REINHOLD ENVIRONMENTAL Ltd.

2018 APC & Wastewater Round Table & Expo Presentation

July 23 & 24, 2018 in Lexington, KY / Hosted by East Kentucky Power Coop

AECOM's 4-R's Approach to ELG Compliance

By: Kimberly Deschenes

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Overview:

1. ELG Summary Review
2. AECOM's Approach to ELG Compliance
3. Review of Case Studies
4. Wrap-Up

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ELG Summary Review

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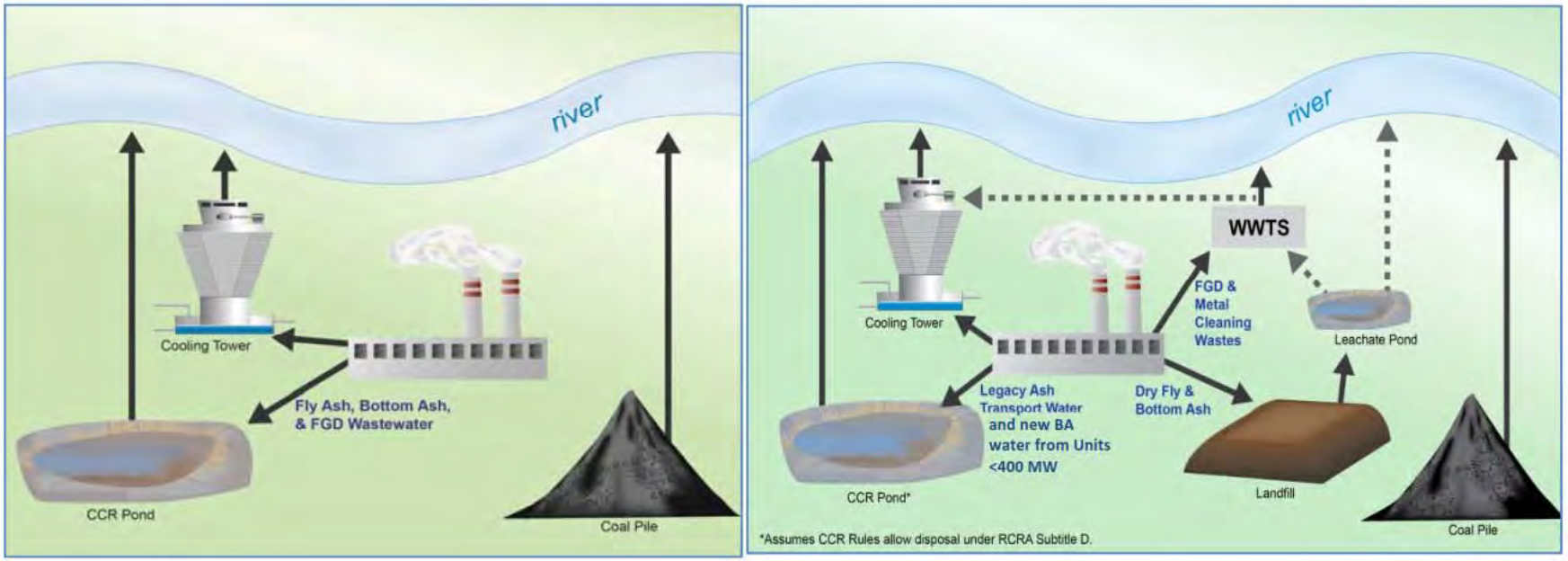
ELG Summary

Typical Layout for a Unit Pre-and Post ELG Compliance



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ELG Summary

ELG Discharge Limits for FGD Effluent Discharges

Constituent	Units	30-Day Average	1-Day Max
Arsenic (total)	microgram/liter	8	11
Mercury (total)	microgram/liter	356	788
Selenium (total)	microgram/liter	12	23
Nitrate/nitrate as N	microgram/liter	4.4	17
TDS	microgram/liter	-	-

ELG Limitations for Regulated Other Plant Flows

Waste Stream	TSS (mg/L)		Oil & Grease (mg/L)		pH	
	Max	30 Day Avg.	Max	30 Day Avg.	Min	Max
Low Volume	**100**	**30**	**20**	**15**	**6**	**9**
Coal Pile Run Off	**100**	**30**	**20**	**15**	**6**	**9**
Landfill Leachate	**100**	**30**	**20**	**15**	**6**	**9**
Non Chemical Metal Cleaning	**100**	**30**	**20**	**15**	**6**	**9**

ELG's for Ash Transport Water

- EPA removed fly ash transport water from the definition of low volume wastes and regulated the stream individually as Ash Transport Water.
  - Transport water is "any process wastewater that is used to convey fly ash, bottom ash or economizer ash from the ash collection or storage equipment, or boiler, and has direct contact with the ash.
  - Ash Transport water does not include low volume, short duration discharges of wastewater from minor leaks or minor maintenance events.
- Post rule conditions may require segregation of legacy wastewaters from newly-generated wastewaters, such as the ash transport streams.
  - Coal combustion residuals may be required to be handled dry and disposed of in landfills or beneficially reused.

Bottom Ash Conversion – Technology Options

Dry Technologies

- ✓ Pneumatic Vacuum Transport System
  - o Suitable for existing grade level bottom ash hopper configurations
- ✓ Dry Flight Conveyor Transport System
  - o Suitable for existing grade level bottom ash hopper configurations
- ✓ Combination of Dry Flight Conveyor & Pneumatic Transport System
  - o Suitable for existing grade level and some below grade bottom ash hopper configurations

Dewatering Technologies

- ✓ Submerged Flight Conveyor (directly beneath BA hopper)
  - o Suitable for existing grade level bottom ash hopper configurations
- ✓ Remote Submerged Flight Conveyor (remote from boiler)
- ✓ Cascading Passive Cell (CPC) Dewatering System (in plant & remote)
- ✓ Dewatering Bins, Settling and Surge Tanks (in plant & remote)
- ✓ Dewatering Bins and Clarifier Thickeners

Fly Ash Conversion – Technology Options

Dry Technologies

- ✓ Pneumatic Dilute Phase Vacuum Transport System
- ✓ Pneumatic Dilute Phase Pressure Transport System
- ✓ Pneumatic Dilute Phase Vacuum–Pressure Transport System
- ✓ Pneumatic Dense Phase Pressure Transport System

Dewatering Technologies

- ✓ Combination Clarifier/Thickeners, Horizontal Vacuum Belt Filters
- ✓ Combination Clarifier/Thickeners, Filter Presses, OTG Sand Filters

Dewater a Combination of Fly Ash, Bottom Ash, Economizer Ash & Gypsum

ELG's for FGD Wastewater

- ELG's set new numeric limits for the FGD wastewater discharge.
  - ELG's will regulate the concentration of arsenic, mercury, selenium and nitrate/nitrite in the wastewater.
- Limits developed by the EPA and implemented by the states.
- ELG limits will be incorporated during renewal of the plant NPDES permit.
- Compliance with ELG regulations is required "as soon as possible" following permit renewal.
  - Zero Liquid Discharge (ZLD) options may be eligible for maximum implementation date of December 31, 2023

Implementing FGD ELG Compliance

FGD Wastewater Processing to Meet ELG Limits

1. Advanced Wastewater Treatment
   - EPA Designated - Best Available Technology (BAT)
     - Physical/Chemical treatment followed by biological treatment.

2. Zero Liquid Discharge (ZLD)
   - ZLD technologies may be eligible for EPA Voluntary Incentives Program (VIP)
     - VIP extends compliance up to the December 31, 2023 deadline
   - ZLD can be more cost effective than treatment for discharge.
   - Eliminates the risk of new limits on wastewater discharge in the future.

FGD Wastewater Processing Technology Options

1. Treatment Options
   - Physical/chemical/biological treatment and discharge (BAT)

2. Zero Liquid Discharge (Disposal Options)
   - Brine concentrator & Crystallizer
   - Waste Water Spray Dryer/Spray Dryer Evaporator
   - In-Duct Injection
   - Stabilization with fly ash and disposal
   - Evaporation ponds

3. Wastewater Stream Reduction
   - High pressure reverse osmosis of FGD wastewater

AECOM's Approach to ELG Compliance

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Implementation Strategy

- ✓ **Phase 1: Assess Current Status**
- ✓ **Phase 2: Fill Data Gaps and Prioritize Needs**
- ✓ **Phase 3: Identify and Evaluate Solutions targeting plant-specific considerations and compliance options**
- ✓ **Phase 4: Engineer and Implement**

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Phase 1 – Assess Current Status

- ✓ **Compile and Review Existing Information at All Sites**
  - ✓ **Verify Water Balance**
  - ✓ **Assess whether additional field sampling is necessary**
- ✓ **Determine NPDES renewal schedule and limits**
- ✓ **Identify impaired streams and critical pollutants of concern**
- ✓ **Identify regulatory requirements and anticipated compliance schedules**
- ✓ **Determine Segregation of Internal Discharge Points for Low Volume Waste Waters**
- ✓ **Summarize Baseline status, Identify what needs to change and what will be effected by the change**

Phase 2 – Fill Data Gaps & Prioritize

- ✓ **Identify Gaps and determine best way to fill them in**
  - ✓ **Field sampling or Modeling**
- ✓ **Develop grouping criteria based on:**
  - ✓ **Compliance schedule**
  - ✓ **Level of Treatment Required**
  - ✓ **Existing Control Equipment Characteristics**
  - ✓ **Discharge Characteristics (e.g., flow, concentration of species) and requirements (limited discharge allowed; no discharge allowed, etc.)**
- ✓ **Develop Plant Priority Rankings**

Phase 3 – Identify and Evaluate Solutions

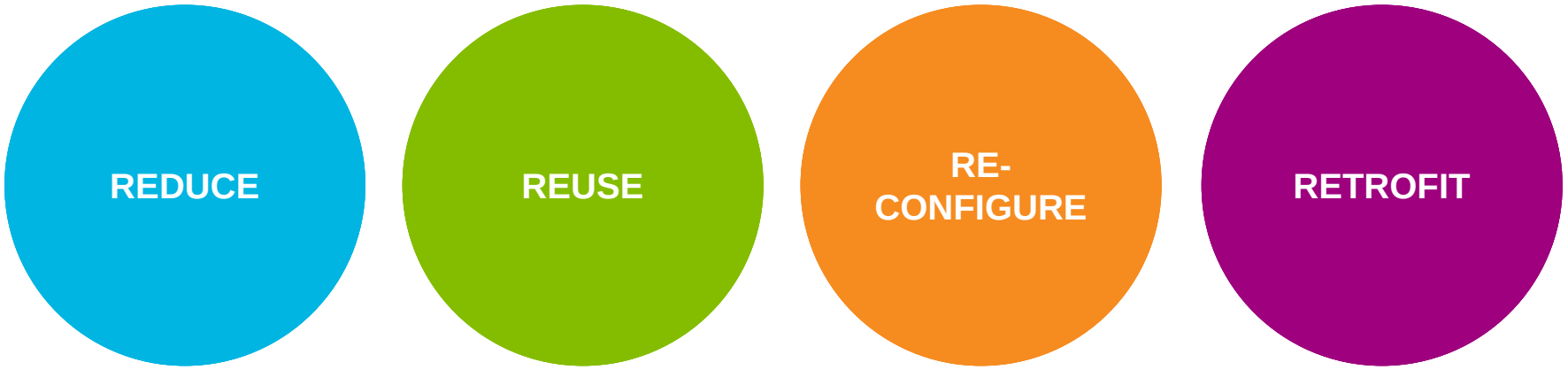
- ✓ **Consider future feed/effluent compositions**
- ✓ **Identify potential technologies or approaches**
- ✓ **Define treatment criteria and performance specifications**
- ✓ **Assess technical feasibility and performance**
- ✓ **Develop screening level cost estimates (considering both capital and O&M)**

Phase 4 – Engineering and Implementation

- ✓ **Permitting**
- ✓ **Complete Detailed Engineering and Design**
  - ✓ **Consider balance of plant requirements**
- ✓ **Procurement**
- ✓ **Construction**
- ✓ **Training, Commissioning and Start-up**
- ✓ **Performance Assessment and Troubleshooting**
- ✓ **Operations and Maintenance**

AECOM's Approach to ELG Compliance

Before you Treat, Explore the Four R's



We Won't Just Take an "End-of-Pipe" Approach to Compliance

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AECOM's Approach to ELG Compliance

Before you Treat, Explore the Four R's

- Most common approach taken by utilities is end-of-pipe wastewater treatment to achieve revised ELG limits
  - Little consideration for current FGD design or operation
- The cost of any approach is proportional to the purge rate
- Compliance solutions fall under one of two categories:
  - Eliminate or Treat Discharge
- In most cases AECOM has evaluated, it was possible to avoid installation or dramatically reduce the capacity of end-of-pipe wastewater treatment through operational modifications

AECOM's Approach to ELG Compliance

Before you Treat, Explore the Four R's

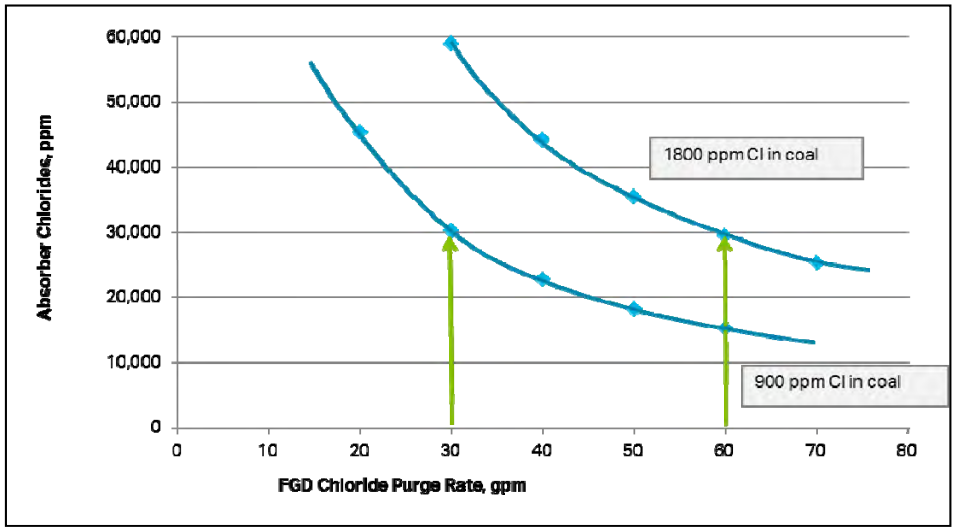
REDUCE-
the amount of wastewater being produced

- Only treat streams mandated by the ELG's
  - Eliminate sources not requiring treatment
- Minimize the size of streams necessary to treat
  - FGD Bleed Stream should be minimized based on chloride control
    - Analyze scrubber materials of construction
    - Determine threshold for chloride concentration
    - FGD Bleed should be the minimum to maintain chloride concentration below threshold
    - Bleed from the most concentrated stream

Approach: Reduce chloride purge stream, many times to levels where it can be "disposed" of

Chloride Analysis to Determine FGD Waste Water Purge Rate

		Mild	Moderate		Severe		Very Severe		
	Chlorides:	500	1,000	5,000	10,000	30,000	50,000	100,000	200,000
Mild	pH - 6.5	Type 316L SS or Duplex 2304 or Duplex 2003							
Moderate	pH - 4.5	316L or Duplex 2003	Type 317LMN or 22% Cr Duplex SS				6% Moly Superaust. SS	Nickel Alloy 625 etc.	
Severe	pH - 2.0	Type 317LMN SS		22% Cr Duplex SS	25% Cr Super Duplex SS				Nickel Alloy C276 etc.
Very Severe	pH - 1.0	Type 317LMN SS	6% Moly Superaustenitic SS			Nickel Alloy 625 etc.			



Significant reductions in ELG compliance cost possible by cycling up chlorides in FGD and/or reducing the amount of chlorides captured by the FGD process

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AECOM's Approach to ELG Compliance

Before you Treat, Explore the Four R's

REUSE-
As much wastewater as possible for other applications

- Based on water quality, determine possibility to reuse for other processes
- Consider lower-cost treatment options for treatment in order to reuse

RECONFIGURE-
Segregate streams requiring different levels of treatment & consolidate those that do

- Remove any streams that do not require treatment
- Separate streams that may need more treatment than others

RETROFIT-
Existing systems or operational procedures to treat effluent streams or make them easier to treat

- Evaluate existing equipment
  - Determine if existing equipment can be repurposed
  - Assess existing operational procedures to determine if optimizations are available

Case Studies

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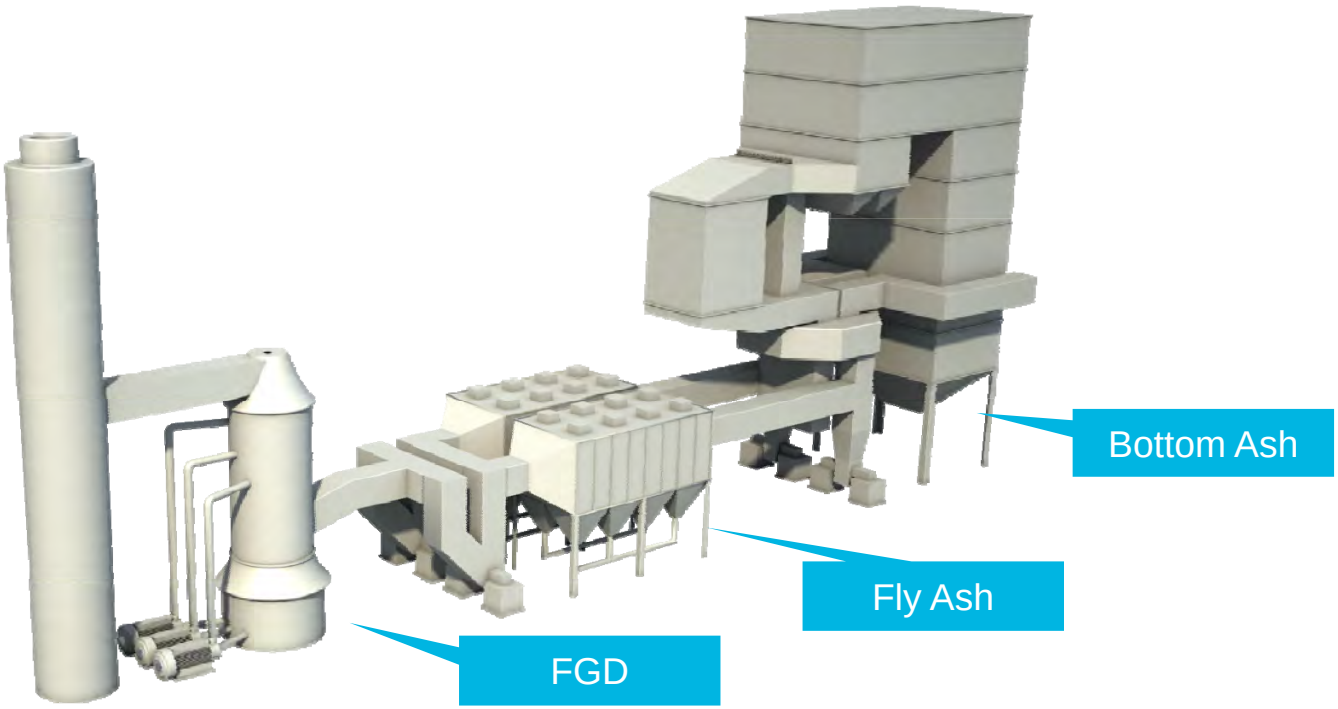
Case Studies



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Bottom Ash Conversion

Problem Statement

Identify the best suited, value engineered, Bottom Ash Dewatering technology configuration which satisfies site specific criteria and constraints

Approach

- Performed initial screening analysis to determine “pass” technologies qualifying for detailed analysis
- Developed system and equipment design basis, optimal conceptual arrangements and process diagrams for each “pass” technology configuration
- Developed capital, NPV & lifecycle costs for each configuration
- Performed weighted criteria analysis to determine and select the best suited, site-specific technology

Solution

- Concluded that the Bottom Ash Dewatering technology to be implemented would utilize two (2) 100% capacity remote submerged flight conveyors, one operational and one spare with recirculated (ZLD) bottom ash transport water.
- Eliminated need for costly dry ash conversion

RETROFIT REUSE

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Fly Ash Conversion

RETROFIT

Problem Statement

Identify the best suited, value engineered, Fly Ash Dry / Dewatering and Transport technology configuration which satisfies site specific criteria and constraints

Approach

- Initial screening analysis to determine “pass” technologies qualifying for detailed analysis
- The initial analysis revealed that only one technology, pneumatic dry transport system, passed
- Developed design bases, conceptual arrangements and process diagrams for two alternate pneumatic transport technology configurations:
    1. Vacuum fly ash collection and transport system
    2. Vacuum-pressure fly ash collection and transport system
- Developed capital, NPV & lifecycle costs for each configuration
- Performed weighted criteria analysis to determine and select the best suited, site-specific technology

Solution

- Concluded that the technology configuration to be implemented would utilize a Pneumatic, Dry, Vacuum – Pressure Fly Ash Collection, Transport and Storage System configured to support fly ash sales and/or conditioned fly ash disposal to on site landfill

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WFGD Conversion to Dry Product

Problem Statement

Power plant approaching the capacity limit in their scrubber pond. High cost associated with opening a new pond.

Approach

- AECOM performed a study to evaluate blending thickened FGD slurry with landfill fly ash
- Conceptual design and costs developed to modify the system to produce a dry stable product suitable for landfill
- The condition of existing equipment, tanks, buildings, piping, etc. were evaluated for re-use to reduce the cost and time to implement

Outcome

- AECOM determined that the FGD slurry and fly ash can be blended to produce a stable landfill product

RECONFIG

RETROFIT

Mix FGD wastewater with scrubber solids, gypsum/sulfite cake, fly ash and lime (if necessary) to produce a stable and fixated waste material

Place fixated material in dry landfill

Return leachate and contact water to FGD

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New WFGD Wastewater Purge Stream

Problem Statement

A utility needed to begin washing their gypsum so, as a result, needed to identify another means of purging chlorides from the FGD process to maintain chlorides within design limits

Approach

- Developed a system material balance
- Completed a feasibility study to evaluate several options for purging chlorides while maintaining the process as ZLD
- Conducted laboratory investigations to evaluate the viability of low-cost options
- Determined that by “wetting” the bottom ash with FGD purge water, adequate chlorides would be retained by the decanted ash

Outcome

- For a very minor cost of retrofit, was able to maintain the FGD process as ZLD
- Implemented approach had no detrimental impact on bottom ash handling or disposal

RETROFIT

WFGD Wastewater Treatment Conversion

Problem Statement

The FGD process was operating with a chloride purge rate of ~200 gpm. A phys/chem process was already in place, but a biological treatment system would have to be added for ELG compliance. AECOM was tasked with finding a lower cost option for compliance.

Approach

- Evaluated the system water and chloride balance, as well as the materials of construction used throughout the FGD process
- Determined the maximum chlorides that the FGD system could operate at, which translated into a purge rate of 30 gpm or less
- Evaluated the impact of using the FGD purge as makeup water for the two other FGD units at the plant which operate as ZLD

Outcome

- For a very minor capital investment, AECOM was able to help the plant achieve ZLD for all of their scrubber processes by sending the FGD purge to the other FGD processes
- Making this change eliminated the need to operate the existing phys/chem system and avoided the addition of a bio system

REDUCE

REUSE

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Large WFGD Purge Stream

Problem Statement

The utility was having to purge a significant amount of water in order to achieve contract moisture levels for the gypsum being produced, due to high fines content.

Approach

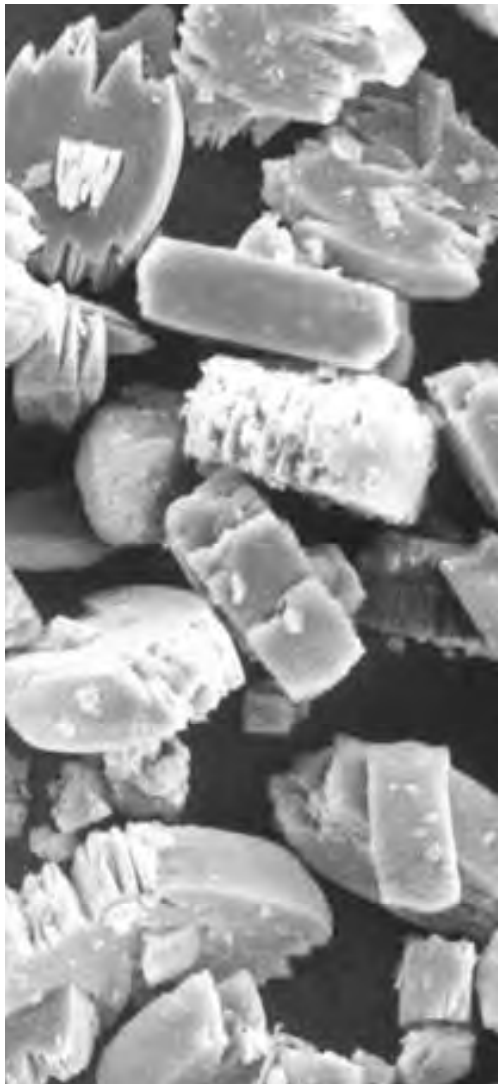
- Evaluated the process and confirmed the source of the fines was the limestone being used, and how it was generating small gypsum crystals
- Recommended a switch to a limestone known to produce good gypsum crystals
- With fines eliminated as the constraint dictating purge requirements, determined an acceptable reduction in volume that kept the process operating within chloride limits

REDUCE

RETROFIT

Outcome

- Eliminated the need for a fines purge stream – 100% of the hydrocyclone could be sent back to the FGD process
- By cycling chlorides up to the design constraints of the process, reduced the chloride purge stream from 800 gpm to just 30 gpm, positioning the client for implementing a low-cost solution for ELG compliance



Sometimes it's the Make-Up Water

Problem Statement

For two separate power plants, AECOM determined that chlorides in the FGD makeup water were significantly impacting the amount of water that had to be purged

Approach

- For two separate power plants, AECOM determined that chlorides in the FGD makeup water were significantly impacting the amount of water that had to be purged

REDUCE

Outcome

- Plant #1 – showed how the need for an FGD purge stream could be eliminated by systematically choosing when water from the river was used to fill the reservoir supplying FGD makeup water
- Plant #2 – showed that by treating the makeup water rather than the FGD effluent, the FGD purge could be reduced to levels that would allow for ZLD technologies to be employed

Low Volume Wastewater Treatment

Problem Statement

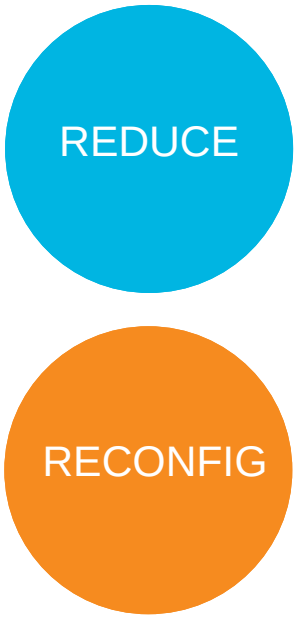
Combined Discharge Stream had showed constituents outside the limits delegated by ELG's, indicating a significant sized stream needing treatment.

Approach

- Evaluated the system and completed waste stream characterization.
- Breaking down individual streams some Low Volume Waste streams met ELG regulations without treatment.
- Other streams, LVW, landfill leachate and coal pile run-off had TSS and pH outside of the designated ELG discharge limits and would need treatment needing treatment.

Outcome

- Only streams needing treatment were separated and rerouted to a waste water treatment facility.
- Initial design flow for treatment was 51 MGD. The plant was able to reduce the size of the stream needing treatment to a peak flow of 30 MGD and average flow of 15 MGD.
- Reduction in flow significantly decreased the capital investment and operating cost to be in compliance with the ELGs.



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Wrap-Up

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RECAP:

Before treatment consider the 4-R's to ELG compliance

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Questions

Thank You