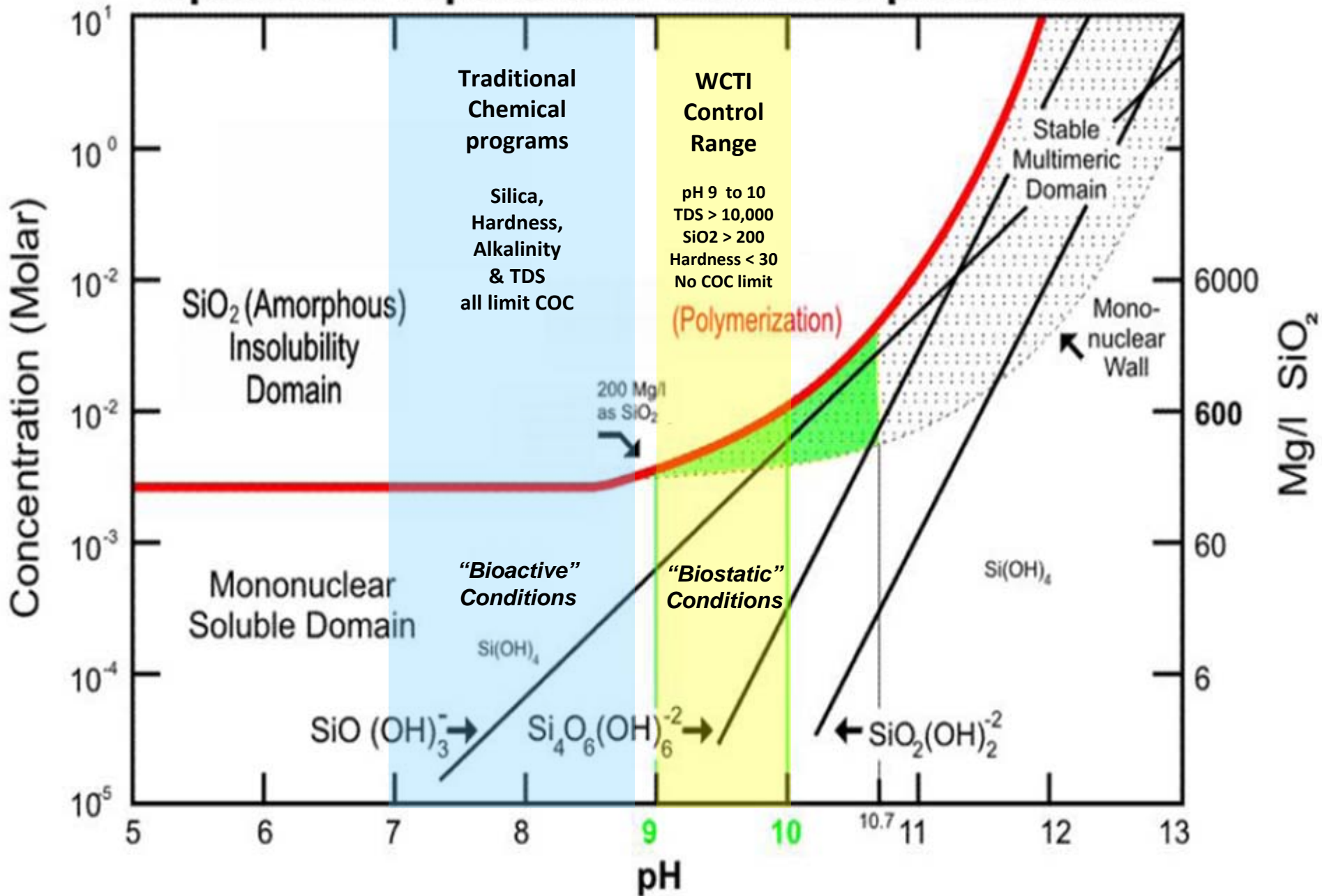
Natural Biostatic Chemistry

- Elevated pH and TDS are naturally biostatic to bacteria, spores and viruses
- Hydrolysis of peptide chains occurs as water pH is increased (used in wastewater treatment)
- Proteins & enzymes also denatured by high TDS
- Natural pH/TDS increase as water is evaporated and concentrated by reduced tower blowdown
- Report by Anderson Engineering (water-cti.com)

HES Softening Economy

- Low regenerate use / high efficiency softening (HES) design @ 4# / CF resin
- Exceeds California efficiency standard of 4000 grains hardness removal per pound of salt.
- Typical salt usage cost of \$0.12 per 1000 gallons vs \$2.00-5.00 water & discharge cost
- Cooling tower discharge is reduced from 20-40% to 1-2% of total evaporative use

Species In Equilibrium with Amorphous Silica



Water Resource Management Case History – Fresh Water

California Steel Mill

Steel Mill Tower ZLD Water Chemistry

Cooling Tower and Soft Makeup Water Chemistry (COC) Ratios				
Sample / Tests	Tower	Filtered Tower Sample	Soft MU	COC
TDS , mg/L (NaCl Myron L 6P)	146,000	146,000	251	582
pH	10.07	10.07	7.58	
Copper, mg/L Cu	0.7	0.25	0.0015	
Iron, mg/L Fe	22.2	ND	ND	
Zinc, mg/L Zn	3.8	ND	ND	
Silica , mg/L SiO ₂	1,050	1,050	30	35
Calcium, mg/L CaCO ₃	62	12.4	<0.1	
Magnesium, mg/L CaCO ₃	16	8.2	<0.1	
Phosphate , mg/L PO ₄	89	-	0.15	593
Nitrate, mg/L NO ₃	2590	2590	4.5	575
Sodium, mg/L Na	145,000	145,000	250	580
Sulfate, mg/L SO ₄	10,260	10,260	18	570
Chloride , mg/L NaCl	22,400	22,400	38	589
Tot. Alkalinity, mg/L CaCO ₃	69,400	69,400	120	578
(COC) = Concentration of Chemistry				

Steel Mill Tower #1 (24 months ZLD) Galvanized Tube Bundle / No White Rust



**Steel Mill Tower
Galvanized Coated Steel Coupon
60 Day Exposure**



Mild Steel Coupons 60 Day Exposure VS Non-exposed

0.017 mpy #1652 VS 0.013 mpy #1664 (control)



Water Resource Management Case History – Recycled Water

Honda Motors HQ

High Ammonia Content Recycled Water

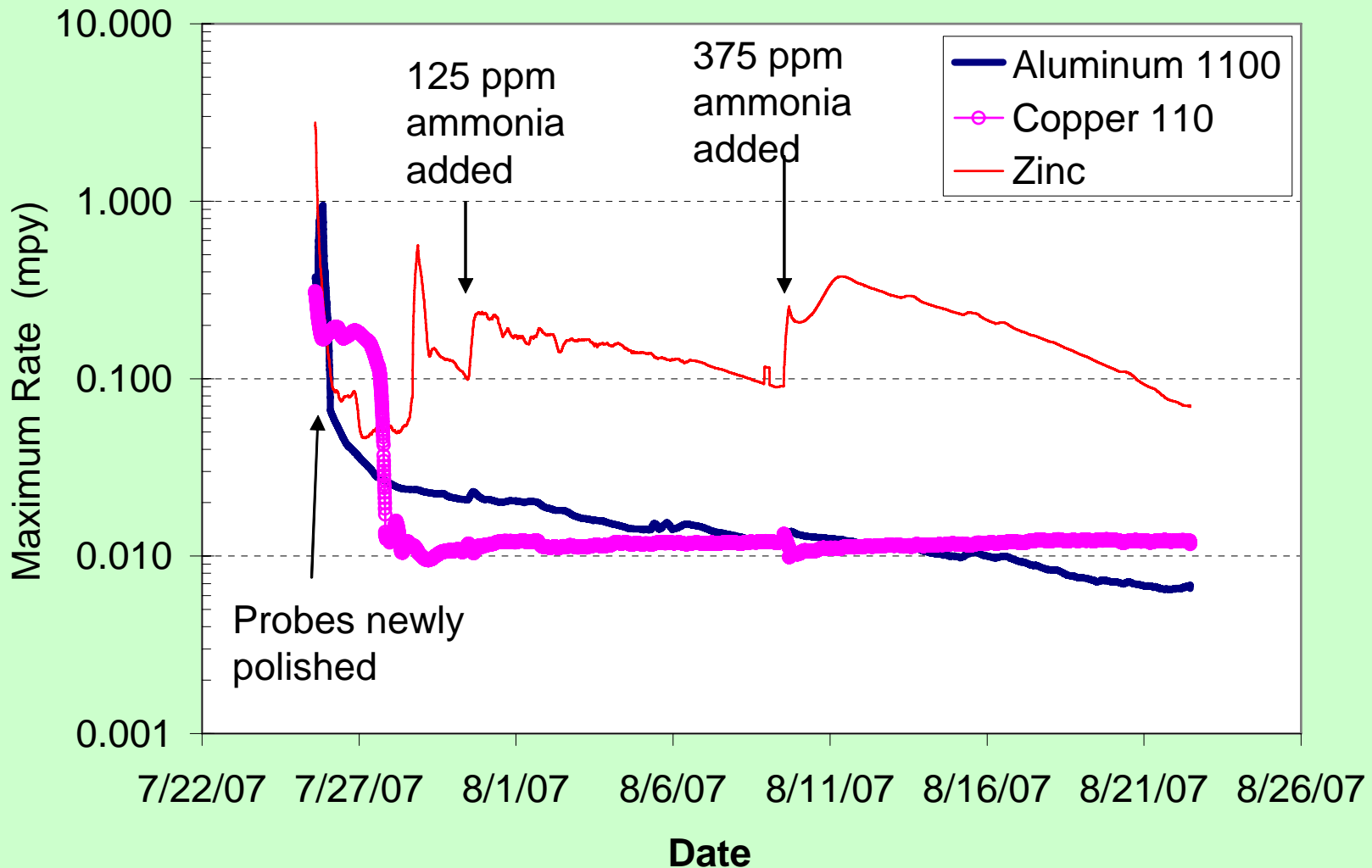
- Municipal “recycled” use in central plant with 2500 tons capacity - copper condenser tubes
- Ammonia = 38 mg/L
- TDS = 730 mg/L
- Total hardness = 224 mg/L
- Total Phosphate = 0.9 mg/L

ZLD Cooling Tower

(California Title 22) Recycled Makeup

ZBD Tower / Soft Reuse Makeup COC Ratios (concentrations of chemistry)			
Sample / Tests (01/04/08)	Tower	Soft MU	COC
TDS, mg/L (NaCl Myron L 6P)	66,000	1100	60
pH	9.85	7.3	NA
Silica, mg/L SiO ₂	530	20	27
Calcium, mg/L CaCO ₃	18	0.2	NA
Magnesium, mg/L CaCO ₃	13	0.1	NA
Sulfate, mg/L SO ₄	7700	128	60
Chloride, mg/L NaCl	12500	212	59
Tot. Alkalinity, mg/L CaCO ₃	15000	257	58
Ammonia, mg/L NH ₄	0.5	38	NA
Total Phosphate, mg/L PO ₄	52	0.9	58
TTA, mg/L as Tolytriazole	5	NA	NA
(COC) = Concentration of Chemistry			

ZBD / Silica treated Tower Water, with TTA Supplement: Ammonia Corrosion of Copper, Zinc & Aluminum Inhibited



Treatment Results

- Ammonia < 1 mg/L at 60 COC tower water
- Copper corrosion rate at < 0.05 mpy
- Mild steel corrosion rate < 0.2 mpy
- Micro-biological growth from ammonia and organics mitigated (10^0 Col / ml)
- No scale, fouling or efficiency losses
- Annual chemical cost (\$80,000) eliminated
- Blowdown water use savings (\$32,000)

Power / Industrial ZLD

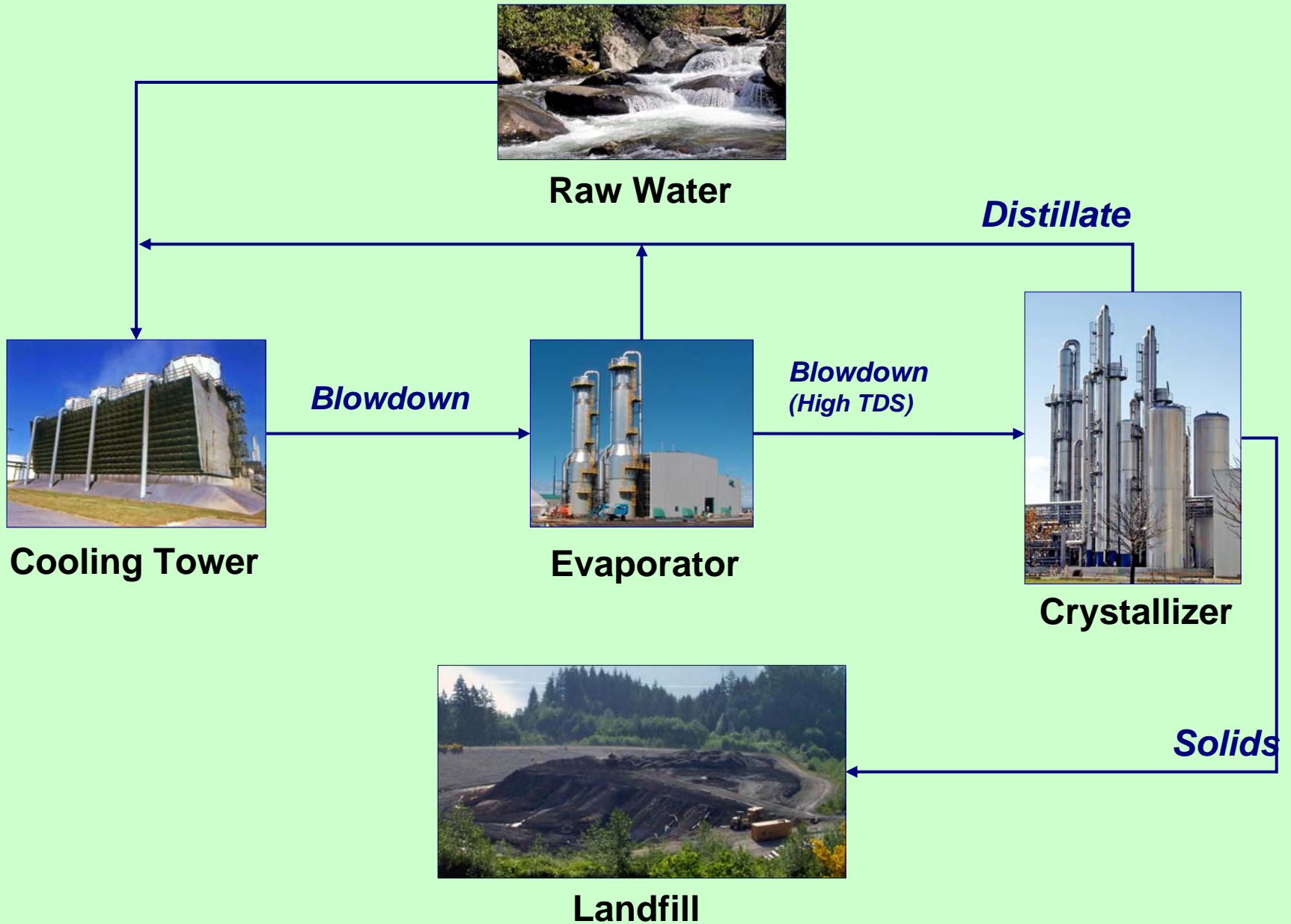
(Site Processed Discharge)

Power Plant ZLD Approaches

- Require combination of chemical precipitation, reverse osmosis, evaporator and crystallizer stages to recover water and produce dry solids
- Capital cost can be 10% of power plant facility
- Operational costs 15% of power plant facility
- Parasitic energy consumption for ZBD systems is a major operational cost
- Complex operation, control and maintenance
- Still use organic chemicals and biocides
- Costs passed on in higher rates to consumers

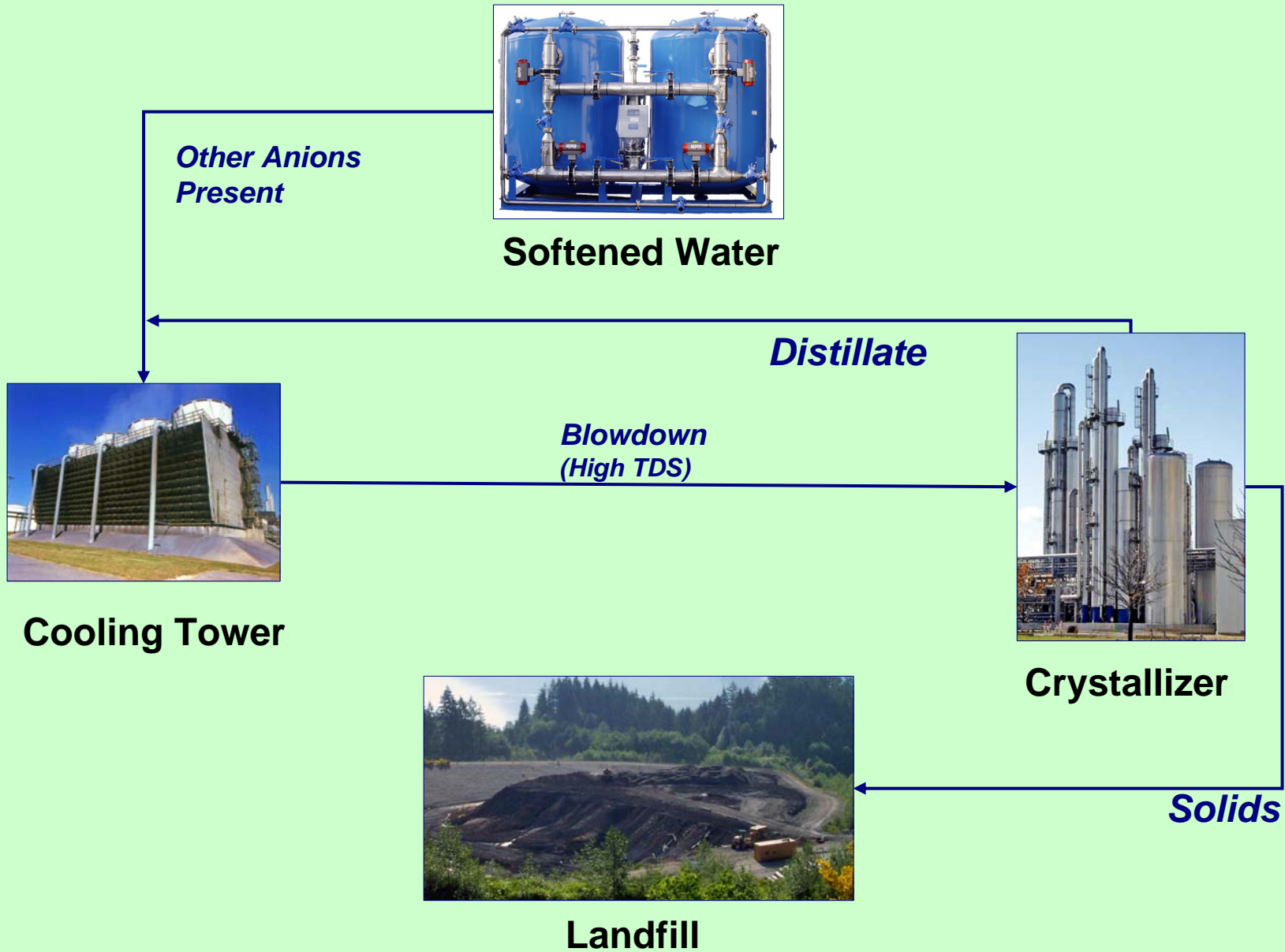
Option A

Conventional Average Cycles of Concentration



Option B

Pre-Treated Make-up with Silica Inhibition Program



Option C

Raw Water Option with Evaporation Pond



Raw Water

Other Anions Present



Cooling Tower

*Blowdown
(High TDS)*



Evaporation Pond

Evaporation Pond

- Utilize waste heat from cooling load to reduce waste discharge volume
- Relatively small land use is required for pond with reduced discharge volume
- Waste disposal parasitic energy consumption is averted

Water Resources Management

New Opportunities

- ZBD reduces water use by 20-40%
- Even greater conservation with waste water use
- No blowdown or pH control systems required
- No chemical storage and feed systems required
- Minimize discharge of organics and toxicants
- HES cost efficient removal of scale ions
- Low investment cost (ROI < 12 months)
- 50% to 75% less cost than chemical treatment

Natural Technology / Waste Heat Ideal for Recycled Water Use

- Use cooling waste heat to evaporate recycled water (minimize parasitic energy use and WTP capacity costs)
- Reduce fresh water energy cost (22% of CA energy use)
- High TDS in recycled water does not cause corrosion
- Biostatic chemistry mitigates biological growth from ammonia and organics (major reuse limitation)
- Non chemical approach exploits natural water minerals
- Qualifies for “green” chemistry, LEED, LEAN processes
- Nitrification of waste water not required

Expanded Economic Options

- Potential tower water sources include recycled water, RO reject, boiler BD, high TDS water
- Use lower cost and efficient heat transfer metals (mild steel, copper, aluminum) for economy
- Mitigates micro-biological and pathogen growth to minimize biocide dependency
- Lowers discharge loading to sewer
- Lowers waste volume for other disposal options (haul, evaporation ponds, crystallizers, ect)

Current Recycled & High Silica Water Applications

- Honda CHQ - 2500T (waste water reuse)
- CSUDH – 1500T (potable to reuse)
- Boeing CHQ – (national program pilot)
- Yahoo & Microsoft Data Centers – (industrial reuse & 35-70 silica)
- Intel – Philippines (>100 mg/L silica)

Water Resource Management Incentives & Support

LEED (gain up to 5 points)

Green Building Association

- WE 2.0 - Innovative WW Technologies (1)
- WE 3.1 - Water Use Reduction – 10% (1)
- WE 3.2 - Water Use Reduction – 20% (1)
- WE 4.1 – Chemical use reduction (1)
- WE 4.2 – Non Potable (recycled) Use (1)

LOW CARBON FOOTPRINT (Green Energy / Chemistry)

- ✓ Minimize heat transfer loss
- ✓ Avoid high energy consuming devices
- ✓ Eliminate manufactured chemicals

LEAN

(natural resource efficient)

- ❖ Minimize water use and disposal cost
- ❖ Optimize energy use (heat transfer) and cost
- ❖ Reduce capital expense / investment
- ❖ Reduce equipment cleaning and replacement
- ❖ Reduce variables for work flow improvement
- ❖ Reduce chemical handling and storage
- ❖ Reduce operator time and safety risks
- ❖ OEE - Optimize Equipment Efficiency

Regional Support

- Municipal Distributor Water Conservation Incentives - MWD & Seattle PU
- California Sustainability Alliance
- National Water Research Institute
- Washington State DOE – Quincy Model
- 2009 CA Water Reuse Association – joint paper with West Basin MWD

Summary

- “ZBD” operation now cost viable for all towers
- Negligible corrosion at high TDS
- Use waste or recycled water makeup
- Ammonia and organics impact mitigated
- Eliminates organic and toxicant discharge with biocides and inhibitor treatment chemicals
- Reduced water use and discharge cost
- **LOW CARBON, LEED and LEAN opportunity**