

REINHOLD ENVIRONMENTAL Ltd.



**2015 APC Round Table  
& Expo Presentation**

July 13 & 14, 2015, in Atlanta, GA / Hosted by Southern Company

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## **Weighing the Economics of Options for Converting to Dry Ash Disposal**

Prepared for: Reinhold APC Roundtable Conference  
Presented By: Kevin L. McDonough

*14 July 2015*



# Discussion Overview

**Regulatory Update & Implications**

**Activity Summary & Technology Selection Criteria**

**Bottom Ash Wet-to-Dry Conversion Technology**

**Dry Bottom Ash Cost & Feature Comparison**



# Safety Moment

## “Haste Makes Waste”



# Key Regulatory Actions

## Coal Combustion Residuals (CCR)

- Issued December 19, 2014
- CFR Publication: April 17, 2015
- Goals
  - ✓ Groundwater Protection Benefits
  - ✓ Preventing Future CCR Impoundment Catastrophic Failures



## Effluent Limitations Guidelines (ELG)

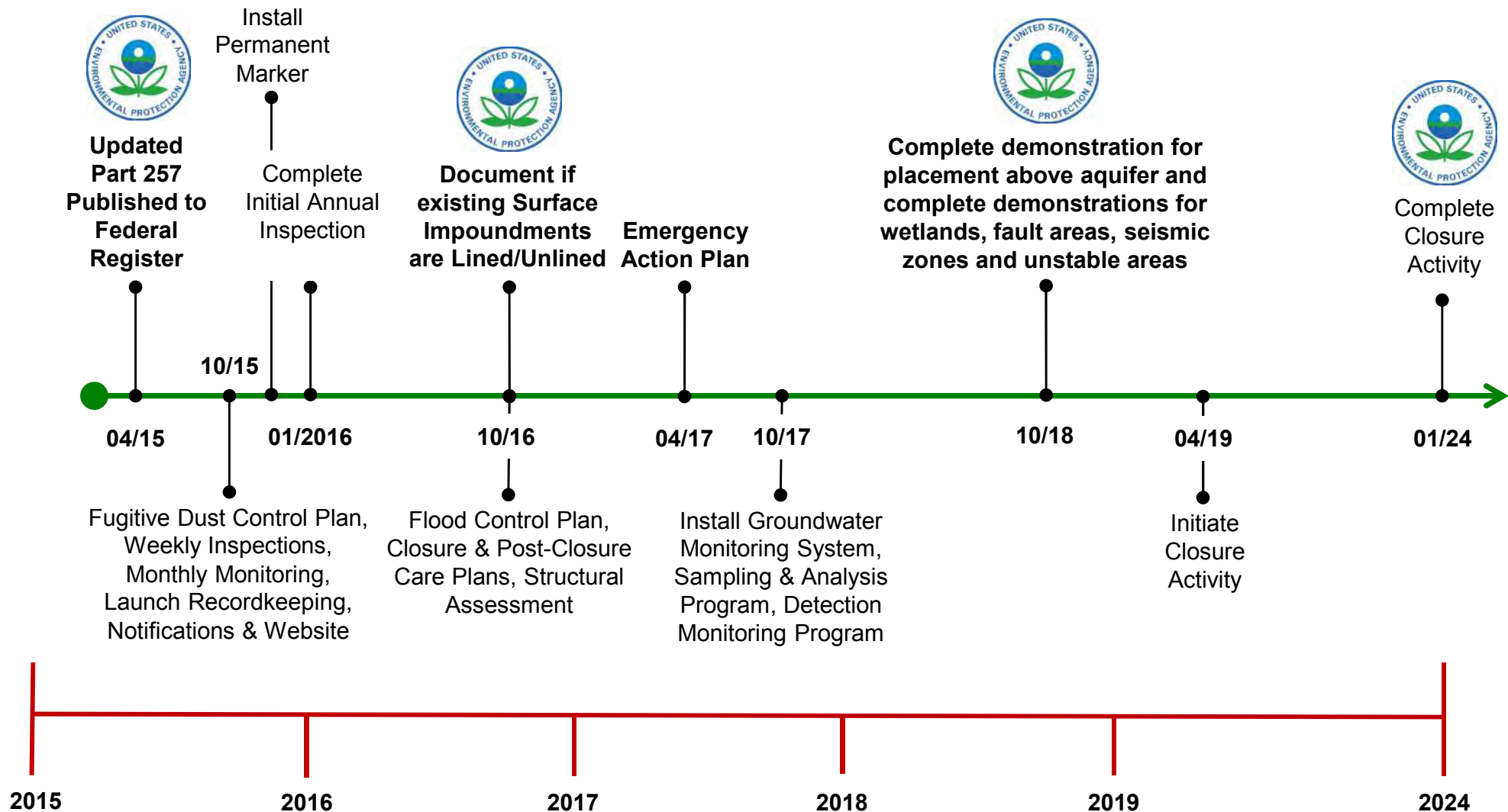
- Proposed Rules Issued April 2013
- Final Rules: Consent Decree = September 30, 2015
- Goals
  - ✓ Strengthen Steam Electric Power Plant Discharge Controls
  - ✓ Reduce Surface Water Pollutant Discharges



- **Regulation Focus Areas:**
  - Location Restrictions: Aquifer, Wetlands, Fault Zones, Seismic Zones, Unstable Areas
  - Design Criteria: Lined/Unlined, Leaking/Not Leaking, Structural Integrity
  - Operating Criteria: Flood Control, Fugitive Dust Control, Inspections (Weekly/Monthly/Annual)
  - Groundwater Monitoring and Corrective Action
  - Closure Requirements and Post-closure Care
  - Recordkeeping, Notification, and Internet Posting

# Coal Combustion Residuals (CCR) Ruling

## Regulatory Timeline – Existing CCR Surface Impoundments



# ELG Ruling

## Steam Electric Main Regulatory Options



Wastestreams	Technology Basis for the Main Regulatory Options			
	3a	3b	3	4a
FGI		Chemical Precipitation + Biological Treatment for units		ation + ment
Fly				g
Bottom				losed- 00W; equal to 00MW
Comb				nt (T)
<b>FGMC Wastewater</b>	Dry Handling	Dry Handling	Dry Handling	Dry Handling
<b>Gasification Wastewater</b>	Evaporation	Evaporation	Evaporation	Evaporation
<b>Nonchemical Metal Cleaning Wastes</b>	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation

**EPA will choose the preferred option and issue as final on 30 September 2015**

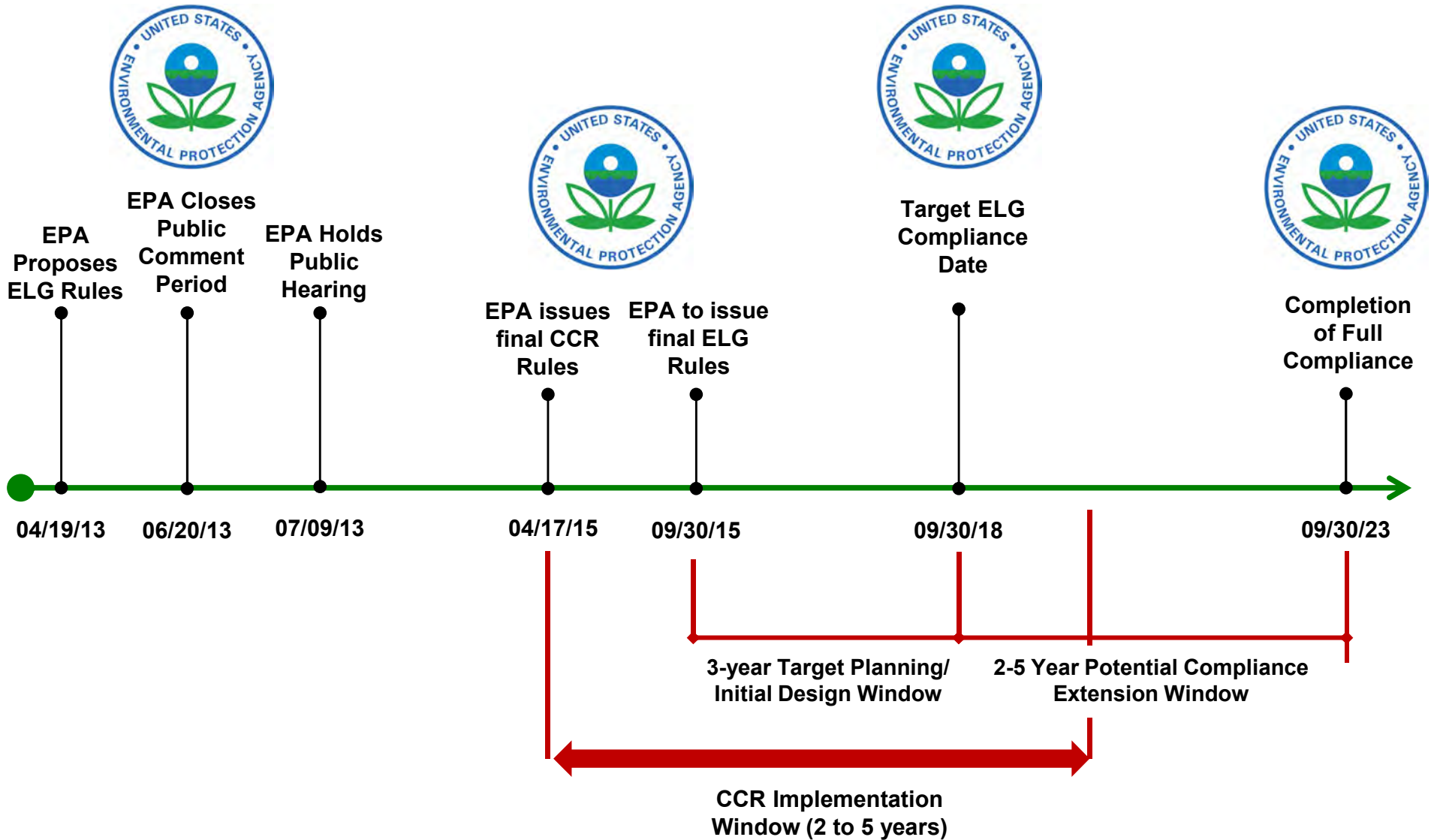


### Bottom Ash BPT Requirements

Pollutant or Pollutant Property	BPT Standard Options 3a, 3b, 3 and 4a (<400 MW)	
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)
TSS	100.0	30.0
Oil and Grease	20.0	15.0

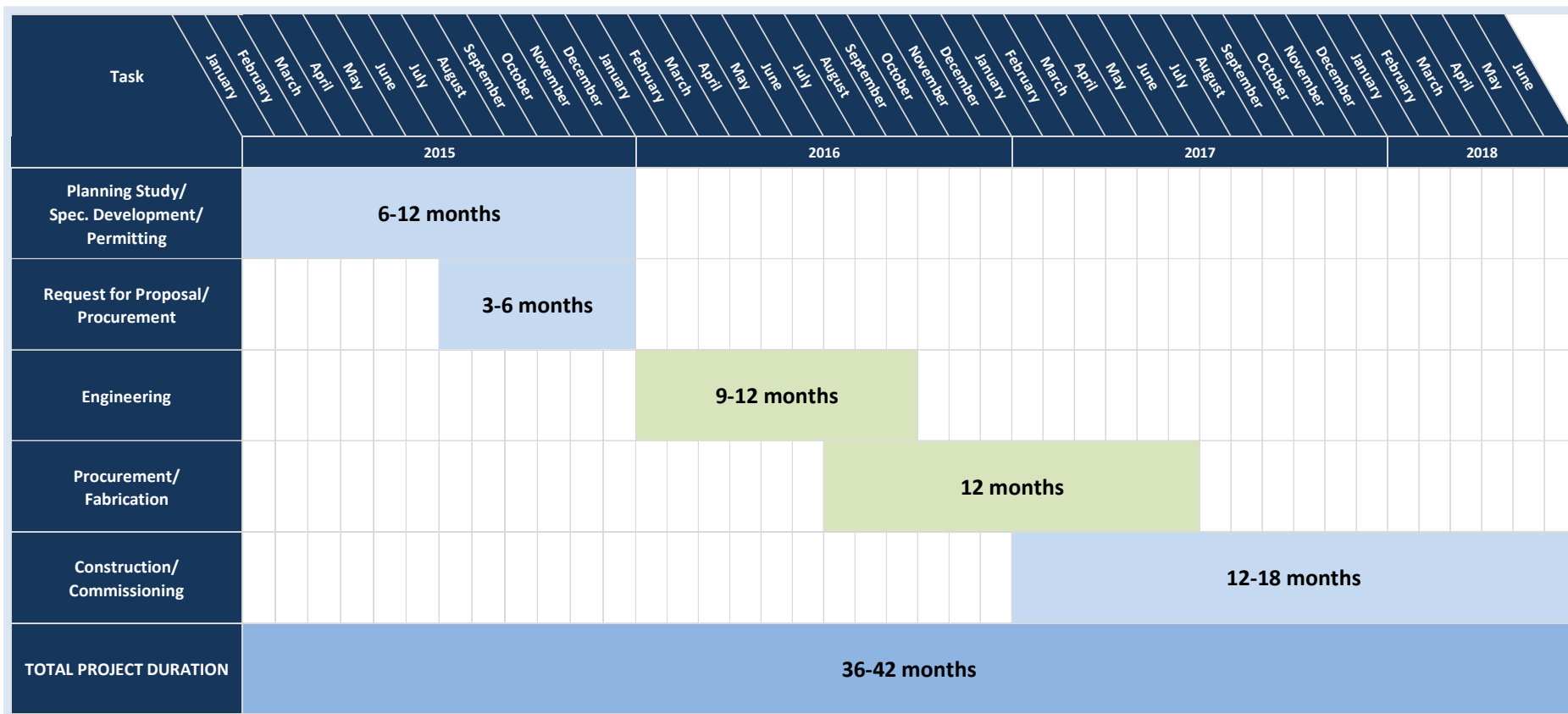
# ELG & CCR Ruling

## Regulatory Timeline



# ELG & CCR Ruling

## Typical Wet-to-Dry Ash Conversion Project Durations



- Rules will likely drive dozens of WTD ash conversion, pond closure, dry landfill and wastewater treatment projects
- Potential to test the capacity of Utilities, AE Firms, Technology Providers & Installation Contractors



# Implications of ELG Ruling

## Fly Ash Wet-to-Dry Conversions (All 4 Options)

- Remaining wet fly ash systems will be converted to dry systems
- Existing wet back-up systems will be decommissioned and will likely require additional redundancy for primary dry systems

## Bottom Ash Wet-to-Dry Conversions

- Under 3 of 4 regulatory options, utilities will have to determine if existing impoundments can meet BPT requirements (TSS, oil and grease)
- Utilities will also have to weigh BA WTD conversion costs against CCR Subtitle D requirements: “Must remove solids and retrofit with a composite liner or cease receiving CCR’s within 5 years of effective date and close the Unit”
- For Option 4a, all generating units >400 MW will have to implement BA WTD conversions; generating units <400 MW will have to evaluate BA WTD conversion costs against BPT requirements



# Discussion Overview

Regulatory Update & Implications

**Activity Summary & Technology Selection Criteria**

Bottom Ash Wet-to-Dry Conversion Technology

Dry Bottom Ash Cost & Feature Comparison

# UCC Wet-to-Dry Summary of Activity

Recently Completed Projects (prior 3-5 years)

Presentation Prepared For:



Owner/Plant	Scope	Technology
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Fly Ash WTD	Dense Phase Vacuum/Pressure System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Western Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System

# UCC Wet-to-Dry Summary of Activity

Recently Completed / Active Projects (3 years to present)

Presentation Prepared For:



Owner/Plant	Scope	Technology
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System
Eastern Plant	Fly & Bottom Ash WTD	Dilute Phase V/P (FA) & CDR (BA) System
Midwestern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Fly Ash WTD	Dilute Phase Vacuum System
Eastern Plant	Bottom Ash WTD	Pneumatic Ash Extractor (PAX) / Vacuum
Eastern Plant	Bottom Ash WTD	Dewatering Bin/Settling Tank/Surge Tank
Midwestern Plant	Bottom Ash WTD	CDR System with Remote SFC's
Midwestern Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Eastern Plant	Bottom Ash WTD	Remote SFC Dewatering System
Eastern Plant	Bottom Ash WTD	CDR System with Remote SFC
Western Plant	Bottom Ash WTD	Submerged Flight Conveyor (SFC)
Eastern Plant	Bottom Ash WTD	CDR System with Remote SFC's
Midwestern Plant	Bottom Ash WTD	CDR System with Remote SFC's/Clarifiers
Midwestern Plant	Bottom Ash WTD	Remote SFC / Clarifier System
Western Plant	Fly Ash WTD	Dilute Phase Vacuum/Pressure System



# Technical Design Considerations

Wet-To-Dry Ash Conversion Project Design Criteria	
Budget	Plant Water Balance Considerations
Outage Requirements	Ash Conveying Capacities
Physical Parameters	Conveying Distance Considerations
Site Environmental Considerations	Operations & Maintenance Issues
Ash Characteristics	Multiple Unit Synergies
Ash Marketability/Beneficiation	Unburned Carbon Concerns

- Evaluate Criteria Against Multiple Alternatives
- Determine Optimal Solution for each Plant
- “One Size Does Not Fit All”



# Discussion Overview

Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

**Bottom Ash Wet-to-Dry Conversion Technology**

Dry Bottom Ash Cost & Feature Comparison



### **Submerged Flight Conveyor – SFC™**

- Long-Term Economical Choice (Low O&M Costs)
- Simple Solution if Space is Available



### **Re-Circulating Hydraulic System (2 Options)**

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements



### **Clarifying Hydraulic System**

- No Changes Under Boiler, Uses Existing Hopper
- Minimizes Outage Requirements
- Allows for Water Reuse (subject to final ELG rules)



### **Dry Hopper Pneumatic Conveying – PAX™**

- No Water, Returns Heat Back to Boiler
- Easiest 100% Dry Option to Move Ash Out of Boiler Building

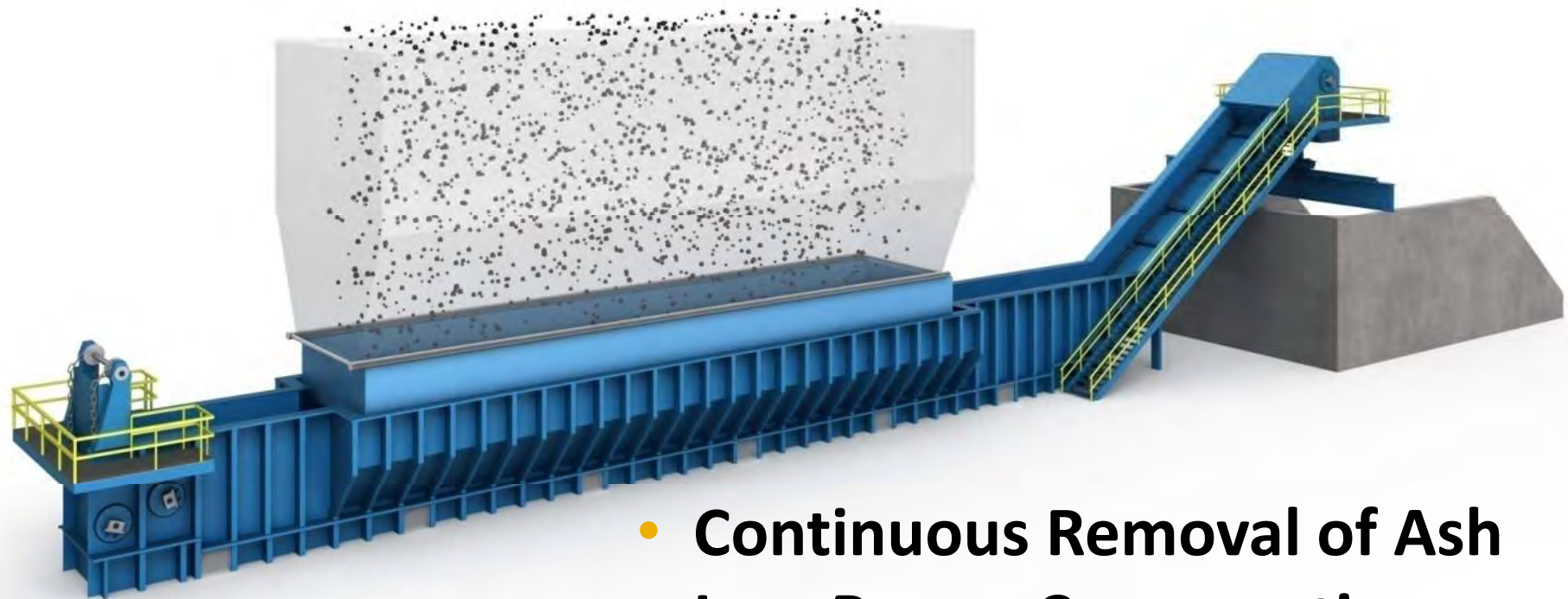


# Submerged Flight Conveyor (SFC) System

# Bottom Ash WTD Conversion Alternatives

## Submerged Flight Conveyor (SFC)

Presentation Prepared For:



- **Continuous Removal of Ash**
- **Low Power Consumption**
- **Easily Incorporates Mill Rejects**
- **Industry Standard on New Units for past 30 years**

# Bottom Ash WTD Conversion Alternatives

## Submerged Flight Conveyor (SFC)

Presentation Prepared For:





# Decision Analysis Favors SFC™ System

	Technology Alternatives								
1 = Worst, 5 = Best	Scale	SFC		Re-Circ System		R-SFC/Clarifier		PAX	
	1-5	(Mechanical)		(Hydraulic)		(Hydraulic)		(Pneumatic)	
Criteria for Determining									
<p><b>Decision Analysis Favors SFC™ System if criteria are weighted for:</b></p> <ul style="list-style-type: none"> <li>• Total Installed Cost</li> <li>• Reduced O&amp;M Costs</li> <li>• Reduced Wastewater Profile</li> </ul>									
Unburned Carbon / Boiler Efficiency	1	1	1	1	1	1	1	5	5
<b>Weighted Total Score</b>			<b>90</b>		<b>85</b>		<b>69</b>		<b>72</b>



# Conventional Dewatering Bin System

# Bottom Ash WTD Conversion Alternatives

## Conventional Dewatering & Recirculation System

Presentation Prepared For:



- **Minimal Outage Time for Conversion**
- **Continue to Use Existing Bottom Ash Hoppers**
- **Easily Incorporates Mill Rejects**

# Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Settling and Surge Tanks

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

## Conventional Dewatering & Recirculation System

Presentation Prepared For:



- **Large Equipment Scope**
- **Greater Foundation Design Requirements**
- **Inconsistent Bottom Ash Dewatering**
- **Higher Maintenance**



# Continuous Dewatering & Recirculation (CDR) System

# Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



- CDR System with Remote SFC's
- Combines SFC Technology with Conventional Recirculation System

# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



## ■ Technical Design Features

### ■ Reduced Equipment Scope

- Combines Dewatering and Particulate Settling into Single Unit

### ■ Provides Multiple Unit Synergies

- Can Receive Sluice Lines from Multiple Units

### ■ Reduced Foundation Design Requirements

- Smaller Footprint than Traditional BA WTD Systems
- Reduced Construction Costs

### ■ Consistent Bottom Ash Dewatering

- Continuous Dewatering Up SFC Incline Section
- Dewateres Bottom Ash to Moisture Levels Suitable for Landfill Disposal or Beneficial Use

# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversions

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:





## ■ Technical Design Features

### ■ Uses Proven SFC Technology

- Robust Design Suitable for Utility Applications
- Standard Sections with Flexibility for Varying Sizes/Flows

### ■ Closed-Loop System

- Sluice Water is Recirculated to Powerhouse
- Runoff Water from Bunker is Returned to SFC
- Zero Discharge to the Environment

# Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's

Presentation Prepared For:



## ■ Technical Design Features

- Achieves Particulate Removal Suitable for Closed-Loop System
  - 400 ppm (24-hour average)



# Water Balance/Wastewater Considerations

Bottom Ash Sluice Water Demands for CDR & Dewatering Bin Systems

Presentation Prepared For:



## Typical Water Requirements:

- High Pressure Sluice Conveying Water = 2,500-3,500 gpm
- Low Pressure Cooling Water/Seal Trough Flushing/Make-Up Water Supply = 150-300 gpm/unit





## Water Balance Key Considerations

- **Losses**
  - Evaporation
  - Water Retention in Ash
  - Hopper Leakage
  - Seal Trough Flushing
- **Gains**
  - Chain Sprays – SFC (for CDR System)
  - Seal Water from Pumps
  - Rain
- **Will Have Net Loss of Water from System**
- **Water Balance can be complex**



## Freeze Protection / Cold Weather Considerations

- Continuous Water Flow from Existing BA Hopper Overflows
- Heat Trace/Insulation for Service Water Piping
- Potential Enclosures/Buildings





## Freeze Protection / Cold Weather Considerations

- Potential Enclosures/Buildings



# Bottom Ash WTD Conversion Alternatives

Continuous Dewatering & Recirculation System (CDR) with Remote SFC's



1 = Worst, 5 = Best	Technology Alternatives				
	Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)	PAX (Pneumatic)
<b>Criteria for Determining</b>					
<div style="background-color: #003366; color: white; padding: 20px; border: 2px solid #003366;"> <p><b>Decision Analysis Favors CDR™ System if criteria are weighted for:</b></p> <ul style="list-style-type: none"> <li>• Reduced Outage Requirements</li> <li>• Physical Space Limitations</li> <li>• Multiple Unit Synergies</li> </ul> </div>					
<b>Weighted Total Score</b>		69	103	97	75



# Remote SFC & Clarifier System

# Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's

Presentation Prepared For:



# ELG Ruling

## Steam Electric Main Regulatory Options



Wastestreams	Technology Basis for the Main Regulatory Options			
	3a	3b	3	4a
FGI		Chemical Precipitation + Biological Treatment for units		ation + ment
Fly				g
Bottom				losed- 00W; equal to 00MW
Comb				nt (T)
<b>FGMC Wastewater</b>	Dry Handling	Dry Handling	Dry Handling	Dry Handling
<b>Gasification Wastewater</b>	Evaporation	Evaporation	Evaporation	Evaporation
<b>Nonchemical Metal Cleaning Wastes</b>	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation	Chemical Precipitation

**EPA will choose the preferred option and issue as final on 30 September 2015**



### Bottom Ash BPT Requirements

Pollutant or Pollutant Property	BPT Standard Options 3a, 3b, 3 and 4a (<400 MW)	
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)
TSS	100.0	30.0
Oil and Grease	20.0	15.0



## ■ Technical Design Features

### ■ Uses Proven SFC & Clarifier Technologies

- Similar features/benefits of CDR System
- Additional Clarification Phase to reduce particulate carryover (TSS)
- Can be recycled or designed for once-through system

### ■ Once-Through System

- Bottom Ash Sluice Water may be used as medium to manage other wastewater streams (subject to Effluent Limitations Guidelines)
- Can be designed for BPT standards for discharge
  - ◆ 30 day running average < 30 ppm
  - ◆ Daily maximum < 100 ppm

# Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Bottom Ash Dewatering and Clarification System with Remote SFC's



	Technology Alternatives					Total	
	1 = Worst, 5 = Best	Scale	SFC	Re-Circ System	R-SFC/Clarifier		PAX
		1-5	(Mechanical)	(Hydraulic)	(Hydraulic)		(Pneumatic)
Water						10	
Out						5	
Tot						6	
Op						8	
Pov						6	
Bo						20	
Mu						15	
Ne						0	
Unburned Carbon / Boiler Efficiency						5	
<b>Weighted Total Score</b>			<b>69</b>	<b>103</b>	<b>117</b>	<b>75</b>	

**Decision Analysis Favors Clarification System if criteria are weighted for:**

- Need Clarified water for Plant Water Balance (Make-up Water Source)
- Prefer Ability to Discharge Water



# Pneumatic Ash Extractor (PAX) System

# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



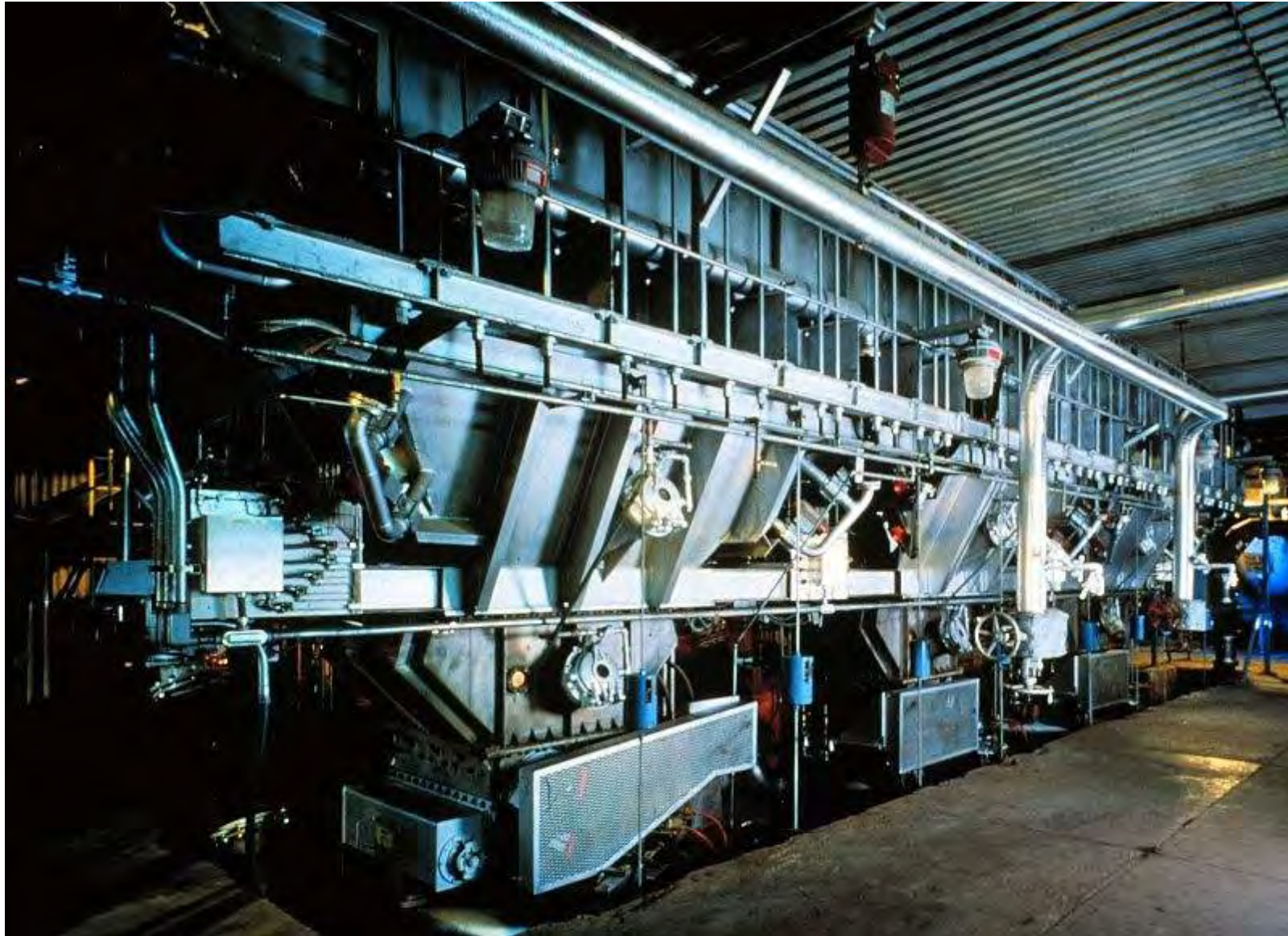
- Easily Retrofitted Around Structural Barriers
- Provides Improved Heat Recovery and Boiler Efficiency
- Does Not Require Water



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

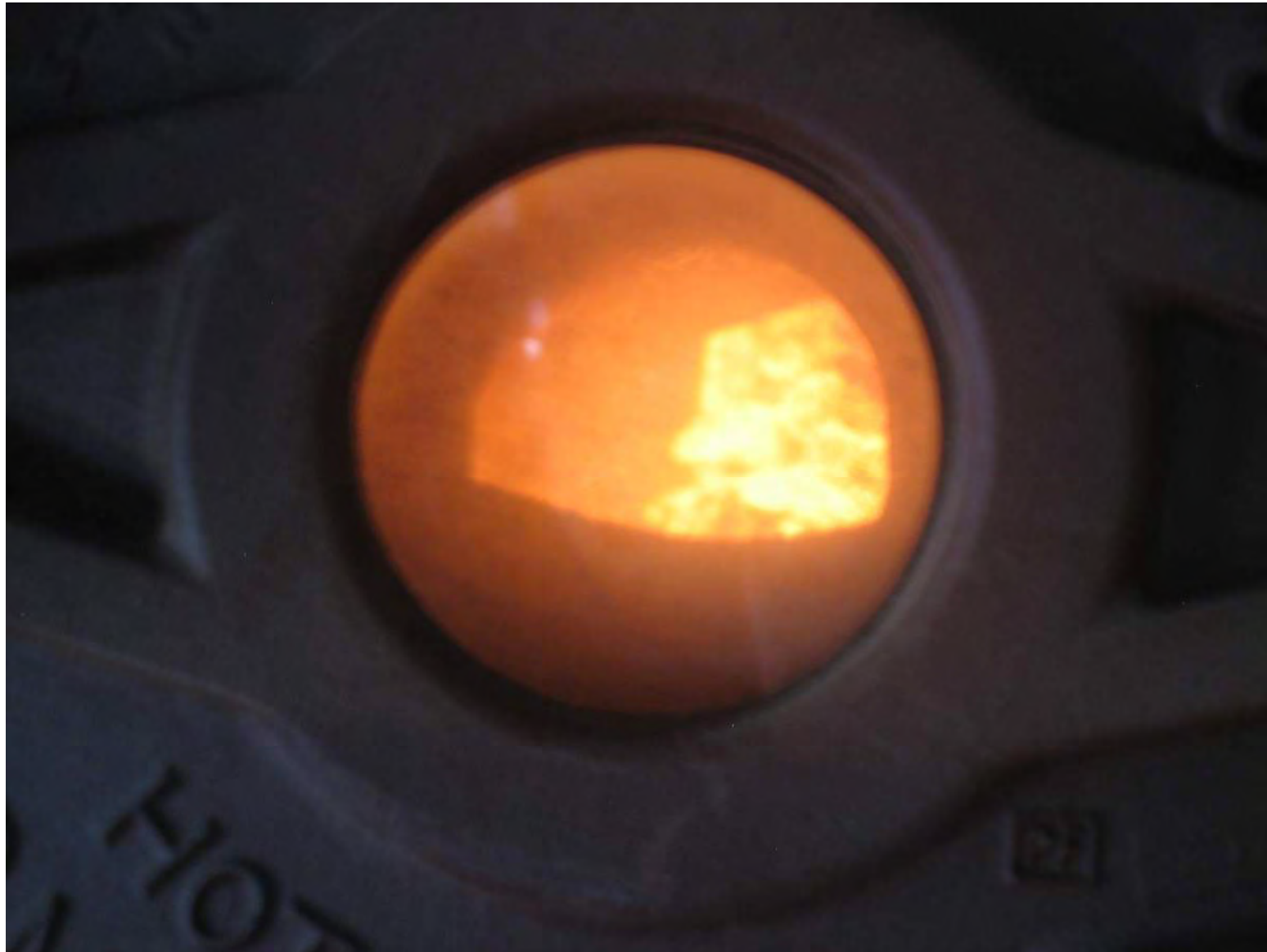
Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

## Pneumatic Ash Extractor (PAX)

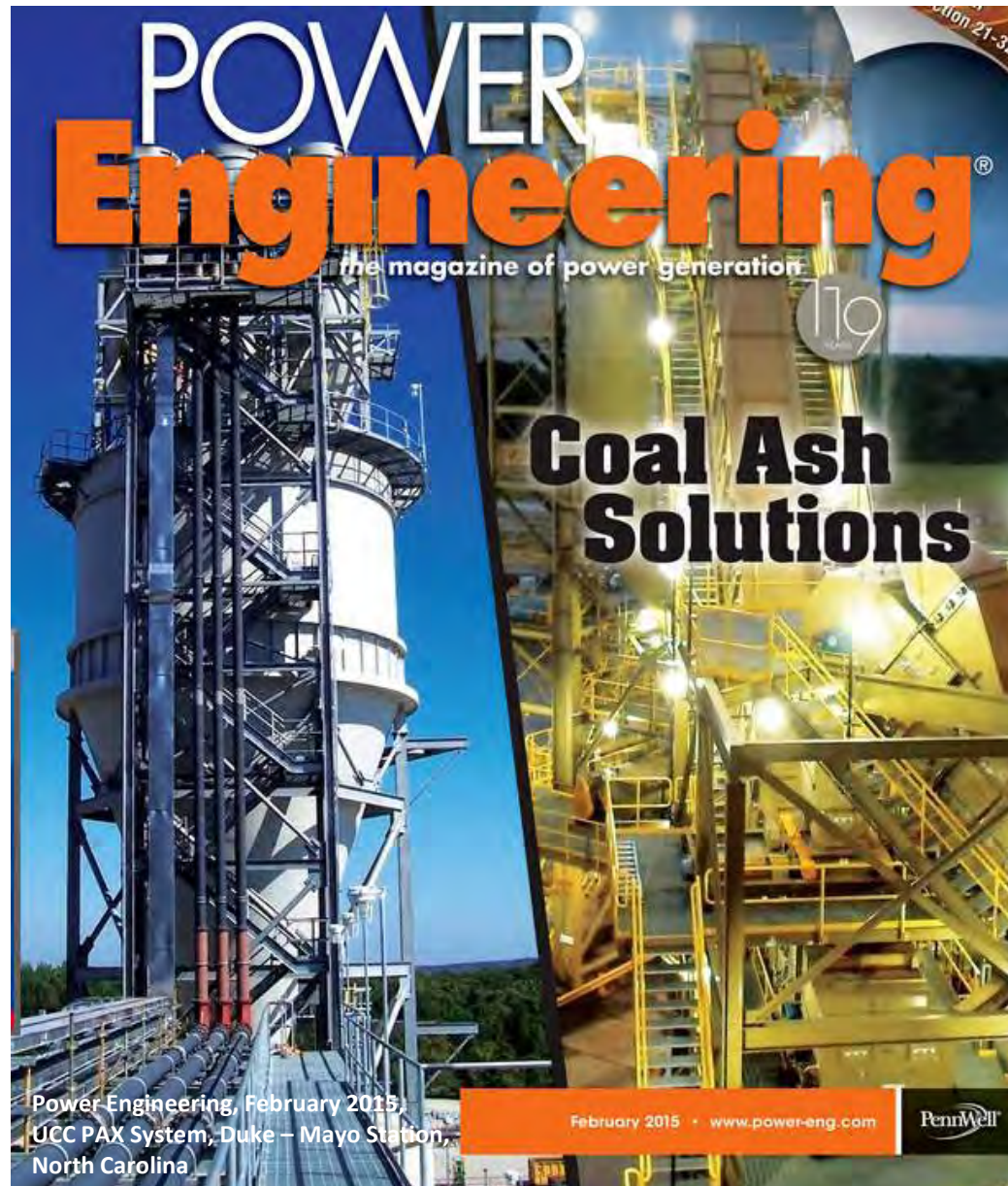
Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)

Presentation Prepared For:



# Bottom Ash WTD Conversion Alternatives

Pneumatic Ash Extractor (PAX)



		Technology Alternatives								
1 = Worst, 5 = Best		Scale 1-5	SFC (Mechanical)	Re-Circ System (Hydraulic)	R-SFC/Clarifier (Hydraulic)	PAX (Pneumatic)				
W	O	T	O	P	B	M	N	Decision Analysis Favors PAX™ System if criteria are weighted for:		tal
								<ul style="list-style-type: none"> <li>• 100% Dry Solution</li> <li>• Physical Space Limitations</li> <li>• Unburned Carbon / Boiler Efficiency</li> </ul>		5
Unburned Carbon / Boiler Efficiency		4	0	0	0	0	0	0	5	20
Weighted Total Score				82		99		83		108



# Additional Water Balance & Wastewater Considerations



### Existing Systems:

- Most Mill Reject (Pyrites) removal systems use sluice conveying
- Most are connected to the Bottom Ash Sluice Conveying System and ponds, while some are independent sluice systems that discharge to separate ponds
- Some plants have Pyrites Dewatering Bins
- 100% Dry Solutions require separate systems



### Key Considerations:

- Not clearly defined in proposed ELG
- Many plants are now requesting separation of Bottom Ash and Mill Rejects to ensure Bottom Ash Marketability
- 100% Dry Systems can be difficult retrofits (physical space, cost)
- Can be readily connected to CDR or SFC systems
- Can have an independent pyrites dewatering system

# Water Balance/Wastewater Considerations

## Pyrites System Considerations

Presentation Prepared For:



## Pyrites Dewatering Bins





### Existing Systems:

- Over half of Economizer Ash removal systems use sluice conveying
- Of these wet systems, most are connected to the Bottom Ash Sluice Conveying System or SFC's
- Some systems collect Economizer Ash with Dry Flight Conveyors (DFC) and transfer to Vacuum System or Sluice Conveying System
- Balance are typically connected to Dry Fly Ash Vacuum System



### Key Considerations:

- Not clearly defined in proposed ELG
  - Economizer Ash = Fly Ash (when collected with Fly Ash System)
  - Economizer Ash = Bottom Ash (when collected with Bottom Ash System)
- 100% Dry Solutions can likely be tied into existing Fly Ash Systems
- Dry collection eliminates potential concern for fines concentrations in closed-loop dewatering systems



# Discussion Overview

Regulatory Update & Implications

Activity Summary & Technology Selection Criteria

Bottom Ash Wet-to-Dry Conversion Technology

**Dry Bottom Ash Cost & Feature Comparison**



# Dry Bottom Ash – Cost Comparison

		Re-Circ Tanks	CDR	R-SFC & Clarifier	SFC	PAX
Costs	Design and material Costs	\$\$\$ (2+ units)	\$\$\$ (2+ units)	\$\$\$ (2+units)	\$\$ (per unit)	\$\$\$ (per unit)
	Installation Cost	\$\$\$\$ (2+ units)	\$\$\$ (2+ units)	\$\$\$\$ (2+ units)	\$\$ (per unit)	\$\$\$\$ (per unit)
	O&M Cost	\$\$\$	\$\$	\$\$\$	\$	\$\$*
Outage Requirement	Pre-Outage Construction Duration	6 months	4 months	5 months	2 months	6 months
	Outage Construction Duration	0-3 days	0-3 days	0-3 days	4-6 weeks	8 weeks
Design & Manufacturing Lead Time		14-18 months	14-16 months	14-16 months	14-16 months	14-18 months



# Dry Bottom Ash – Features Comparison

		Re-Circ Tanks	CDR	R-SFC & Clarifier	SFC	PAX
Boiler & Yard Space	Yard Piping Corridor	Yes	Yes	Yes	No	Yes
	Boiler House Exit Corridor for Mechanical Conveyor	No	No	No	Yes	No
	Equipment Area Foot Print	6500 sq ft	4,000 sq ft	6000 sq ft	1500 sq ft	1500 sq ft
Multiple Unit synergies	Storage Bin Serves more than one boiler	Yes	Yes	Yes	No	Yes
Easily Incorporates Mill Rejects		Yes	Yes	Yes	Yes	No
Easily Incorporates Economizer Ash		Yes/No	Yes	Yes	Yes/No	Yes/No



# Technical Design Considerations

**Define Criteria As Early As Possible**

**Evaluate Criteria Against Multiple Alternatives**

**Determine Optimal Solution for each Plant**

**“One Size Does Not Fit All”**

**Determine Fleetwide Synergies**

**Begin Schedule Planning ASAP**



# Questions ?



# Wet-to-Dry Conversions

