REINHOLD ENVIRONMENTAL Ltd.

2015 Wastewater-Ash Round Table Presentation

September 22, 2015, in Charlotte, NC / Hosted by Duke Energy

BURNS McDONNELL

2015 Wastewater-Ash Conference

Weighing the Economics of Options for Converting to Dry Ash Disposal

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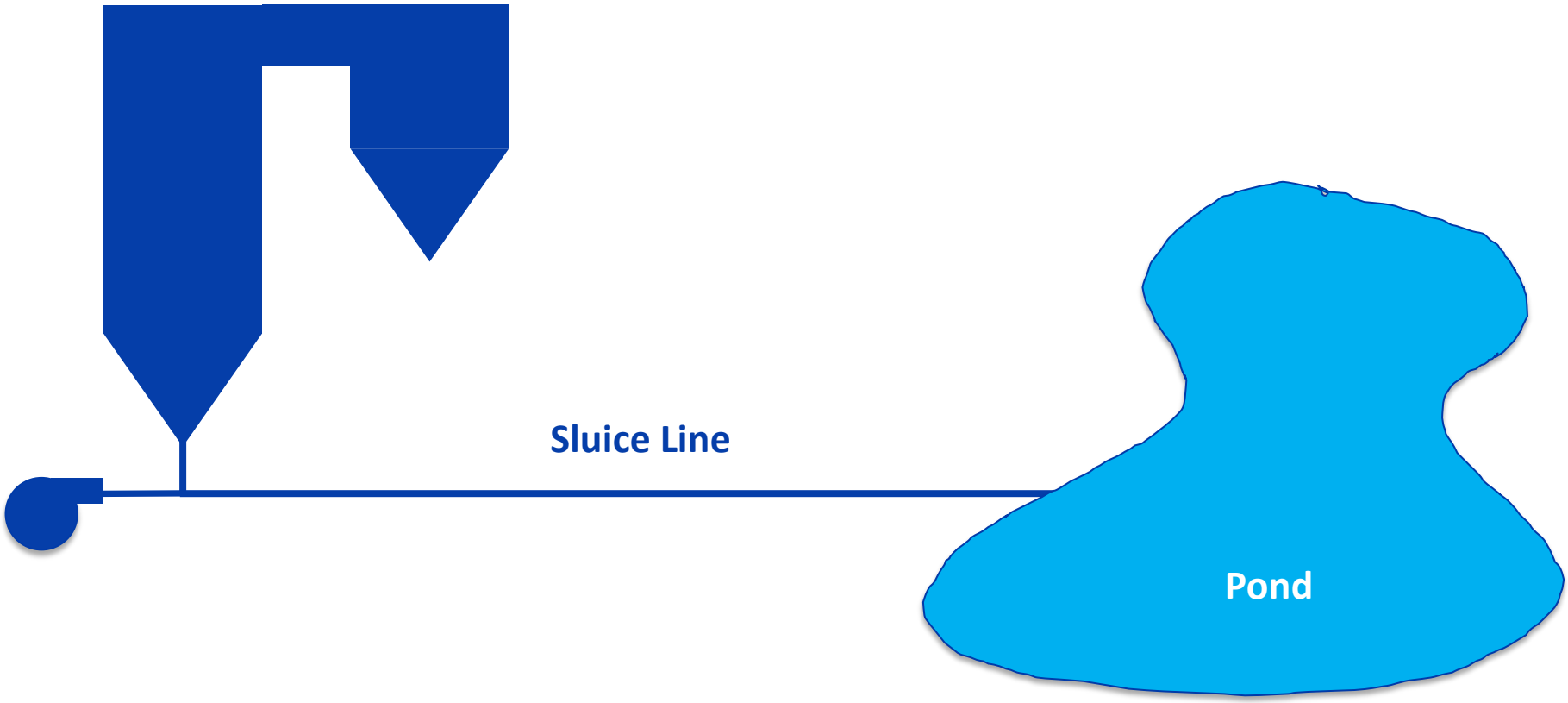
September 22, 2015

Agenda

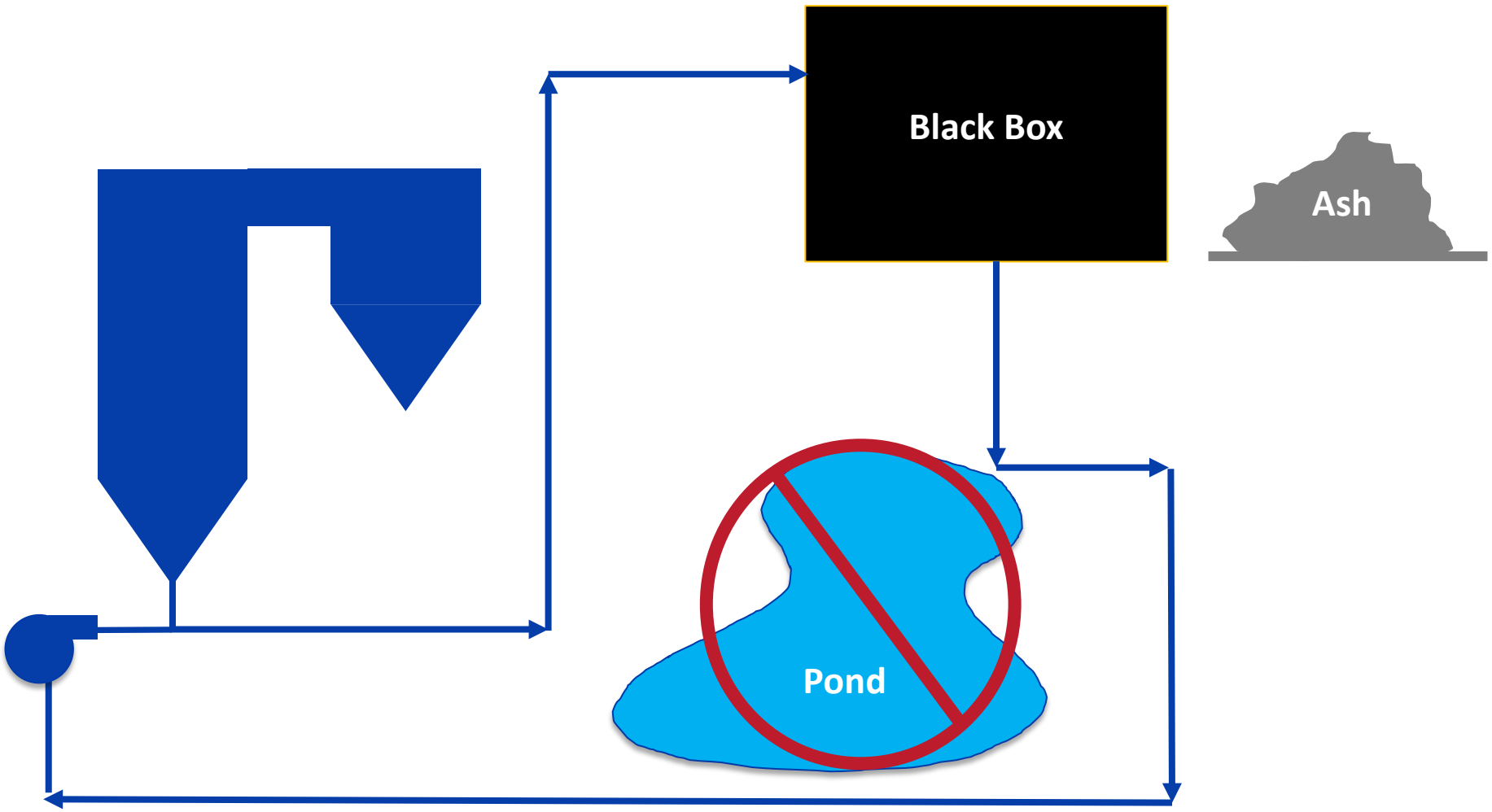
- Basic Bottom Ash Handling
- Available Technologies
- Case Studies
- Conclusion

Typical Sluice System



Local/Underboiler System

Remote System



Available Technologies

- Underboiler Technologies
  - Underboiler Drag Chain Conveyor
  - Pneumatic Conveying System
  - Dry Belt/Tray Conveying System
  - Vibratory Ash Conveyor
- Remote Technologies
  - Remote Drag Chain Conveyors
  - Remote Dewatering Bins
  - Dewatering/Settling Basins

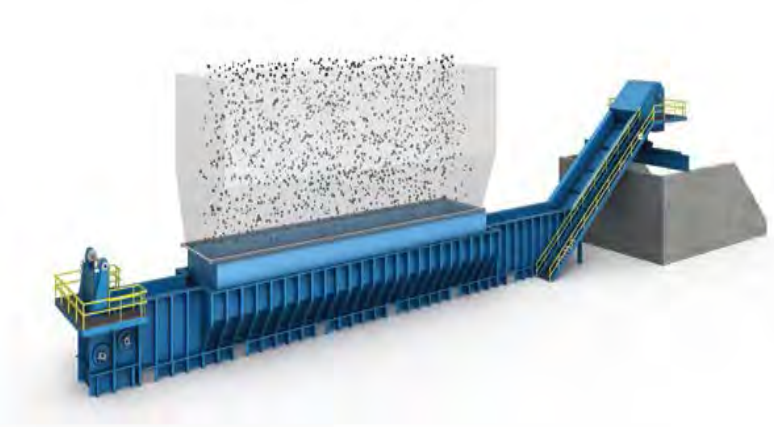
Local Drag Chain Conveyor

Advantages

- Proven Reliability
- Hundreds of installations
- Robust Design
- Low Cost

Disadvantages

- Extended installation outage
- Large footprint required at bottom of boiler
- Closed cooling loop may be needed



Bottom Ash Conversion
Major Technologies Available

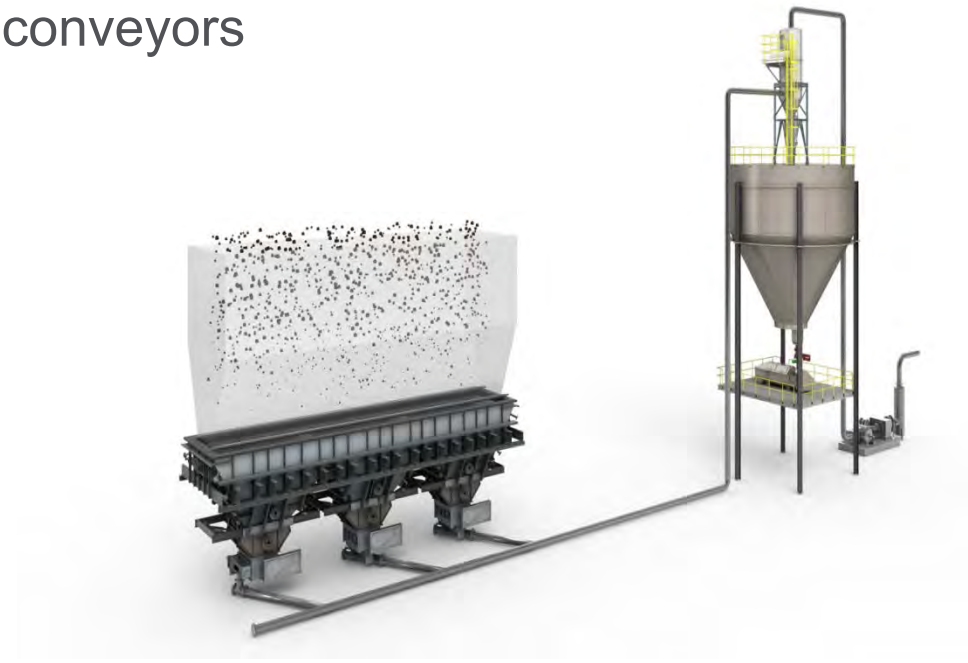
Pneumatic Bottom Ash System

Advantages:

- Completely dry system
- Local or remote storage silo
- Piping more easily routed than conveyors

Disadvantages:

- Cost
- Major demolition
- Longer outage
- Higher O&M cost (Pipe Wear)
- Permitting Concerns
- Only PC boilers



Bottom Ash Conversion
Major Technologies Available

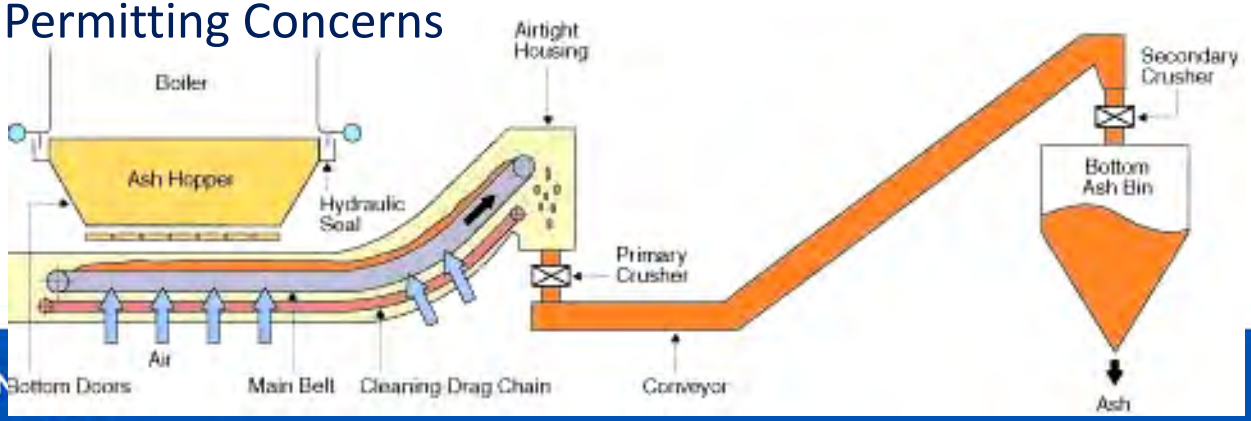
Dry Belt / Tray Conveying

Advantages:

- Completely dry system
- Local or remote storage silo

Disadvantages:

- Cost
- Boiler space requirements
- Major demolition
- Longer outage
- Only PC boilers
- Permitting Concerns



Bottom Ash Conversion
Major Technologies Available

Vibratory Conveying

Advantages:

- Completely dry system
- Local or remote storage silo

Disadvantages:

- Cost
- First of a kind in power market
- Boiler space requirements
- Major demolition
- Longer outage
- Only PC boilers
- Permitting Concerns

Remote Drag Chain Conveyor

Advantages

- Minimal outage & demo
- Minimal impact on boiler footprint
- Fully redundant system possible
- No water discharge

Disadvantages

- High Capital Cost
- Regulatory uncertainty (ELG)
- Aging sluice system remains a part of the system
- Distance from the plant makes O&M difficult
- Manual loading of ash
- Potential risks associated with TSS carryover
- New application of a technology

Dewatering Bin System

Advantages

- Minimal outage & demo
- Minimal impact on boiler footprint
- No water discharge
- System loads directly to truck

Disadvantages

- High Capital Cost
- Maintenance intensive with poor history
- Chemical addition required
- Regulatory uncertainty (ELG)
- Aging sluice system remains a part of the system
- Distance from the plant makes O&M difficult
- Potential risks associated with TSS carryover

Settling Basin Option

Advantages

- Minimal outage & demo
- Minimal impact on boiler footprint
- Fully redundant system
- No water discharge
- Low Cost
- Few moving parts
- Large volume for extended ash storage

Disadvantages

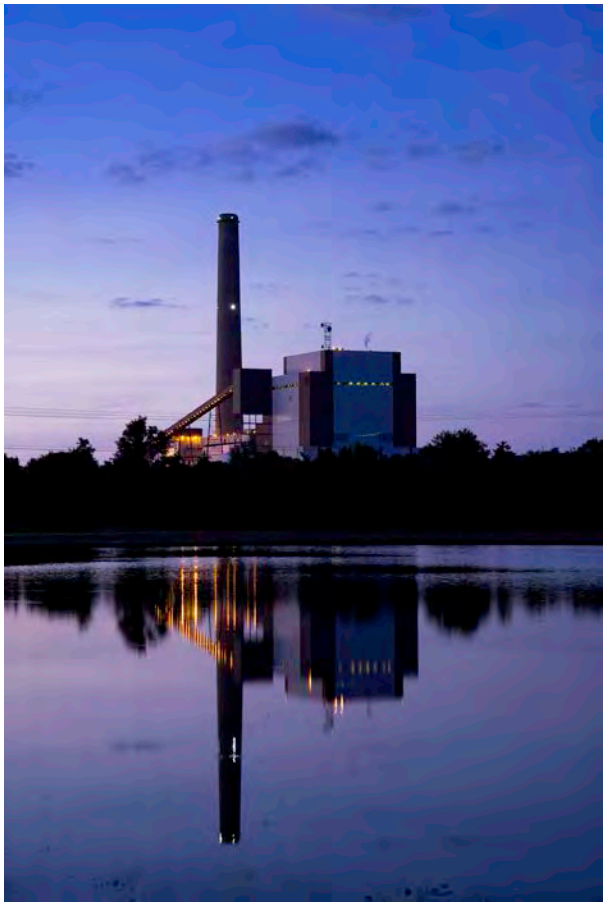
- Short track history
- Chemical addition may be required
- Regulatory uncertainty (ELG) with excess water
- Aging sluice system remains a part of the system
- Distance from the plant makes O&M difficult
- TSS carryover risks
- Large footprint
- Ability to dewater the ash
- Potential for double handling
- Loadout to trucks
- Winter freezing issues with slope

Case Study #1

- 1 - 750 MW PC Boiler
- Located in Northern Midwest
- Bottom Ash – Sluicing System
- Fly Ash – Dry Fly Ash and Waste Ash Handling
- Pond Closures needed (CCR and ELG)

Case Study #1 (750MW PC Boiler)

- Technologies Considered
  - Pneumatic Bottom Ash System
  - Local Drag Chain Conveyor
  - Remote Drag Chain
  - Settling/Dewatering Basins
- Ruled Out
  - Dewatering Bins
  - Vibratory Conveyors
  - Dry Belt Conveyors



Case Study #1 (750MW PC Boiler)

- Local Drag Chain Conveyor Drivers
  - Plant preference for underboiler technology
  - Conveyor angle skewed
  - Tight fit around pulverizers
  - Lowest cost option
  - Plant familiarity with system
- Decision Makers
  - $15MM
  - 6-8 week outage needed
  - Outage Schedule does not sync with CCR Rule
  - Pulverizer maintenance concerns
- NOT CHOSEN

Case Study #1 (750MW PC Boiler)

- Pneumatic System Drivers
  - Plant preference for underboiler technology
  - System navigated well around pulverizers
  - No water usage
  - Higher Cost than other underboiler option
  - Pipe Wear
  - Requires a new silo
- Decision Makers
  - $25MM
  - 6-8 week outage needed
  - Outage Schedule does not sync with CCR Rule
  - Permit concerns
- NOT CHOSEN

Case Study #1 (750MW PC Boiler)

- Settling Basin Drivers
  - Far from plant
  - No pulverizer access concerns
  - Only short outage required
  - Low Cost
  - Closed Loop system not common or well proven
- Decision Makers
  - $20MM – 3 Cell System
  - Outage Schedule syncs with CCR Rule
  - Low Cost
  - Maintenance concerns, winter concerns, TSS concerns
- NOT CHOSEN due to lingering concerns about how to handle winter months, double handling, and operator intensive operations

Case Study #1 (750MW PC Boiler)

- Remote Drag Chain Conveyor Drivers
  - Far from plant
  - No pulverizer access concerns
  - Only short outage required
  - High Cost
  - New application of this technology
- Decision Makers
  - $35MM – Dual Conveyor, $25MM Single Conveyor
  - Outage schedule syncs with CCR Rule
  - High Cost
- CHOSEN due to outage requirements and lower overall maintenance concerns than the settling basin option

Case Study #2

- 150MW & 50MW PC Boilers
- Located in Northern Midwest
- Bottom Ash – Sluicing System
- Fly Ash – Dry Fly Ash and Waste Ash Handling
- Pond Closures needed (CCR, ELG and State)

Case Study #2 (50MW & 150MW PC Boilers)

- Technologies Considered
  - Pneumatic Bottom Ash System
  - Remote Drag Chain Conveyors
  - Settling/Dewatering Basins
- Ruled Out
  - Dewatering Bins
  - Vibratory Conveyors
  - Dry Belt Conveyors
  - Underboiler Drag Chain Conveyor

Case Study #2 (50MW & 150MW PC Boilers)

- Settling Basin Drivers
  - Only short outage required
  - Closed Loop system not common or well proven
  - Would have to clean close ponds to make space
- Decision Makers
  - $9MM
  - Available land
  - Floodplain
  - Maintenance concerns, TSS concerns, public perception
- NOT CHOSEN due to concerns with cost, floodplain concerns, land available, and familiarity with other technologies.

Case Study #2 (50MW & 150MW PC Boiler)

- Remote Drag Chain Drivers
  - Only short outage required
  - High Cost
  - New application of a technology
- Decision Makers
  - $12MM – Single Conveyor
  - Outage Schedule
  - High Cost
- NOT CHOSEN due to overall high cost

Case Study #2 (50MW & 150MW PC BoilerS)

- Pneumatic System Drivers
  - Plant already has pneumatic on two units
  - No water usage
  - Pipe Wear
  - Requires a new silo (footprint)
- Decision Makers
  - $9MM
  - 8 week outage needed
  - Outage Schedule already in place
- CHOSEN due to low cost and system familiarity

Case Study #3

- 1 - 750 MW PC Boiler
- Located in Northern Midwest
- Bottom Ash – Sluicing System
- Fly Ash – Dry Fly Ash and Waste Ash Handling
- Pond Closures needed (CCR and ELG)

Case Study #3 (750MW PC Boiler)

- Technologies Considered
  - Local Drag Chain Conveyor
  - Remote Drag Chain Conveyors
  - Dewatering Bins
- Ruled Out
  - Vibratory Conveyors
  - Dry Belt Conveyors
  - Settling Basins

Case Study #3 (750MW PC Boiler)

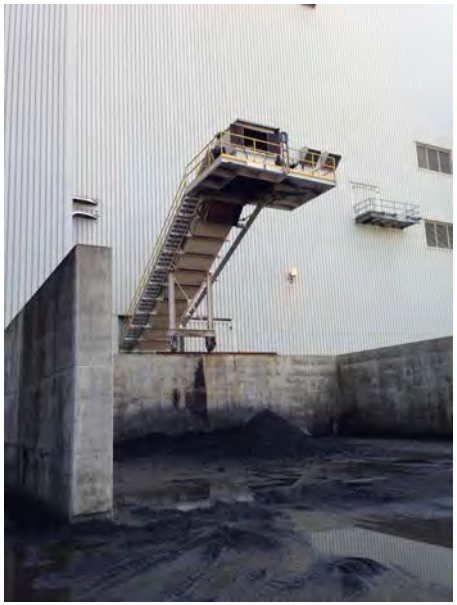
- Remote Drag Chain Drivers
  - Far from plant
  - Only short outage required
  - High Cost
  - New application of a technology
- Decision Makers
  - $35MM – Dual Conveyor
  - Outage Schedule syncs with CCR Rule
  - High Cost
- NOT CHOSEN due to higher cost, proximity to plant and familiarity with other technologies

Case Study #3 (750MW PC Boiler)

- Remote Dewatering Bin Drivers
  - Far from plant
  - Only short outage required
  - High Cost
  - Operations History with technology
- Decision Makers
  - $35MM – Dual Train System
  - Outage Schedule syncs with CCR Rule
  - High Cost
- NOT CHOSEN due to higher cost, proximity to plant and past history with this technology

Case Study #3 (750MW PC Boiler)

- Local Drag Chain Conveyor Drivers
  - Plant preference for underboiler technology
  - Lowest cost option
  - Plant familiarity with system
- Decision Makers
  - $15MM
  - 6-8 week outage needed
  - Outage Schedule syncs with CCR Rule
- CHOSEN due to low cost, familiarity with technology and already planned outage schedules



Questions???