REINHOLD ENVIRONMENTAL Ltd.

2016 APC-Wastewater Round Table & Expo Presentation

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Flexibility of RSC²™ Design to Accommodate Various Processes & Waste Streams

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Outline

- Regulatory Overview
- A-S-H® RSC²™ Remote Submerged Chain Conveyor
- How RSC²™ Accommodates Closed Loop Flow
- System Water Balance & Plant Wide Water Management
- Water Quality Considerations
- RSC²™ Module Approach for Advanced Treatment

ELG (for units > 50 MW)

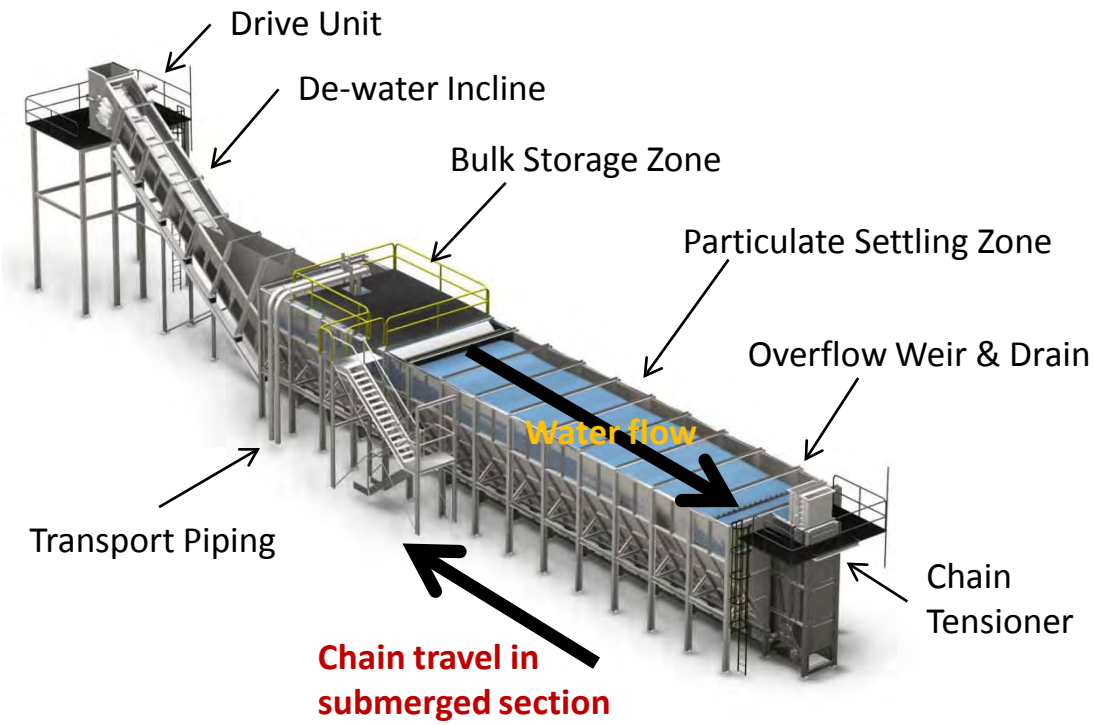
Waste Streams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	Dry Handling
Bottom Ash Transport Water	Dry Handling/Closed Loop
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Combustion Residual Leachate	Impoundment
Nonchemical Metal Cleaning Waste	[Reserved]

What Water Applies to ELG?

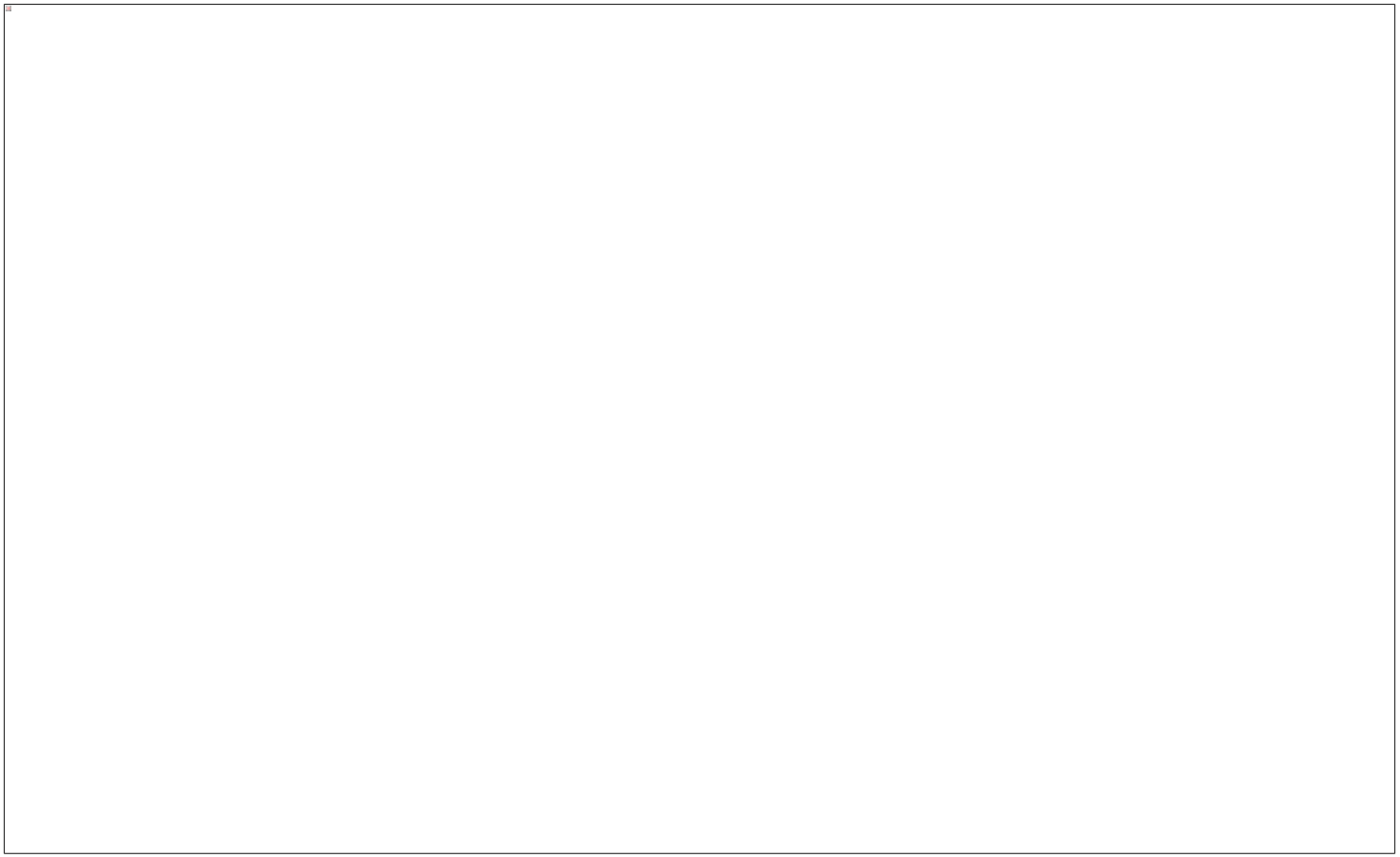
- Includes
  - Transport water (bottom ash and economizer)
    - 1,500 – 3,500 GPM/line
  - Water from draining a wet sluicing containment vessel
    - 100,000 – 500,000 Gallons
- Excludes
  - Quench water (ash hopper service water)
    - 300 – 500 GPM/unit
    - Note quench water becomes transport water in wet sluicing systems
  - Discharges from minor maintenance events
    - Valve leaks, minor line leaks, grinder or pump seal failures, etc.

A-S-H® RSC²™ Remote Submerged Chain Conveyor

- Located remote from boiler area
- Usually can keep existing sluice system as-is
  - Minimal outage time for installation
- Dewaters ash to landfill-able moisture content
- Clarifies transport water

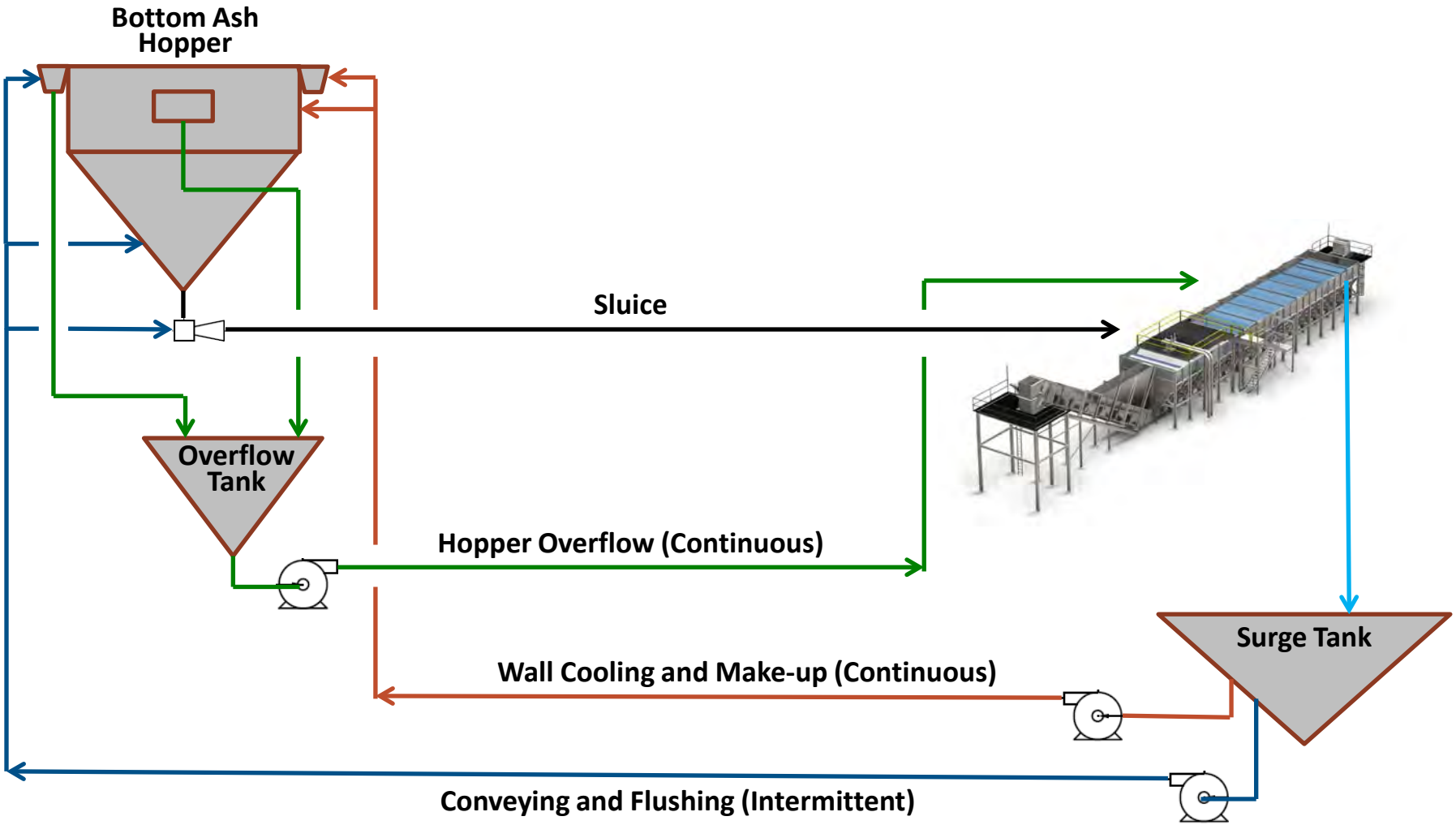


(3) 50% Capacity RSC²™ Units for (4) Boilers



Dewatered Ash Pile

How RSC²™ Accommodates Closed Loop Flow



Surge Tank

- Surge tank manages water inventory in system
- Minimum volume required for recirculating pump suction
- Capacity to drain system volumes
  - RSC2™ volumes
  - Ash hopper volumes
  - Piping volumes
  - Overflow tanks

System Water Balance

- Water losses
  - Ash hopper evaporation (5 – 15 GPM/unit)
  - Retained moisture in dewatered ash (2 – 20 GPM/unit)
  - Hopper leakage?
  - Natural evaporation (<1 GPM yearly average)
- Water additions
  - Seal water for pumps (20 – 100 GPM total for all pumps in system)
  - Rain if not in building (<1 GPM yearly average)

- Need to ensure net loss of water in system
  - Helps control water chemistry
  - Consider mechanical pump seals
  - Ways to get rid of water from system?

Plant-Wide Water Management

- Ways to get rid of ash transport water
  - Makeup to FGD
    - Consider water quality requirements
  - Fly ash conditioning

- Other ways to use closed loop ash system
  - Non-chemical metal cleaning wastes with significant solids content
    - Boiler wash
    - Air pre-heater wash
    - Precipitator wash
  - ELG would not allow ash transport water to go to low volume waste pond after being used in another process

Reuse of Ash Transport Water to FGD Systems

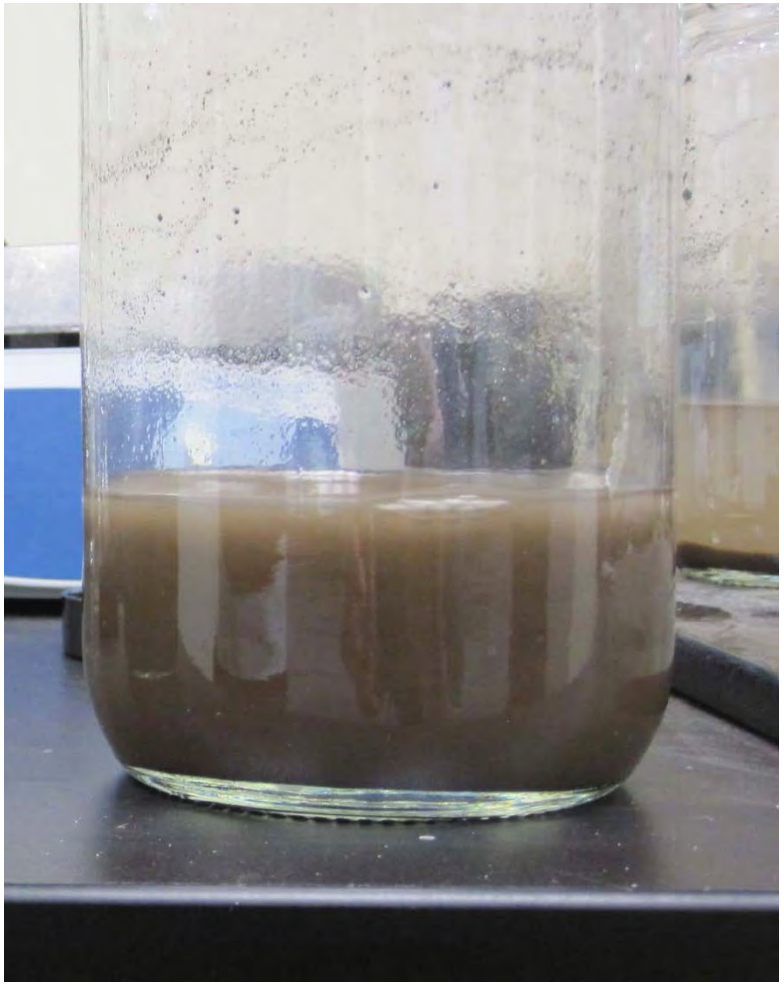
- Ash transport water generally has low TDS, which makes it suitable for FGD makeup
  - Some coal sources may require scale control measures in the bottom ash system. These measures should be evaluated for impact to FGD.
- Need to ensure low TSS (<100 ppm)
- Possible impacts of poor makeup water quality are:
  - Lowered gypsum purity
  - Altered gypsum morphology
  - Lowered limestone dissolution
  - Mist eliminator scaling
  - Increased metals of concern in the system effluent

Equipment Wash-down Water

- Not necessarily required to be closed loop but RSC²™ can be used to treat and re-use this water
  - Boiler wash
  - Air pre-heater wash
  - Precipitator wash
- Water quality
  - Typically high in fines content
  - Can be very low pH (pH = 2)
- Fines can be captured in RSC²™ with advanced treatment modules
- Consider dewatered moisture content
  - Fine ash will require longer dewatering time in bunkers than bottom ash

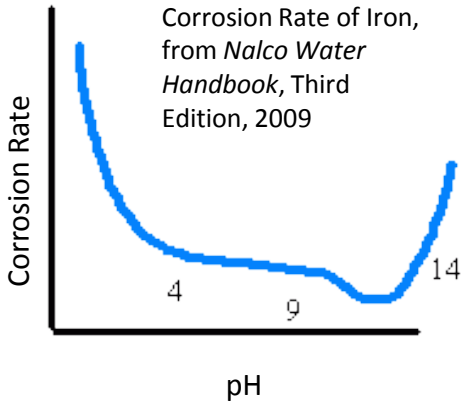
Water Quality in Closed Loop

- Corrosion
- Scale formation & Fouling
- Total suspended solids (TSS)



Water Quality – Corrosion

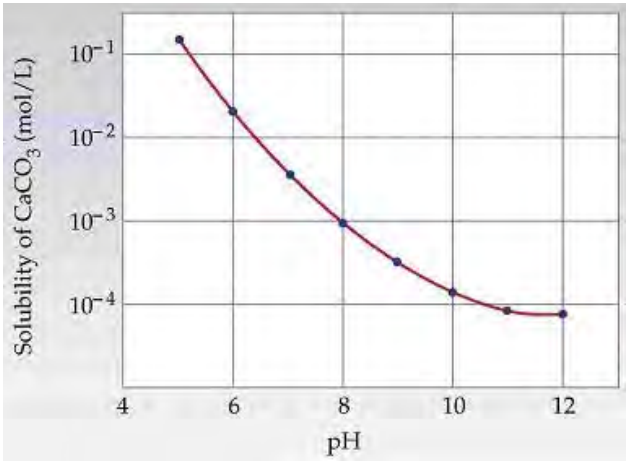
- High sulfur coals can produce low pH (4 – 6)
- Low sulfur coals tend to produce high pH (10 – 12)
- Largely depends on how much makeup water is added to system
- Wet/dry interfaces most susceptible
  - Overflow weirs and trough
  - Dewatering incline
- Acid or caustic injection can be used



Corrosion Rate of Iron, from *Nalco Water Handbook*, Third Edition, 2009

Water Quality – Scale Formation

- Common with sub-bituminous coals
  - Usually calcium carbonate or aluminum hydroxide
- Factors affecting scale formation
  - Dissolved solids concentration
    - Concentration increases with water recirculation
  - pH
    - $CaCO_3$ precipitates at high pH
    - Sub-bituminous slurry samples pH = 10 – 12
  - Temperature
    - $CaCO_3$ solubility decreases at higher temperature (more dissolved solids precipitate as scale)
    - Closed loop systems will run a little higher water temperature (90 – 110 F)
  - Fouling due to deposition of suspended solids
    - High suspended solids increase scale potential by increasing number of nucleation sites



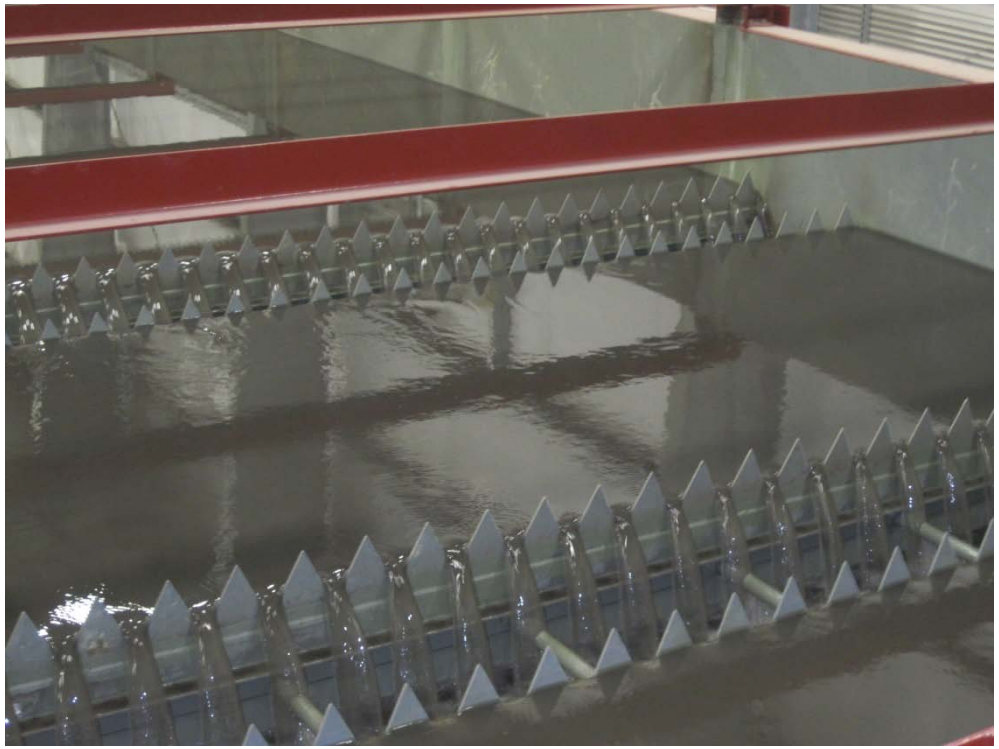
http://www.ldeo.columbia.edu/~sanpisa/OceanSed%20project/class%20project/caco3phsol.JPG

Water Quality – Scale Formation

- Controlling scale formation
  - pH adjustment
    - Keep pH below critical value for precipitation
    - Not always successful long-term due to continual buildup of dissolved solids
  - Scale inhibitors
    - Polymers attach to crystals to inhibit growth

Water Quality – Suspended Solids

- Impact of overflow TSS
  - Erosive wear
    - Pumps
    - Nozzles
  - Sludge accumulation
    - Seal water troughs
    - Refractory cooling pipes
    - Surge tanks
  - Fouling
    - Pipes
    - Pump intakes

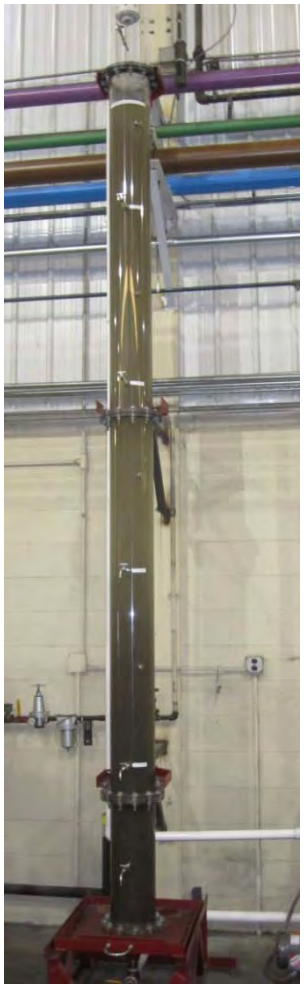


Water Clarification – Extensive Lab Testing

RSC²™ Scale Model

Lamella Clarifier Scale Model

Hydrobin/Settling Tank Scale Model



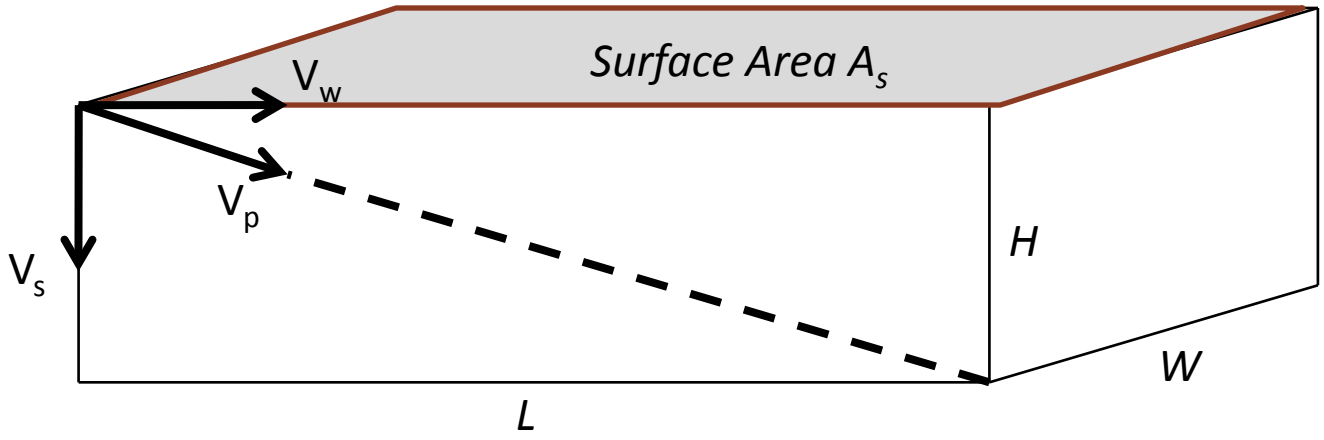
Settling Column

RSC²™ Module Approach

- Base RSC²™ can be configured with additional features to improve water quality
  - Longer settling section
    - 800 – 1000 ppm practical limit
  - Lamella plates
    - 200 – 400 ppm practical limit

RSCC with Lamella Plates

Longer Settling Section Clarification for Horizontal Flow

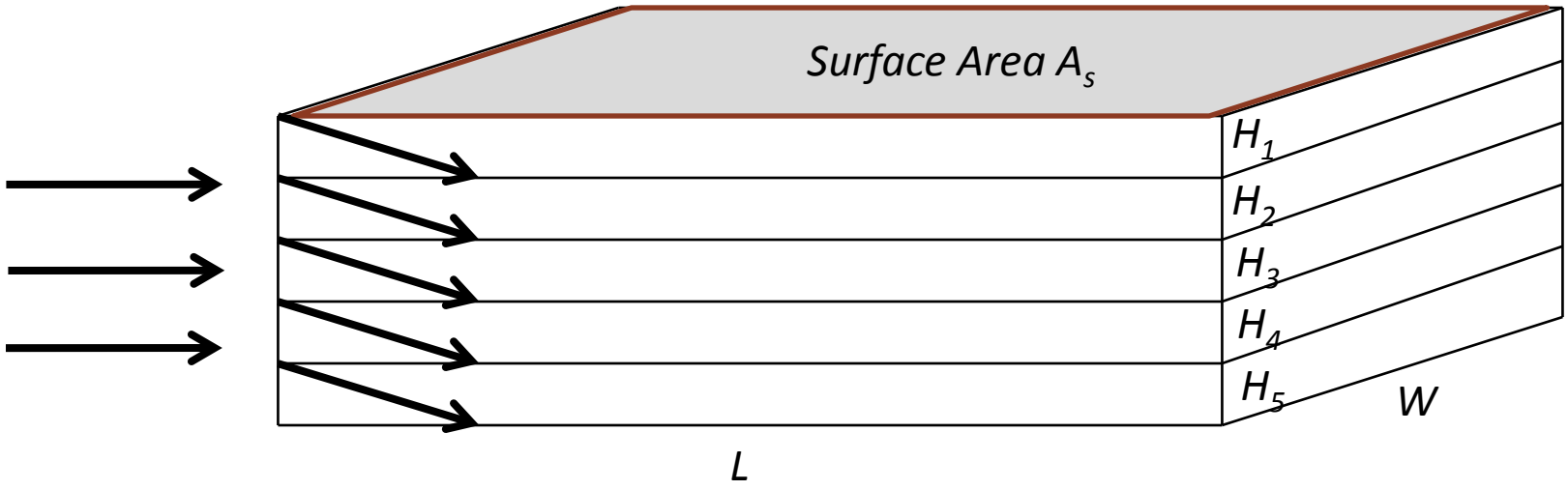


For a particle starting at the top of the tank to settle, Settling Time < Water Detention Time

$$\text{Settling Time} = \frac{H}{V_s} \qquad \text{Water Detention Time} = \frac{H*W*L}{Q}$$

$$\frac{H}{V_s} < \frac{H*W*L}{Q} \quad \text{simplifying,} \quad \frac{Q}{A_s} < V_s \quad \text{where} \quad V_s = \frac{d_p^2(\rho_s - \rho_w)g}{18\mu}$$

Lamella Plates



For a particle starting at the top of the tank to settle, Settling Time ≤ Water Detention Time

$$\text{Settling Time} = \frac{H_1}{V_s} = \frac{\frac{1}{5} H_{TOTAL}}{V_S}$$

$$\text{Water Detention Time} = \frac{H_{TOTAL} * W * L}{Q}$$

$$\frac{\frac{1}{5} H_{TOTAL}}{V_s} \leq \frac{H_{TOTAL} * W * L}{Q}$$

simplifying,

$$\frac{Q}{A_s} \leq 5 * V_s$$

Summary

- RSC²™ complies with ELG for bottom ash transport water by cleaning up water for reuse in closed loop
- Consider system water balance and need for draining tanks for maintenance
- RSC²™ can be configured to provide advanced water treatment
  - Allows use of ash transport water as makeup to FGD
  - Provides flexibility to treat miscellaneous plant wastewater
    - Equipment washdown water
    - Consider isolating such water from ash transport water by using extra or spare RSC²™

THANK YOU

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