

REINHOLD ENVIRONMENTAL Ltd.



**2019 REINHOLD Round Table
Presentation**

June 24 & 25, 2019, in Birmingham, Alabama / Hosted by Southern Company

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ONE SOURCE. MANY SOLUTIONS.

				
Boiler Tube Company of America	TEiC CONSTRUCTION SERVICES	TEiC HEAT EXCHANGER SERVICES		Struthers Wells <small>a TEi line of products</small>

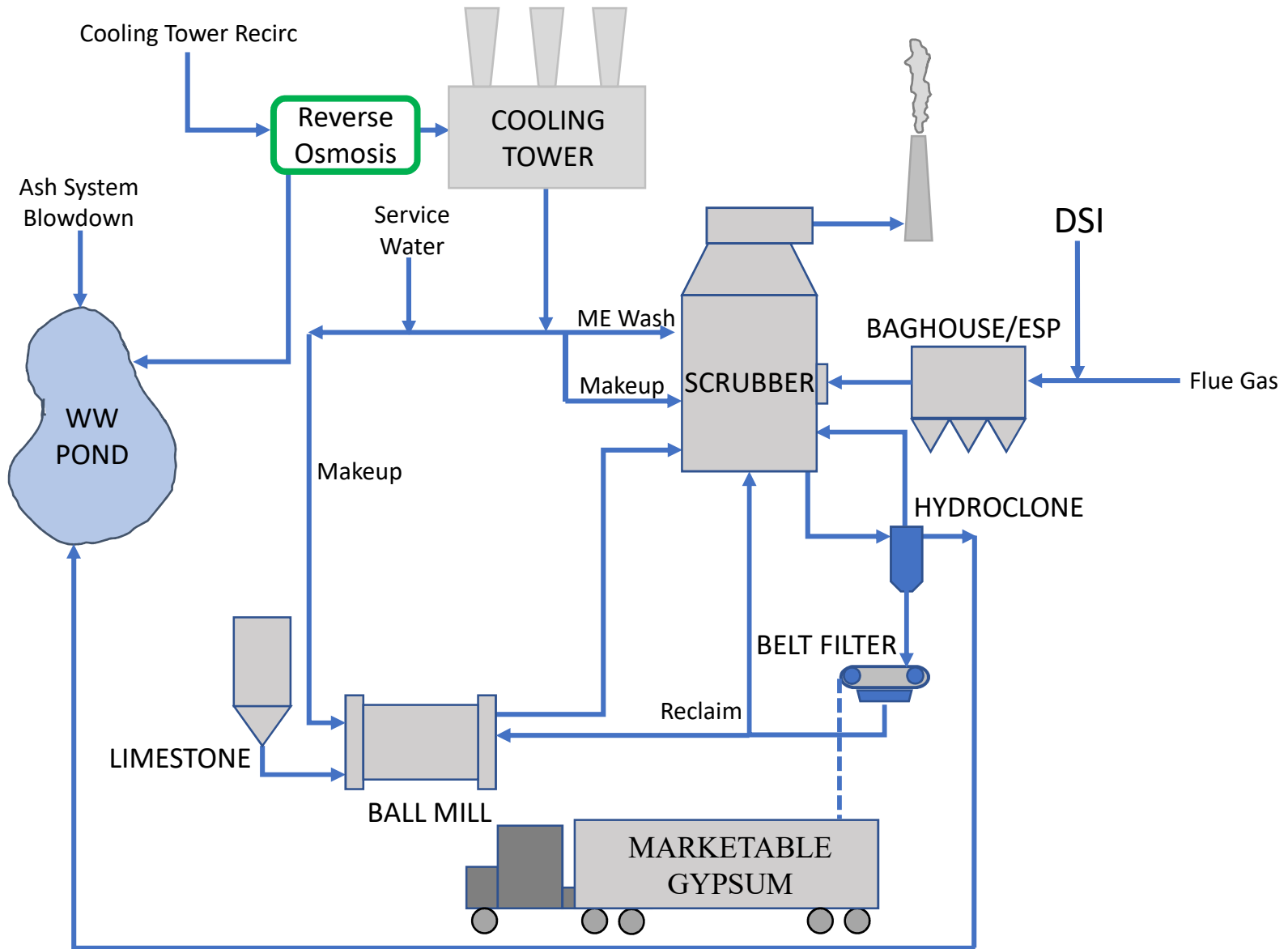
Options for Recovering, Treating, and Reusing Water from Coal Ash and FGD Systems

Utility OEM Suppliers Provide Optimal Solutions

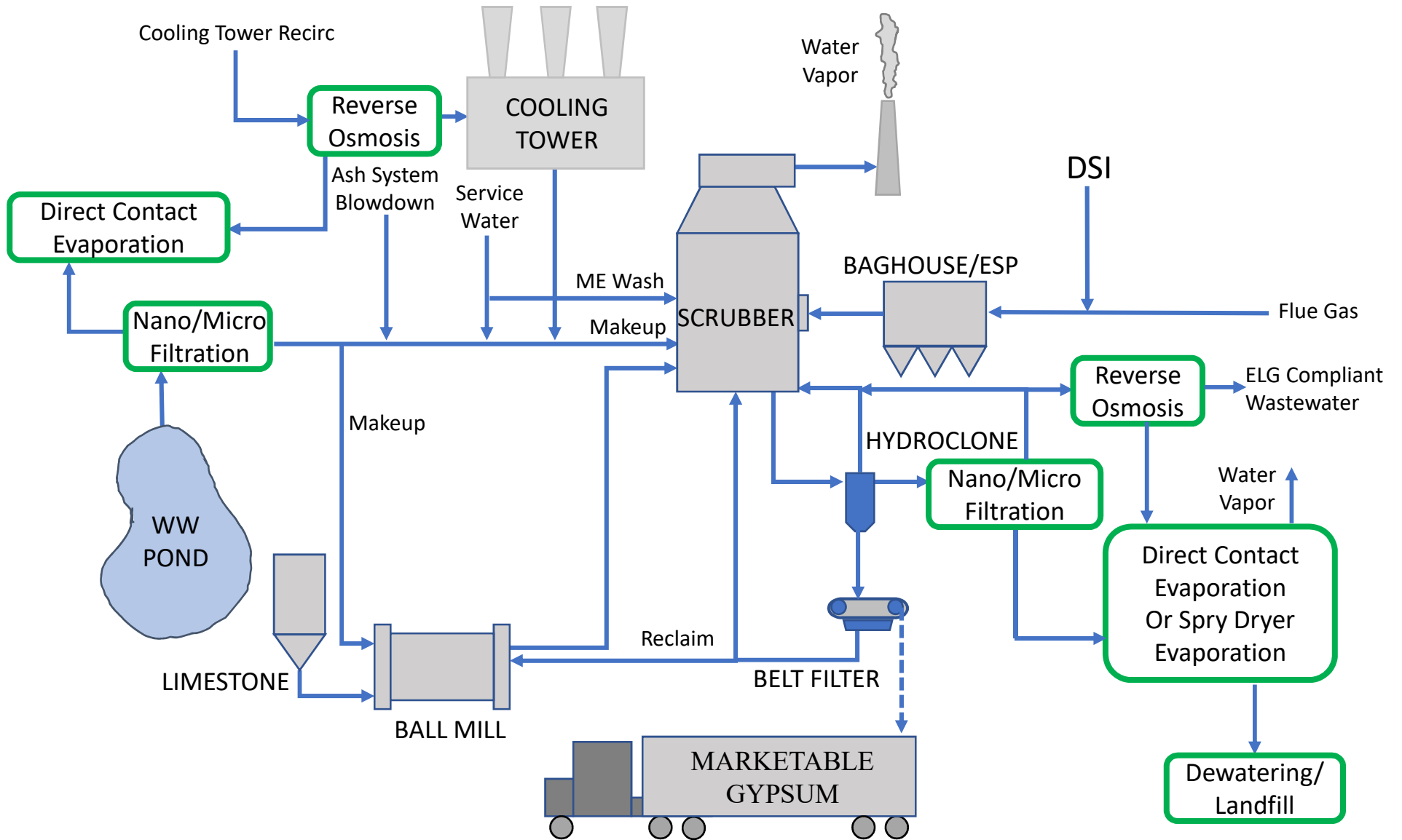
One Source – Many Solutions

- Utility OEM suppliers provide engineering, equipment, solutions, and aftermarket support to the utility industry from chute-to-stack
- Utility OEM teaming up with sub-suppliers to provide an optimized solution for each customer that meets utility requirements and considers capital and life cycle costs
- Work completed with a single contract instead of multiple subcontracts
- Utility OEM continues to provide aftermarket support

Wastewater PFD



ZLD PFD w/ Utility OEM Integration



- Reclaiming water from ponds and water purge from closed loop ash systems
- Concerns with reclaim and cycling up water in WFGD absorber
 - Cl concentration
 - Fines concentration
 - Gypsum Quality
 - Limestone blinding
- WFGD Operation with Dual-Fuel Firing
- Designing water treatment for reclaimed waters and WFGD effluent
 - Nanofiltration
 - Brine Concentration
 - Alternative Evaporation

- **Reclaiming water from ponds and water purge from closed loop ash systems**
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Geotextile Tubes

- Used in a wide variety of projects where dewatering of sediments and industrial wastes is required
- Made to custom sizes per engineered specifications
- Are cost effective and ecologically-friendly compared to other dewatering methods
- Applicable for dewatering of contaminated sediments, coal ash, mine tailings, WWTP sludge, organic and inorganic materials, silts and sands



Geotextile Tubes – Cont.

- Supports environmental and dredging contractors, as well as “superfund” contaminated sites
- Effluent is often clean enough to be returned to the source.
- Currently engaged in the largest coal ash project to date with 700,000+ cubic yards of coal ash being dredged and dewatered.



Bottom Ash Water

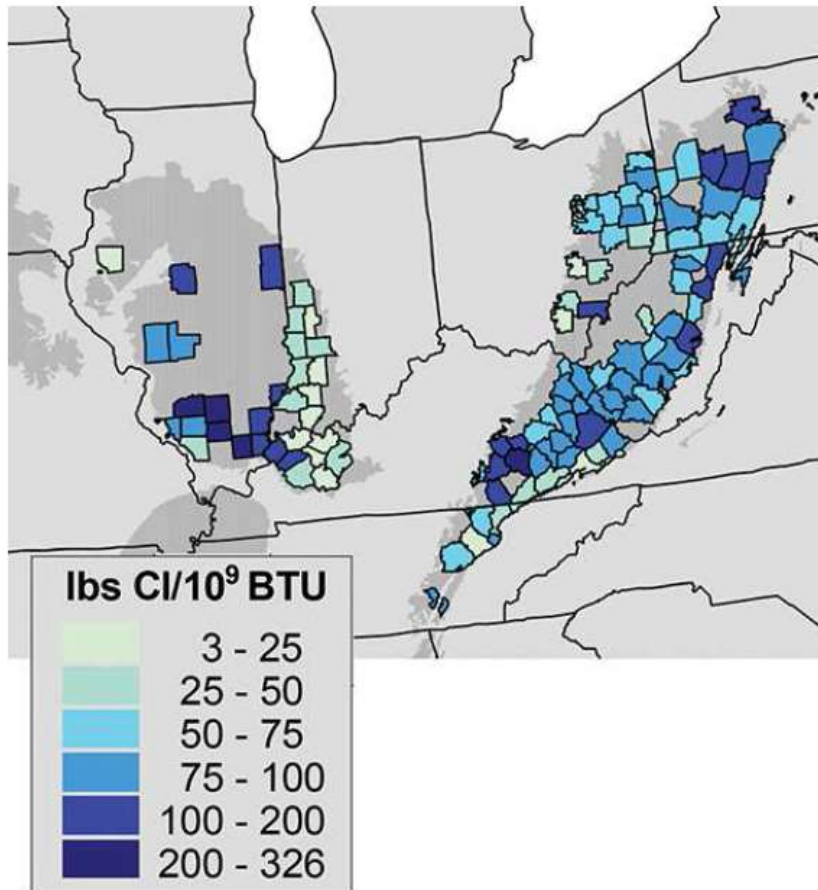
Water reclaimed from pond or purge from closed loop ash system

- Water samples show low levels of Aluminum & Fluoride
- Cycling up Al & F in the WFGD can cause limestone blinding



- Reclaiming water from ponds and water purge from closed loop ash systems
- **Concerns with reclaim and cycling up water in WFGD absorber**
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What Influences the WFGD Purge Rate?

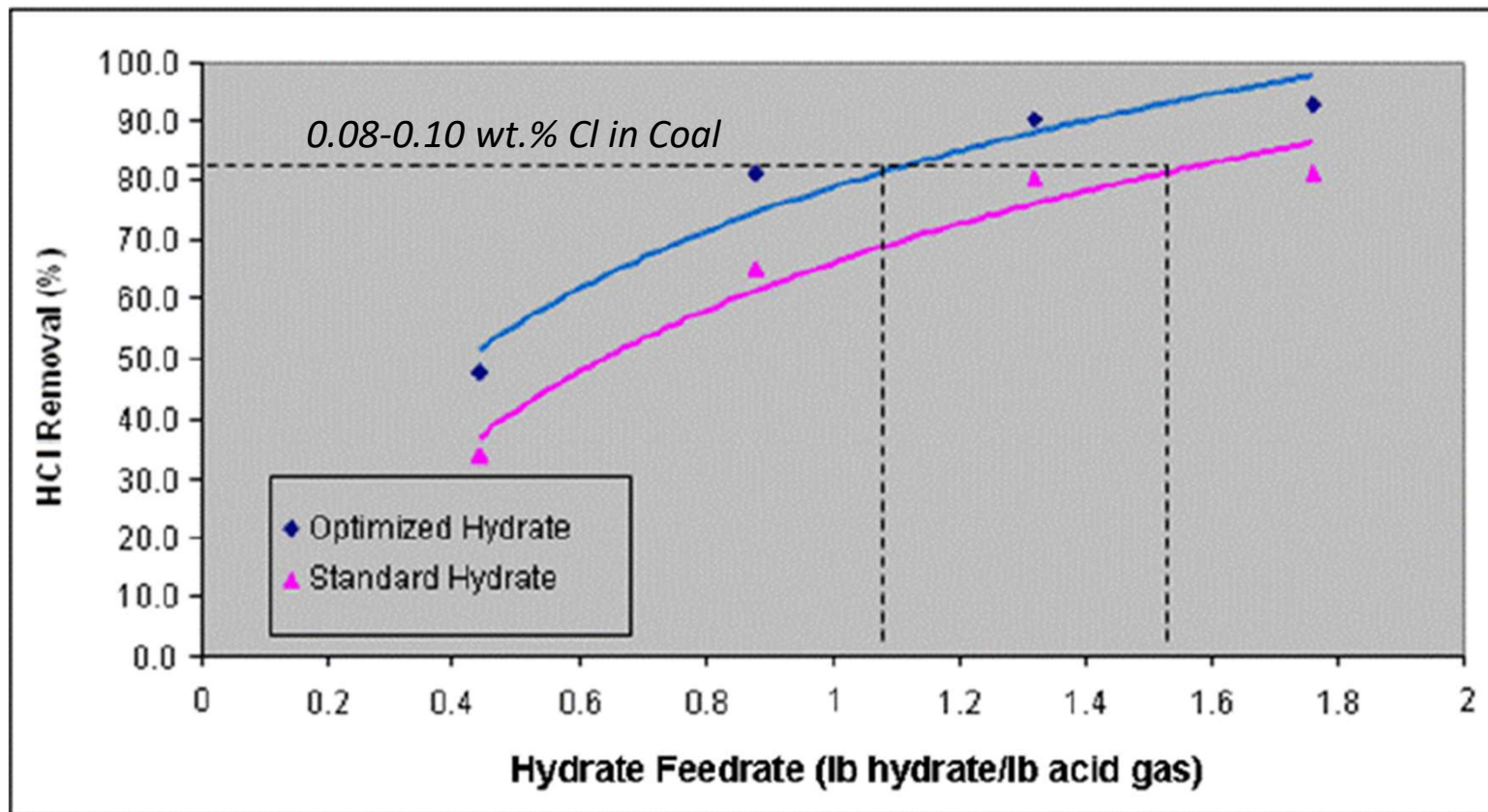


Chlorine in the coal

- Chlorine in the coal is converted to HCl through combustion
- HCl is primarily captured from the flue gas through the DSI and the WFGD systems
- HCl leaves the process via the ash and WFGD water discharges

HCl Removal with DSI

- DSI removes a fraction of HCl along with SO₃
- Economic evaluation required to optimize HCl removal versus lime consumption, ash quality, and wastewater purge rate



Dry Sorbent Injection Options for Controlling Emissions of HCl and Related Acid Gases
 Melissa Seweel - Lhoist North America at TAPPI Peers Conference 2012

Materials of Construction Limits

Chloride concentration maintained in absorber slurry

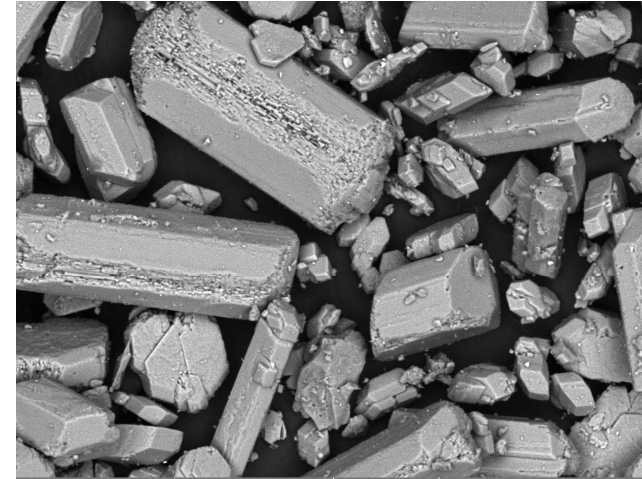
- Additional chlorides through makeup water sources
- Existing materials of construction limit chloride concentration
- Chlorides leave the WFGD process with the water through effluent purge and gypsum byproduct
- Potential impact on mercury reemission



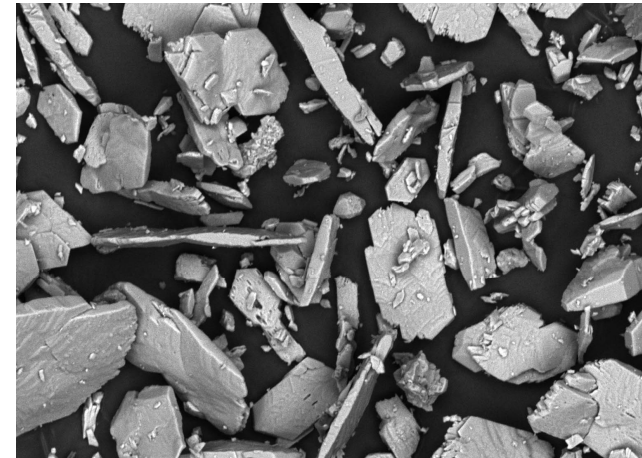
Cycling Up Chlorides Can Lead to Cycling Up Fines

Consist of:

- Gypsum
- Fly ash
- Limestone inerts
- Mercury/selenium
- Cycle up with chlorides
- Impacts gypsum dewatering
- Accelerates erosion rate of rotating equipment and liners
- Re-emissions of mercury
- Foaming issues



Example of desirable crystal morphology



Crystal morphology with excessive fines present

Removing Fines from the Process and Addressing Foaming

Remove fines upstream of WFGD

- Maintain ESP/baghouse
- Filter makeup water
- Improve quality of limestone

Remove fines from WFGD reclaim

- Secondary Hydrocyclones
- Clarifier Tank and filter press

Add anti-foam to WFGD

- Solution tank with agitator for mixing and storing diluted (10:1) anti-foam chemical solution.
- Feed pump(s) and piping to the absorber
- Feed control valve(s) and a foam detector probe with transmitter



Gypsum Marketability

- Marketable gypsum requires cake washing to remove chlorides and salts
- Unmarketable gypsum
 - Remove chlorides from process
 - Spray fines on formed section of cake



Cycling Up Chlorides Can Increase Potential for Limestone Blinding

Understand cause

- Sulfite blinding
- Aluminum/Fluoride blinding

Reduce potential for a blinding event

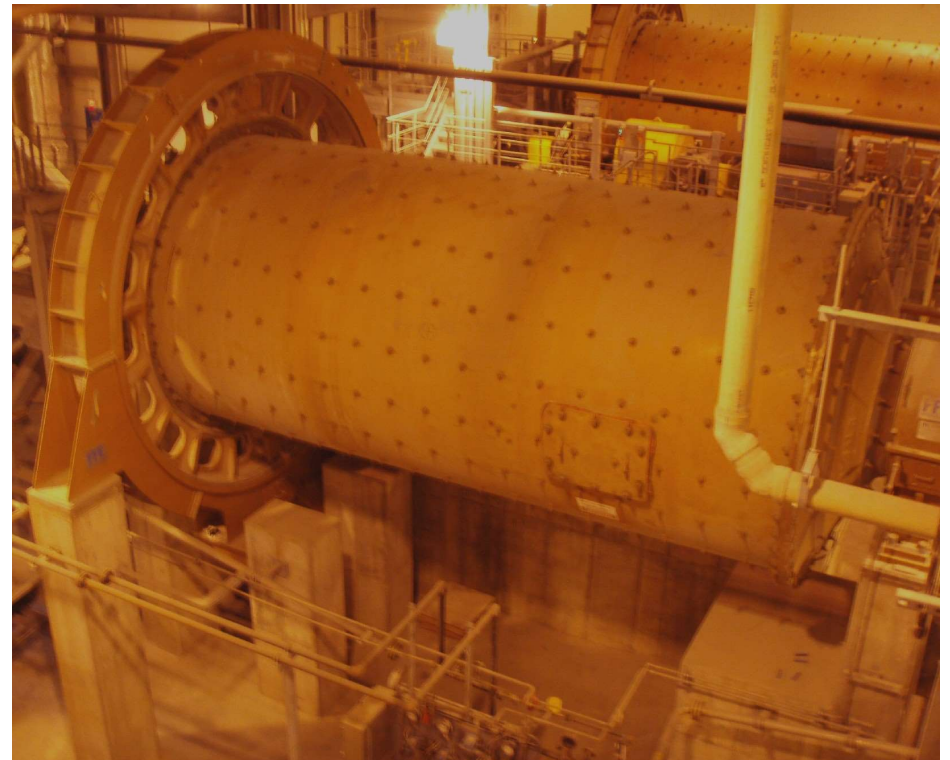
- Address oxidation issues
 - Maintain spare blower available for service
 - Maintain air distribution in reaction tank
- Remove sources of Al and F
 - Improve particulate removal upstream of WFGD
 - Treat reclaim water
- Complete chemistry modeling of slurry to determine AlF_x concentration in slurry



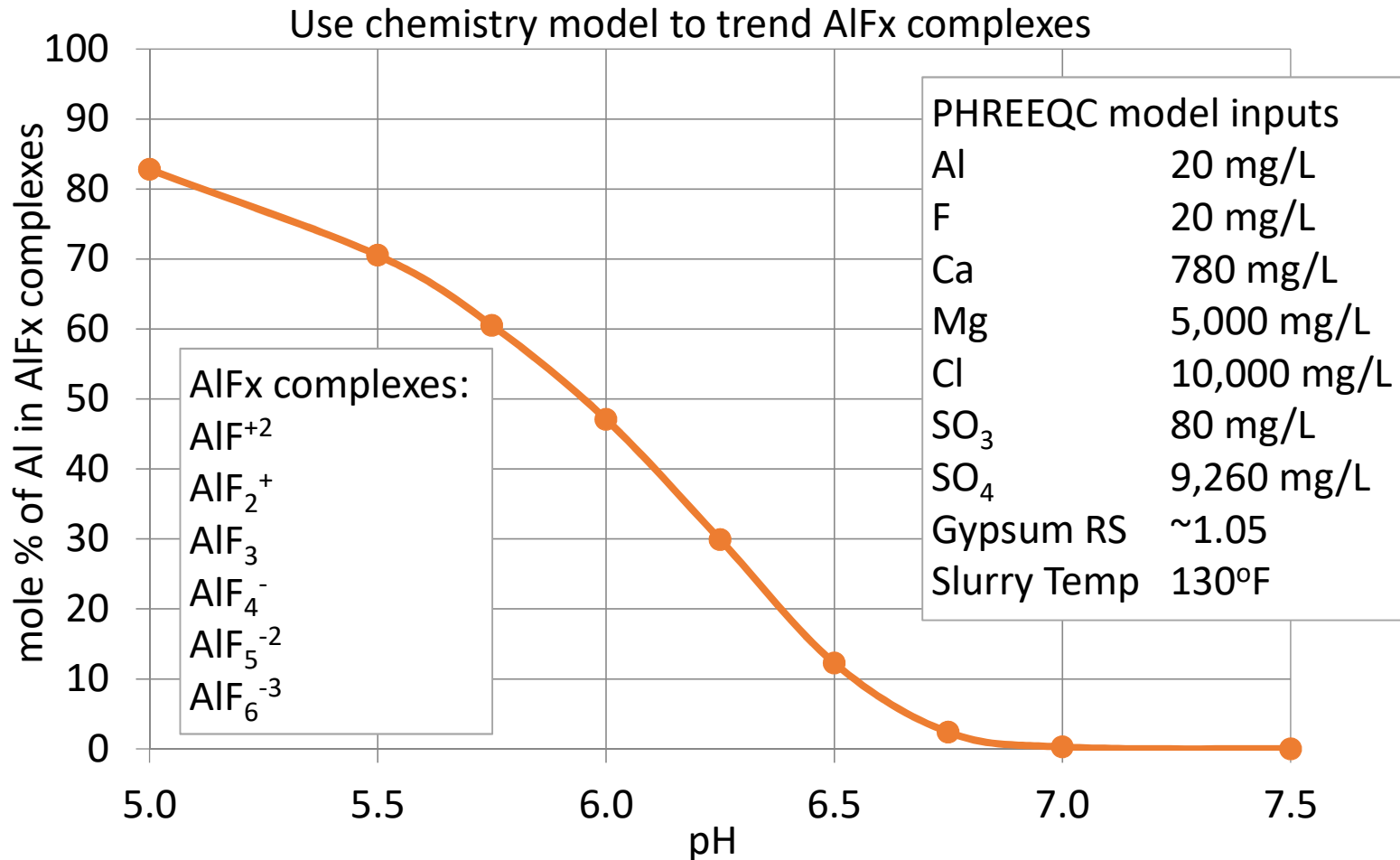
Addressing Limestone Blinding Events

Treating/preventing a limestone blinding event

- Re-establish oxidation air
- Add sorbent or buffer to boost slurry pH and precipitate Al and F
 - Hydrated lime
 - Soda ash
 - DBA/sodium formate
- Review limestone slurry feed logic
- Utilize finer grind limestone
- Use chemistry modeling to look at pH required to decrease Al_xF_x concentration in slurry
- Periodic spiking of sorbent to precipitate Al/F components prior to a blinding event



Decrease in AlFx Complexes with Increased pH

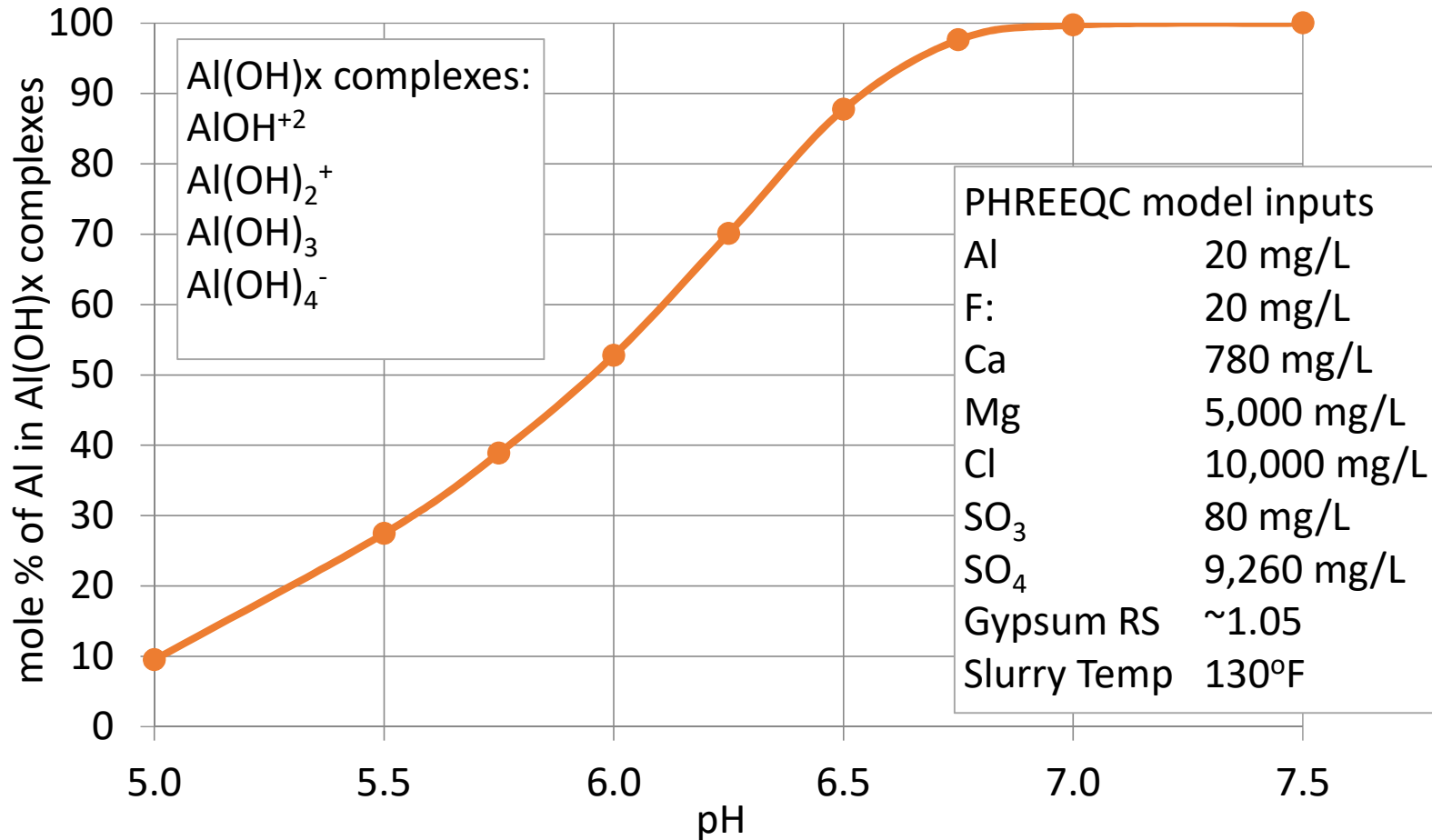


Chemistry Modeling and Graphics Support:

Benson Environmental

Lewis B. Benson · 412-225-8816 · LewB@BensonEnvironmental.com

Increase in Al(OH)_x Complexes with Increased pH



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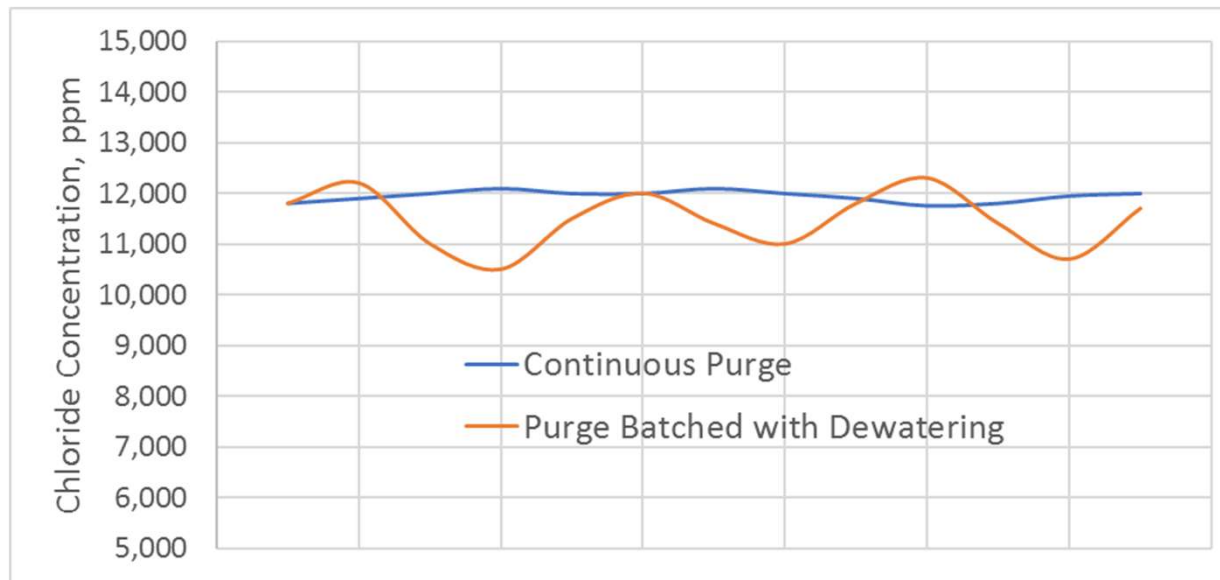
Continuous Purge

Traditional purge streams

- Often the effluent discharge is located at dewatering
- Creates a cyclic operation for chloride control
- Cannot purge at reduced load operation when there is less dewatering

Continuous purge streams

- Allows for continuous purge to downstream treatment
- Easier to maintain chloride concentration



Excess Water

Absorber Level

- Reduce operating level with load to provide more allowance for mist eliminator wash and reclaiming from dewatering at reduced load when system not evaporating water since these items are on/off operation

ME Wash

- ME wash logic to be revised to not initiate a wash sequence at low absorber level
- Individual ME wash header flows should be reviewed
- Leaking ME wash header valves to be repaired/replaced

Absorber Slurry Density

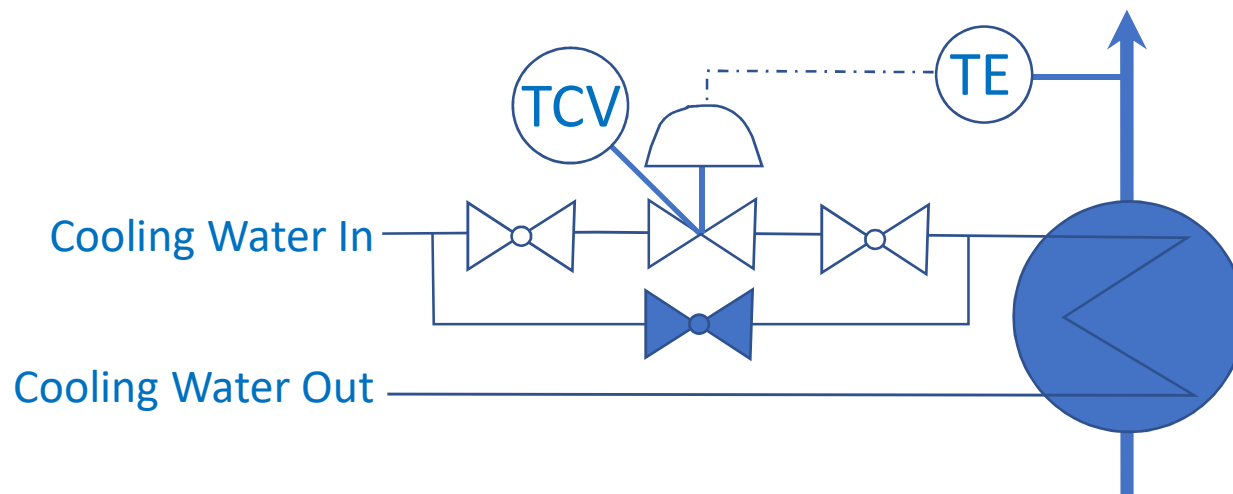
- Increase slurry operating density range from 14.5-15.5% to 14-17% to minimize number of flushes

Flushing

- Optimize flushing durations and cycles
- Use reclaim water as flush water

Minimize Cooling Water Requirement

- Add temperature control valves at equipment
- Reclaim cooling water and recycle pump seal flush water to mist eliminator wash tank



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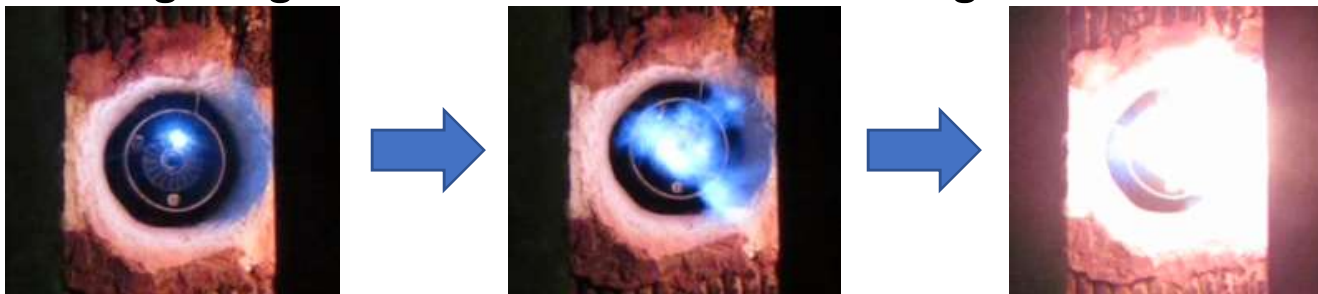
Changes to Flue Gas Profile

Change in emissions leaving the boiler when firing gas only

- 1/3 the NO_x emissions of coal
- Lower CO (typically <50 ppm)
- Lower VOCs (typically <0.001 lb/MMBtu on a methane basis)
- Virtually no SO_x emissions (small amount of Sulphur added as odorant)
- Virtually no PM
- 50-80% less CO₂ than coal

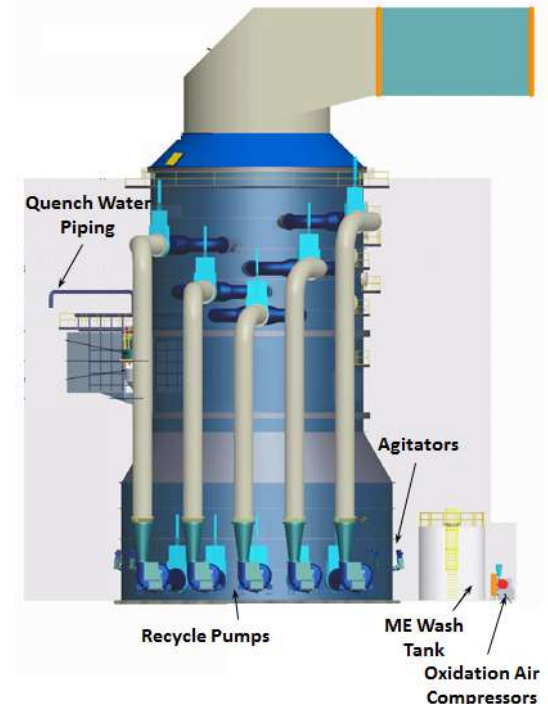
Change in flue gas when firing gas only

- Flue gas flow will typically decrease with natural gas by approximately 5-10% due to reduction in excess air requirements
- Flue gas temperature leaving the boiler bank will typically decrease slightly with natural gas firing due to increased heat absorption in the SH/RH sections from having a higher effectiveness due to no slag



WFGD O&M Considerations for Gas Only Firing

- Utilize flue gas bypass if available - remove oxidation air and recycle pumps from service to reduce power consumption
- Maintain absorber(s) in service to evaporate water
 - Utilize a minimum number of recycle pumps to quench flue gas
 - Remove oxidation air from service to reduce power consumption
- Quench flue gas with at absorber inlet
 - Add quench system to absorber inlet and control water rate based on flue gas temperature
 - Remove oxidation air and recycle pumps from service to reduce power consumption

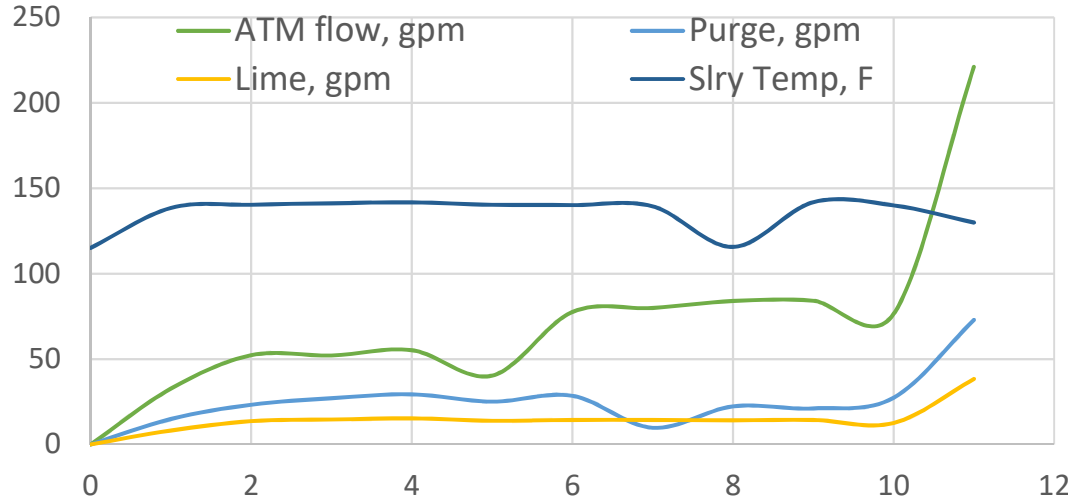


Quench System at Absorber Inlet

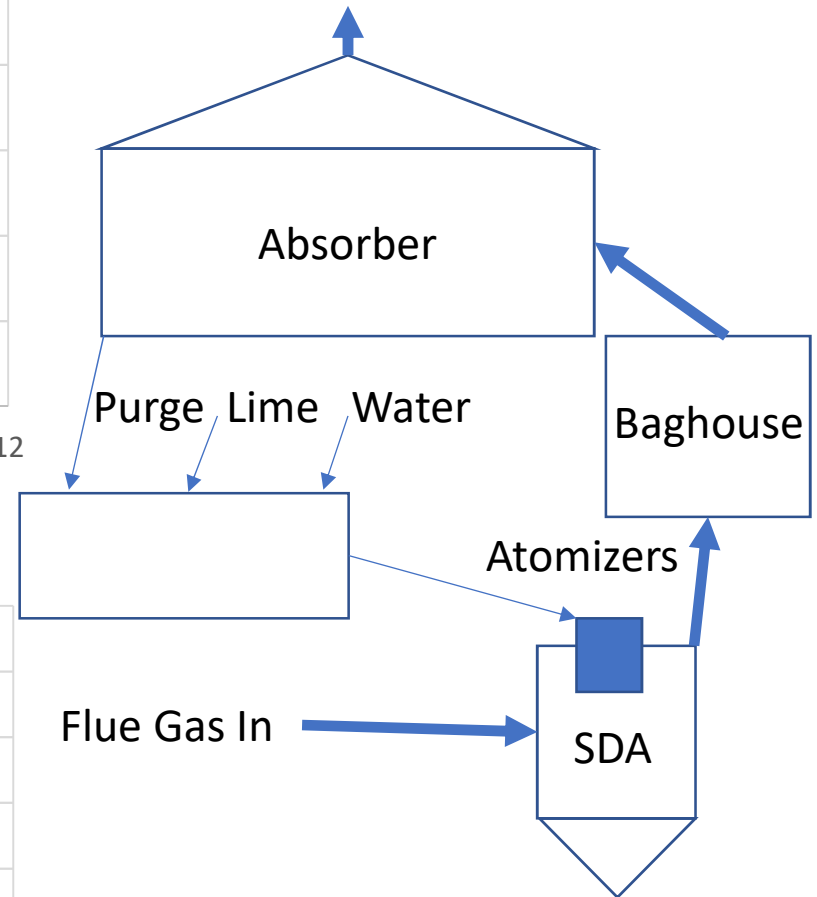
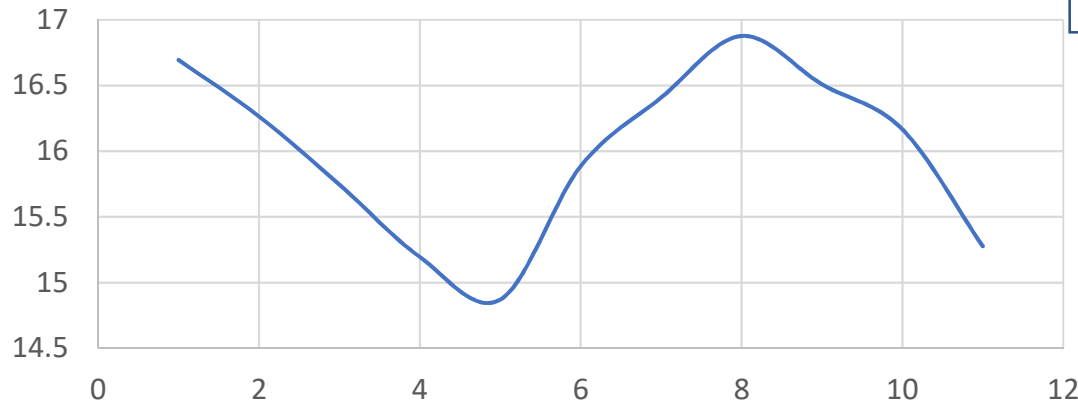
ONE SOURCE. MANY SOLUTIONS.

Duke Cliffside Lessons Learned – FGD Temp and Solids

Natural Gas and Coal SDA operation

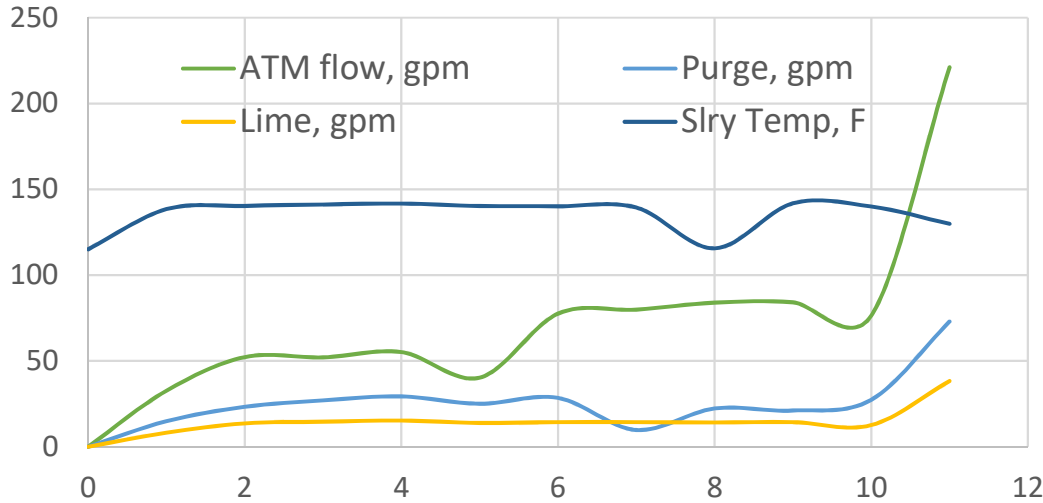


Absorber Density

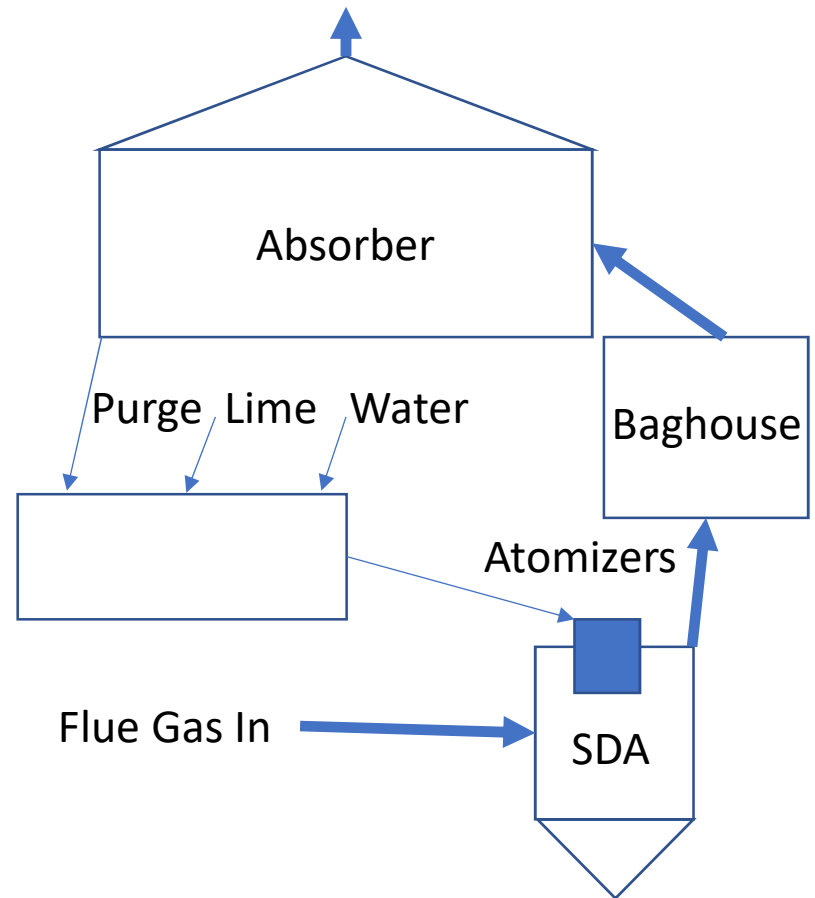
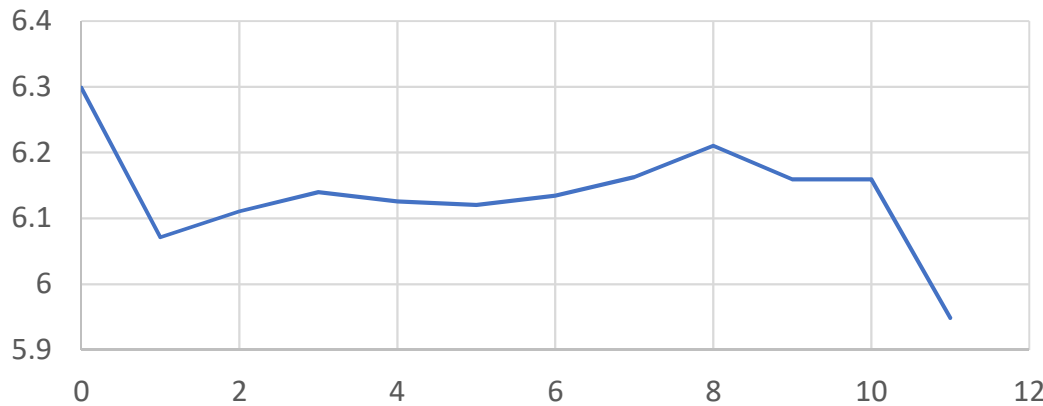


Duke Cliffside Lessons Learned – FGD pH

Natural Gas and Coal SDA operation



Absorber pH

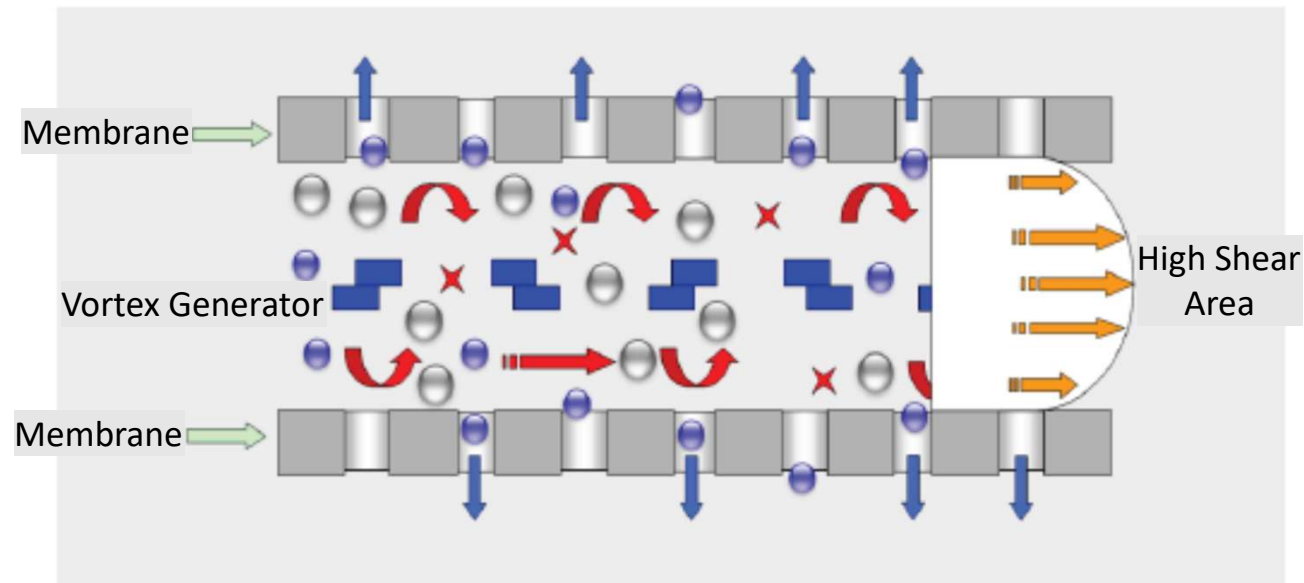


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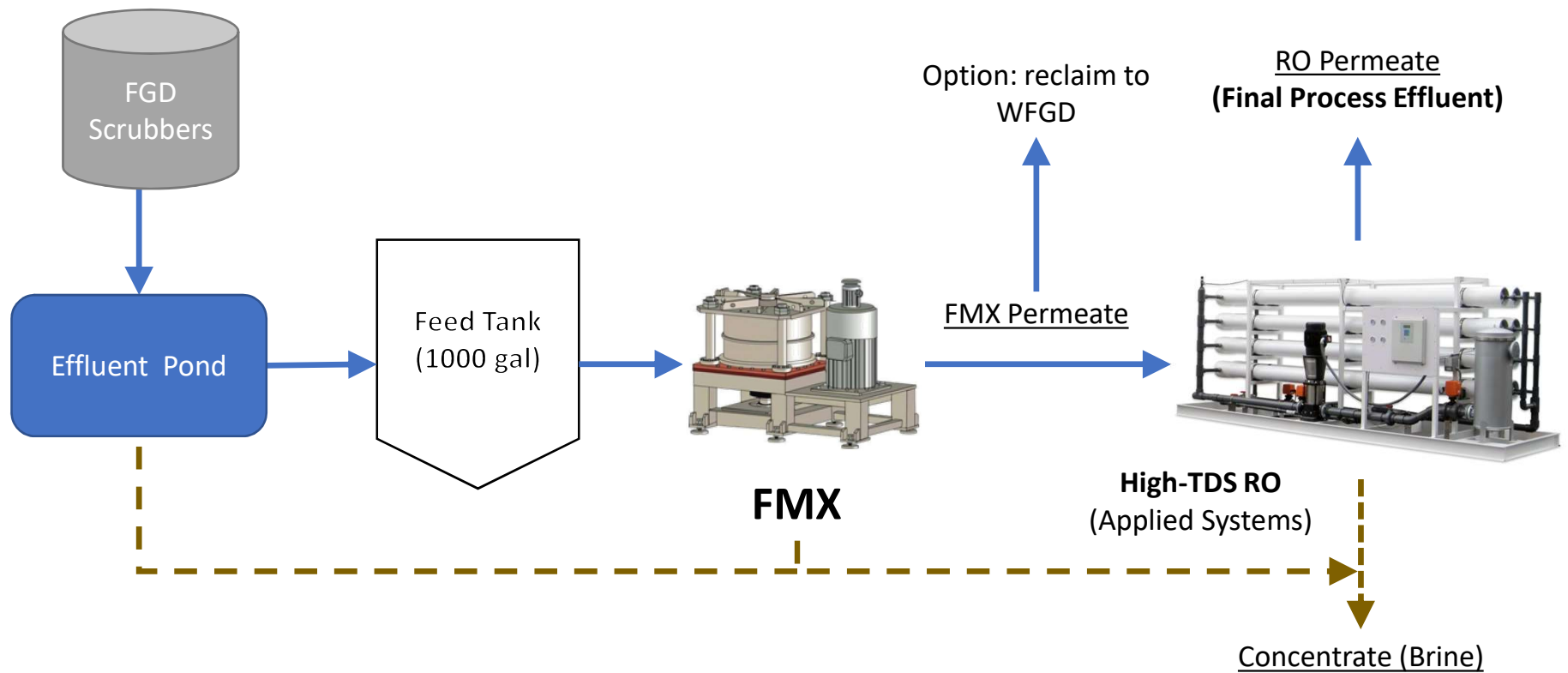
Nanofiltration – FMX System

Intermediate Step to Reduce Further Effluent Discharge after Optimization or Treat Pond Water

- FGD effluent high in TDS and TSS leads to fouling in traditional RO systems
- Nanofiltration membrane system utilizes vortices to eliminate fouling
- The membrane is dependent on the type of water recovery and chloride levels



Case Study (2018): Single Pass Mode with RO polish



Case Study:

3-month RESULTS

Raw FGD

Steam Electric Power Plant
Southeast US

FEED: FGD Holding Pond

PRETREATMENT: None

AVERAGE FLUX: 128 LMH

RECOVERY: 80-85%

TOTAL VOLUME TREATED:
525,042 gal (w/anti-scalant)

Validated using RO Pilot (Applied Systems High-TDS RO):

ANALYTICAL RESULTS: RECOVERY AVERAGES (N=7)

	UNITS	FEED	FMX EFFLUENT	FMX % REMOVAL	FMX+RO EFFLUENT	FMX+RO % REMOVAL	2015 ELG BAT Daily Max	All samples met BAT?
TDS	ppm	3887	1857	52%	192	95%	NA	NA
Sulfate¹	ppm	2379	929	61%	20	99%	NA	NA
Arsenic	ppb	11.14	8.46	>24% ²	6.09	>28% ²	11	✓
Mercury	pptr	240	16.6	>93% ²	< 5	> 98% ²	788	✓
Selenium	ppb	1,927	726	62%	6.84	99%	23	✓
NO _x -N _(aq)	ppm	5.6	5.6	NA	1.25	78%	17	✓

¹ Main contributor in scale formation

² Sample results below LDL levels mean removals are underestimated

Meeting ELG

FMX+RO Effluent was able to meet and exceed 2015 EPA BAT targets.

FGD Wastewater Discharge Limits		
	BAT	
	DAILY MAX	30 DAY AVERAGE
Arsenic	✓	✓
Mercury	✓	✓
Selenium	✓	✓
NO _x -N _(aq)	✓	✓

BOTTOM LINE

Add FMX for the most reliable, cost-effective FGD wastewater solution

- Volume Reduction
- Permit Compliance
- Discharge-Quality
- Smaller Evaporator
- Protects RO systems

Making ZLD Economical

- Volume reduction + brine concentration optimizes the cost of ZLD treatment and provides flexibility in operation
- Meets compliance with all discharge regulations and provides ELG compliant water for reuse
- Test units available



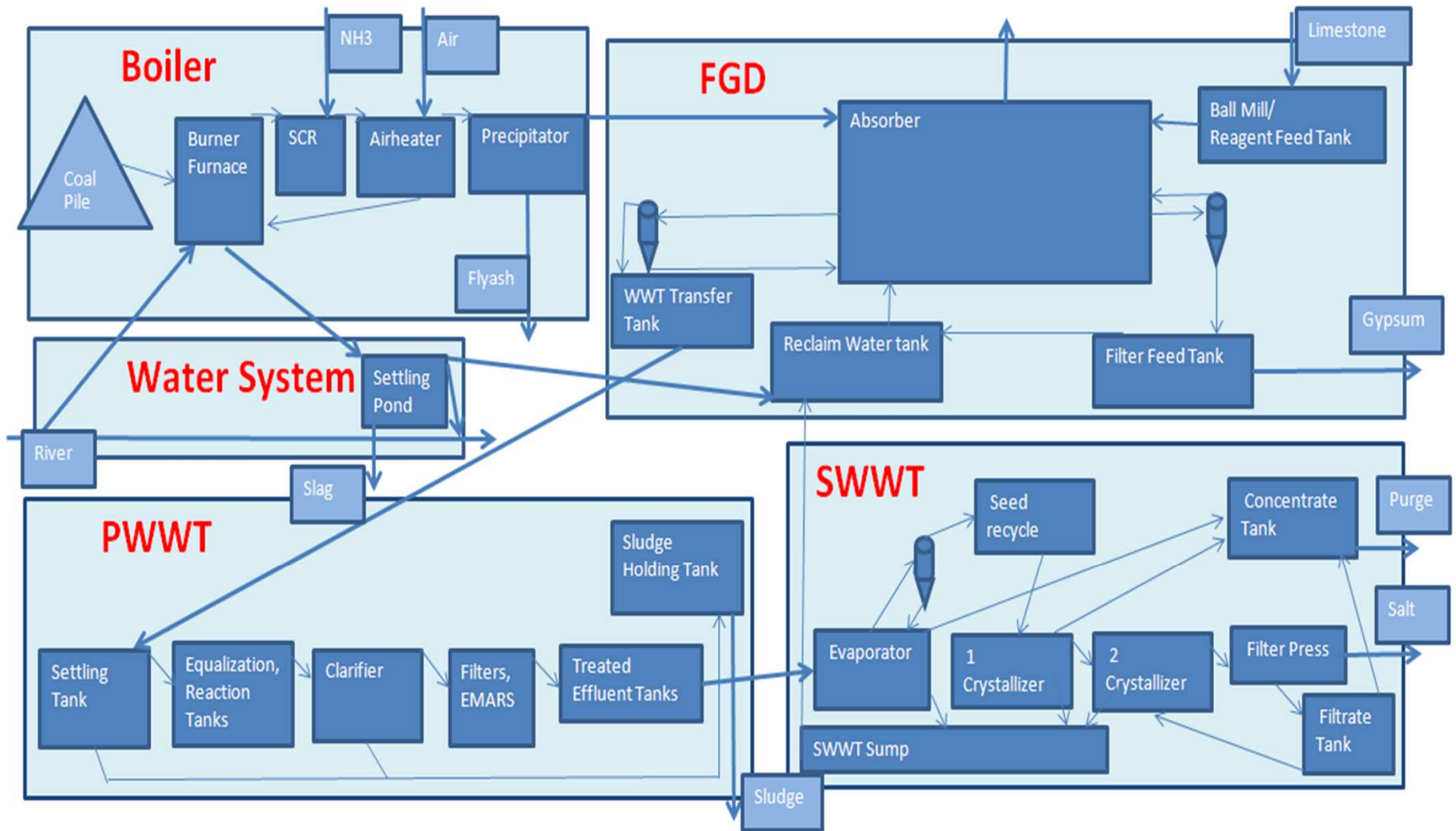
Brine Concentration - Falling Film Evaporator



Filter Press and Crystallizers



Material Balance



Primary Sludge Balance

Infeed

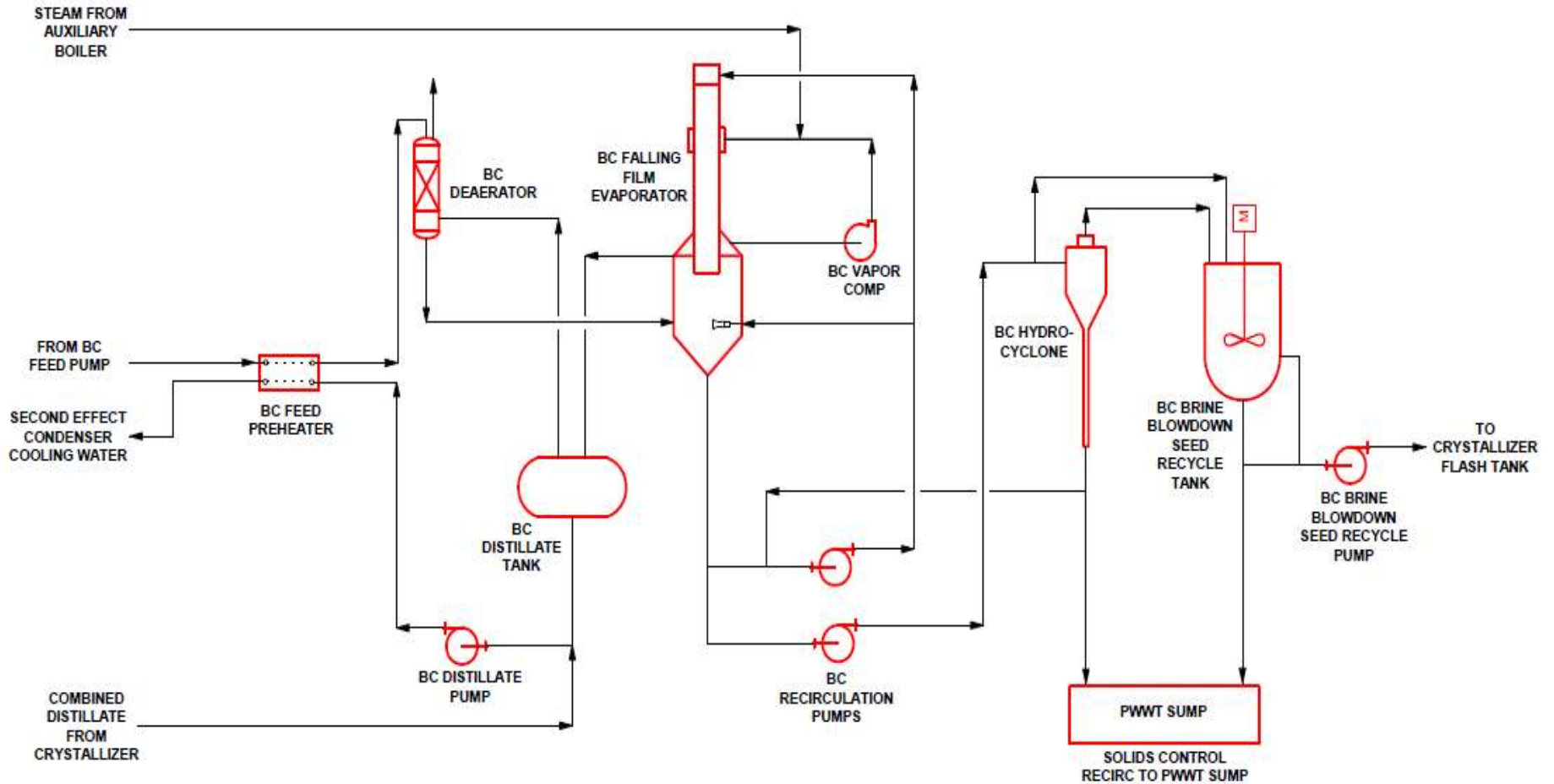
Influent Water Quality Analysis (Ion Balanced Majors)	
Feedrate	42 gpm
<u>Cations</u>	ppm as ion
Calcium	6,500
Calcium (determined by (OH) balance) added in reaction tank	2324
Magnesium	1,400
Sodium	670
Potassium	51
<u>Anions</u>	ppm as ion
Sulfate (dissolved)	1,000
Chloride	16,000
HCO ₃	260
TSS (mostly CaSO ₄ solids)	0.75%

Sludge

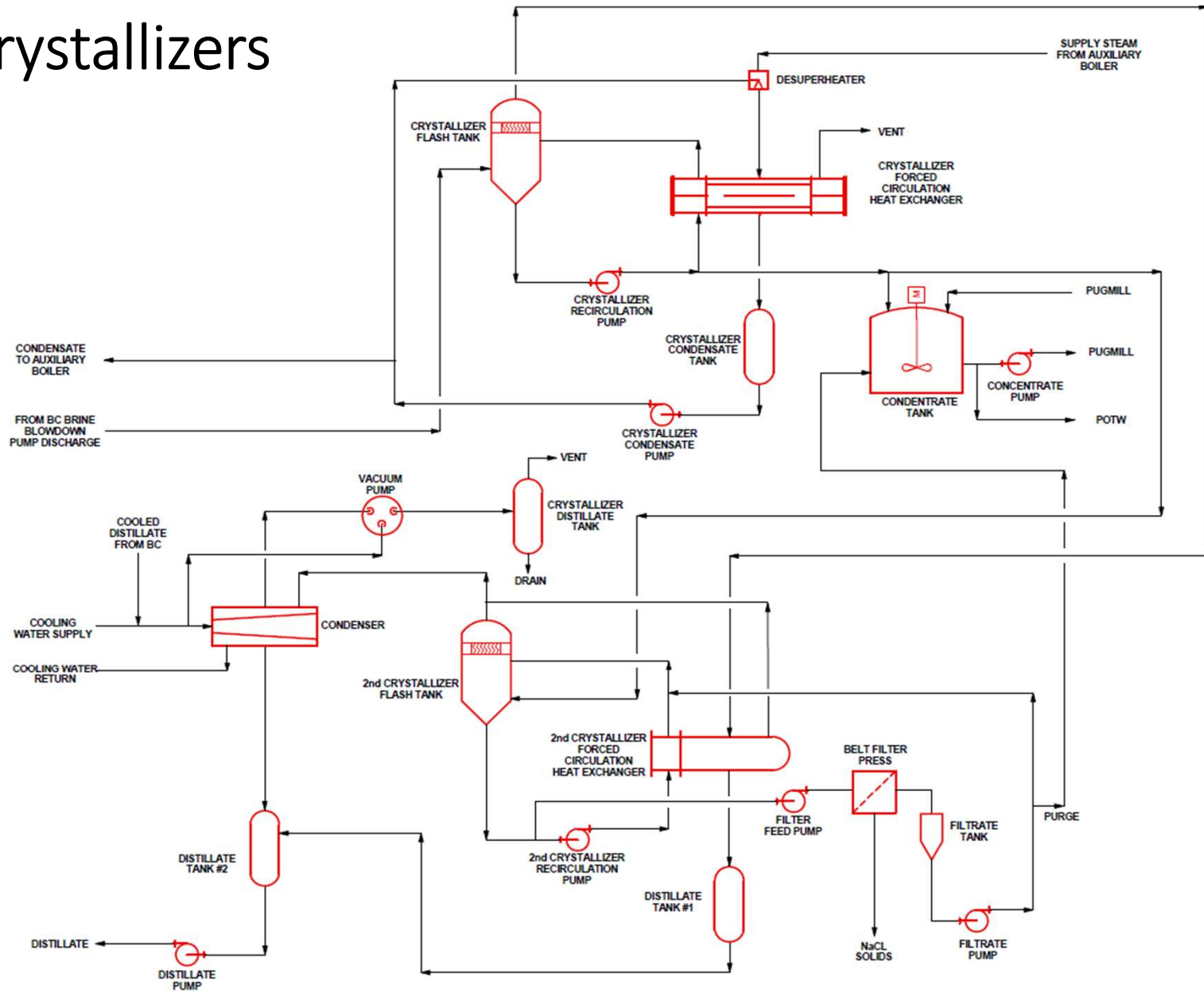
Solids Generation	
	Tons/day
CaSO ₄ (infeed solids)	1.86
CaCO ₃ (driven by Ca balance)	5.48
Mg(OH) ₂ (driven by Mg balance)	0.84
Moisture (Free)	45%
TOTAL	14.88
Actual (Avg over 21 days in 2/2013)	14.85

$$\text{Solids} = \text{Flowrate} * \text{concentration} * \text{MW}$$

Brine Concentrator (seeded)

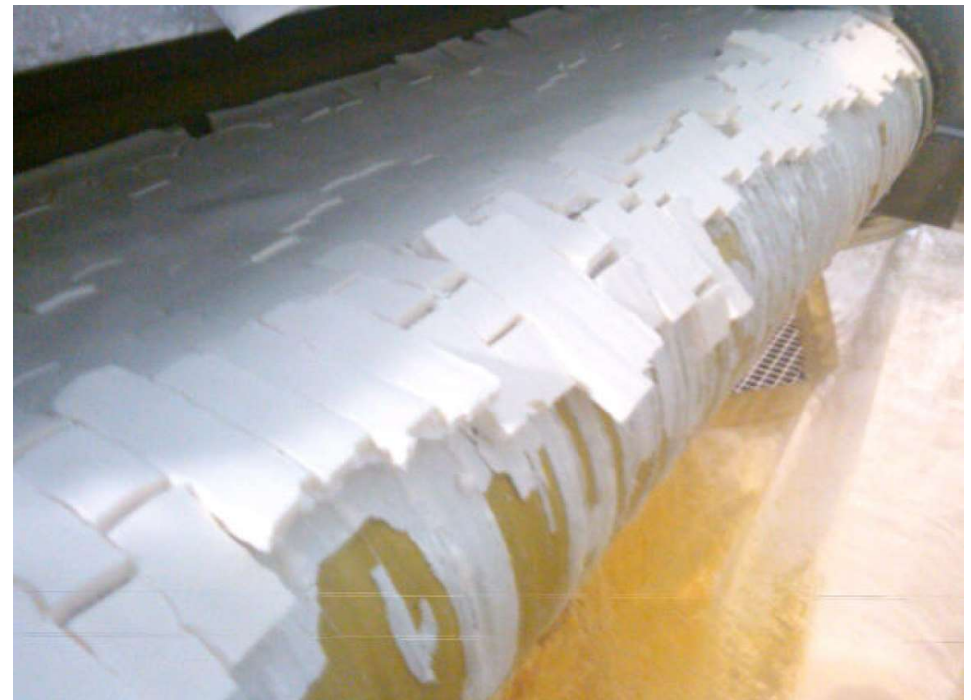


Crystallizers



Salt Generated

Solids Generation	
	Tons/day
CaSO4	0.7
NaCl	6.57
Moisture (Estimated, Free)	20%
TOTAL	8.72
Actual (Avg over 6 days in 2/2013)	8.03



Brine Concentrator Material Balance Challenges

- Balance requires equilibrium
 - Fuel changes
 - Absorber and other tanks “capacitance” require equilibrium calculations to verify acceptable concentration
- Limestone-gypsum balance is very important but challenging
 - Gypsum measurement
 - Reagent density and reagent tank consumption
- Element partitioning

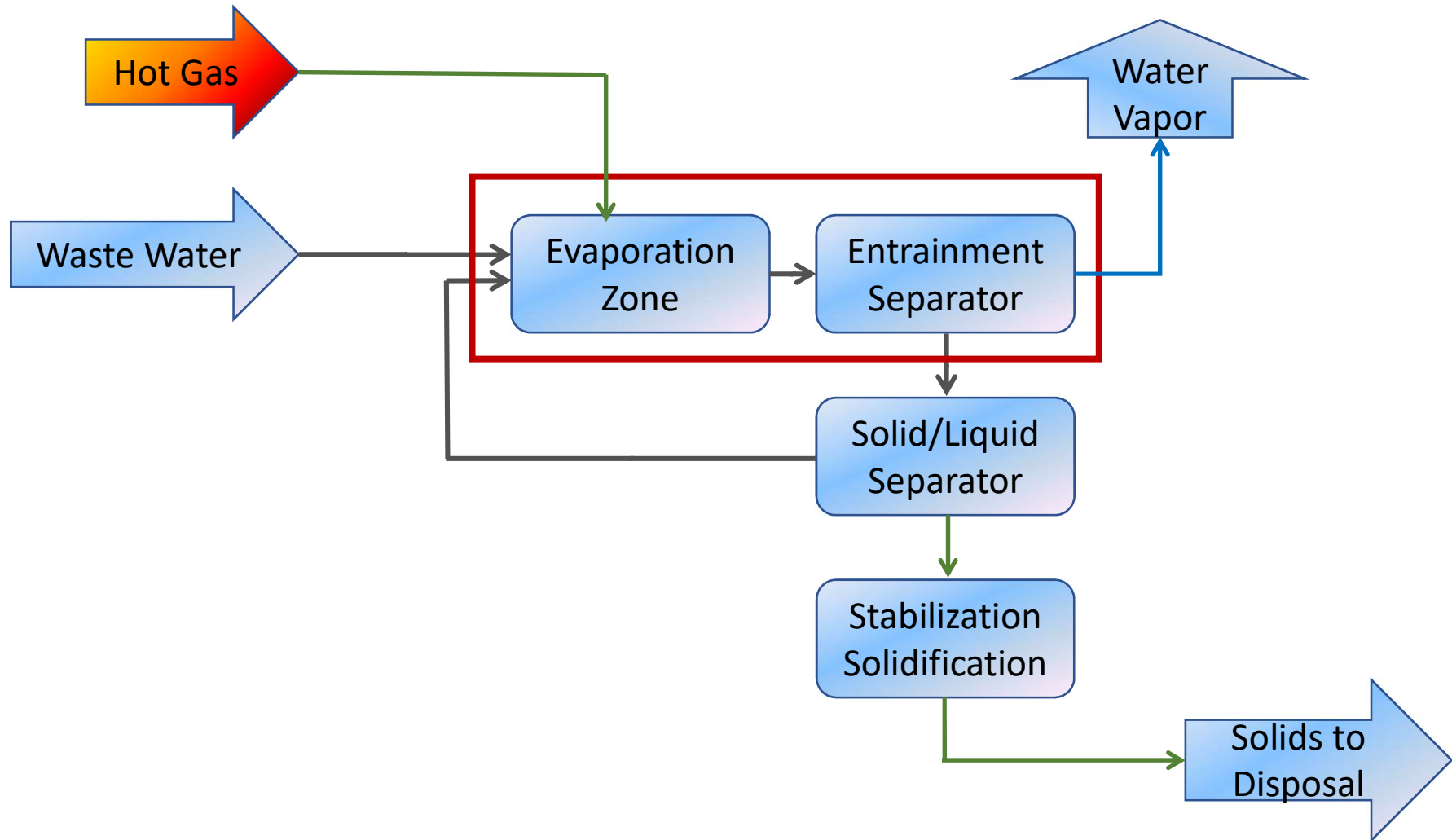
Alternative Evaporation - Direct Contact Evaporation



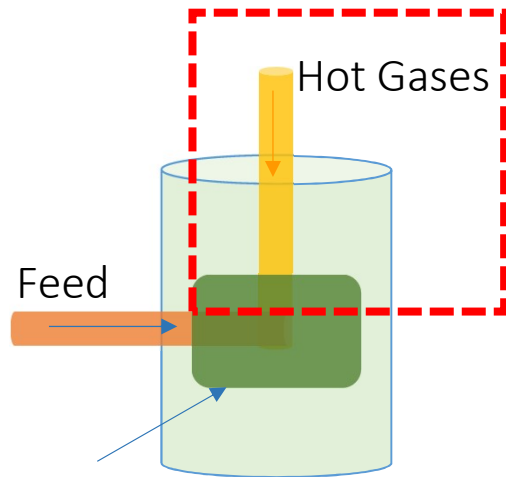
- ① Heat Source
- ② Concentrator Section
- ③ Feed and Recirculation
- ④ Droplet Separator
- ⑤ Sump
- ⑥ Exhaust

Mobile Test Units Available

Direct Contact Evaporator Process Flow Diagram



Direct Contact Evaporation vs. Falling Film

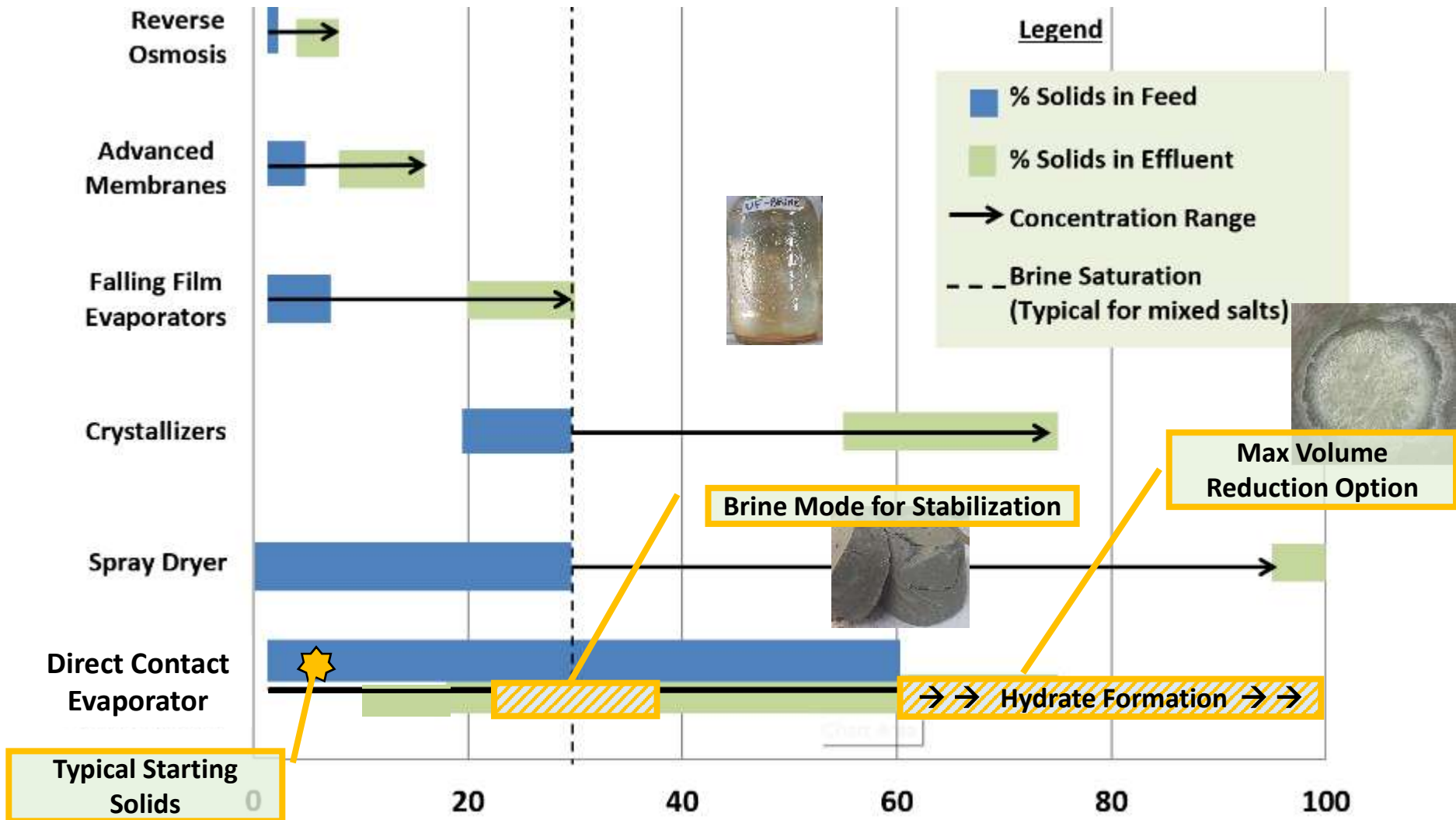


Direct Contact
"Concentrator"



- Compact
- No heat exchange surfaces or membranes to foul; low-cost materials
- Direct use of waste heat (exhaust gases) and/or natural gas
- Patented Gas-Liquid Section creates large surface area for rapid evaporation
- Require no pre-treatment
- Simple to operate and maintain

Direct Contact Evaporator Process Flexibility







Power Industry Experience

EPRI Project at Plant Bowen



- FGD wastewater treatment/concentration using flue gas as a waste heat source
- 24/7 study realized 93% availability.
- Integration on operating 900 MW unit successful.
- Fly-ash improved mixing and better solids production
- 97% volume reduction producing solids for disposal passing TCLP

Chemistry Overview – Southern Plant Bowen

	Infeed FGD Purge Water	Process Circulation	Settling Tank Discharge	Secondary Settling
Total Solids	~3.5%	30-40%	50-60%	70-80%
Total Diss. Solids	~3.5%	30-35%	~10%	<10%
Specific Gravity	1.0	1.2	~1.5	> 1.5
Calcium (mg/L)	~6,500	~55,000	~55,000	N/A
Sodium (mg/L)	~120	>30,000	>20,000	N/A
Chlorides (mg/L)	~15,000	>210,000	>230,000	N/A
Sulfates (mg/L)	~1,000	~350	~300	N/A
				

Thermal Heat Source Flexibility

While economical running on natural gas, the direct contact evaporator delivers the industry's lowest cost to treat when utilizing unconventional waste heat.

IC Engine Exhaust



Flue Gas



Flare Gas



GT Exhaust



Electric Heater (pilot)



Biogas

Brine Dewatering

- Multiple options for dewatering including:
 - Dewatering tubes
 - Centrifuges
 - Filter presses
- Enhanced stabilization of metals such as selenium
- Producing a solid with improved properties over crystallized salt
- Elimination of a crystallization step



Utility OEM Suppliers Provide Optimal Solutions

One Source – Many Solutions

- Utility OEM suppliers provide engineering, equipment, solutions, and aftermarket support to the utility industry from chute-to-stack
- Utility OEM teaming up with sub-suppliers to provide an optimized solution for each customer that meets utility requirements and considers capital and life cycle costs
- Work completed with a single contract instead of multiple subcontracts
- Utility OEM continues to provide aftermarket support

Special Thanks to:

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