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Outage Wash Design Considerations and Alternatives

Prepared for: WPCA / TVA Ash Pond Seminar

Presented By: Kevin L. McDonough & David Donkin

18 September 2019

Safety Moment

Presentation Prepared For:

Bottom Ash Transport Water Treatment

UCC Remote Submerged Flight Conveyor (R-SFC) & Clarifier System

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Discussion Overview

- Regulatory Considerations
- Overview of R-SFC / Clarifier Technology
- Design Approach and Performance Results
- Additional Water Management Considerations

Discussion Overview

- **Regulatory Considerations**
- Overview of R-SFC / Clarifier Technology
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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
- CFR Publication: November 03, 2015
- Goals
  - ✓ Strengthen Steam Electric Power Plant Discharge Controls
  - ✓ Reduce Surface Water Pollutant Discharges

ELG Ruling

EPA Stay on FGD Wastewater and Bottom Ash Transport Water

Wastestreams	Technology Basis
FGD Wastewater	Chemical Precipitation + Biological Treatment
Fly Ash Transport Water	Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW
Bottom Ash Transport Water	Dry Handling / Closed-loop for units >50W; Impoundment (equal to BPT) for units <50MW
Combustion Residual Leachate	Impoundment (equal to BPT)
FGMC Wastewater	Dry Handling
Gasification Wastewater	Evaporation
Nonchemical Metal Cleaning Wastes	Chemical Precipitation

ELG Ruling

Specialized Definitions

- **Transport Water**
  - Any 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.
  - Transport water does not include low volume, short duration discharges of wastewater from minor leaks (e.g. leaks from valve packing, pipe flanges, or piping) or minor maintenance events (e.g., replacement of valves or pipe sections).
- **Low Volume Waste Sources include:**
  - Boiler blowdown
  - Floor drains
  - Recirculating house service water systems

Bottom Ash Transport Water Management

Technical Options

- **Dry Ash Handling System**
  - Submerged Drag Chain System
  - Dry Pneumatic System
  - Dry Mechanical System
- **Closed-loop Recirculation System**
  - Conventional Dewatering Bin / Settling / Surge Tanks
  - Continuous Dewatering & Recirculation System with Remotely-located Submerged Flight Conveyors (CDR)
  - Dewatering Basin Recirculation System
- **FGD Source or Make-Up Water Feed System**
  - Viability based on Bottom Ash & FGD Water Requirements
  - Must Investigate BA System vs. FGD System Water Balances

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UCC Wet-to-Dry Ash Conversion Update

WTD Projects Awarded to UCC (2009-2019)

Project Type	# of Projects Awarded	# of Units Converted
Bottom Ash Wet-to-Dry Conversions	**56**	**117**
Fly Ash Wet-to-Dry Conversions	**26**	**56**

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UCC Wet-to-Dry Ash Conversion Update

Coal Units: Dry Ash Handling Systems

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Project Type	Unit Conversion %
% of U.S. Fleet installed with or converted to Dry Fly Ash (Includes Projects In Progress)	**>98%**
% of U.S. Fleet installed with or converted to Dry Bottom Ash (Includes Projects In Progress)	**>50%**

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UCC Wet-to-Dry Ash Conversion Update

Summary of Recent UCC Bottom Ash WTD Activity

UCC SFC System
Under-Unit

- 36 Plants (58 Units)

UCC CDR System
Remote SFC

- 22 Plants (72 Units, 48 RSFC)
- 3 New Projects Underway

UCC PAX System
(100% Dry)

- 9 Plants (17 Units)

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- **Overview of R-SFC / Clarifier Technology**
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Bottom Ash WTD Conversion Alternatives

Conventional Dewatering & Recirculation System

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- Multiple Tank Arrangement
- Greater Foundation Design Requirements
- Inconsistent Bottom Ash Dewatering
- Limited Clarification Capability

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Bottom Ash WTD Conversion Alternatives

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

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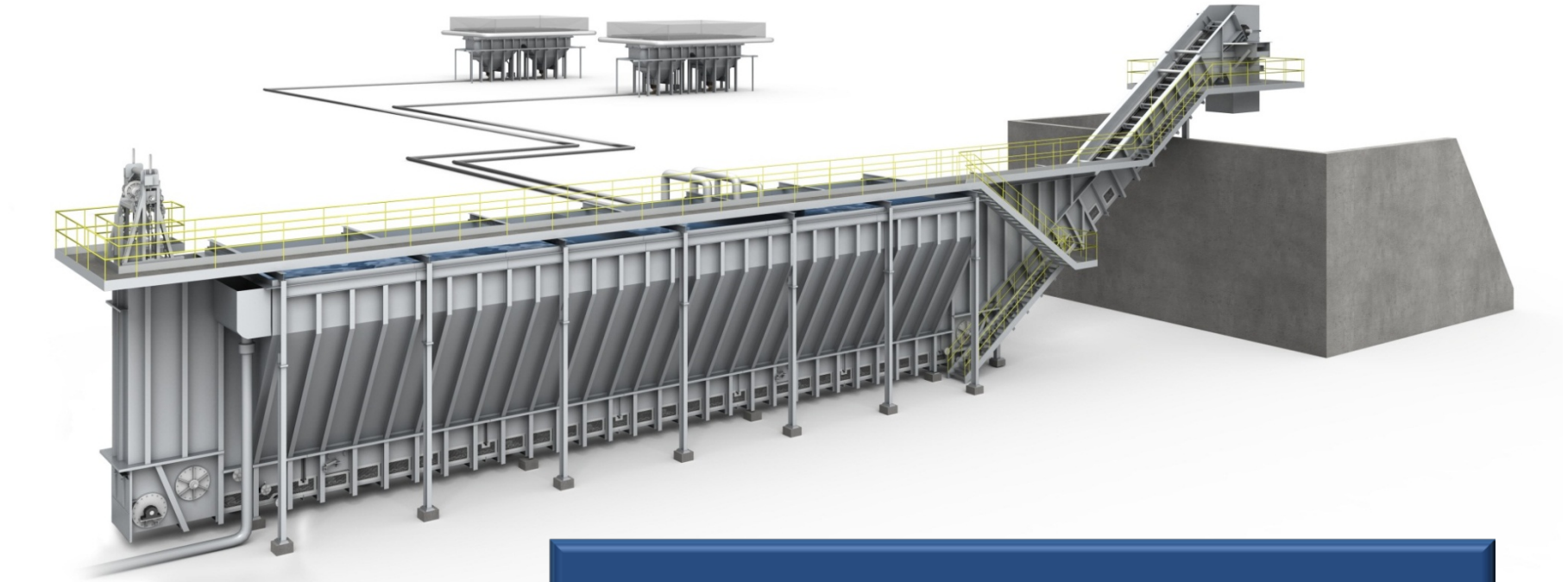

- CDR System with Remote SFC's
- Combines SFC Technology with Conventional Recirculation System

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Bottom Ash WTD Conversion Alternatives

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

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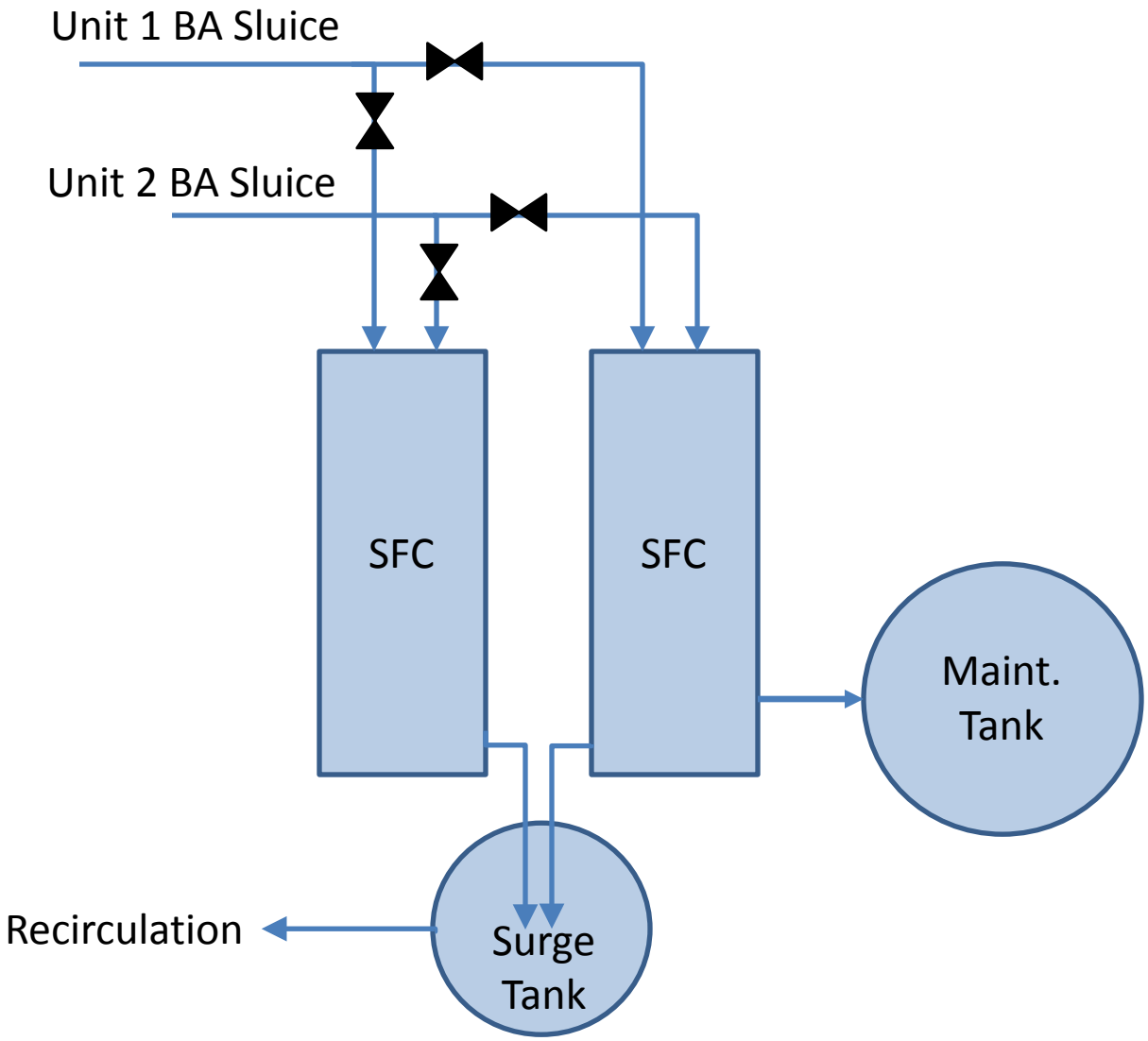
Design Basis Requirements

Bottom Ash CDR System with Remote SFC's (100% Redundancy)



Remote SFC & Clarifier System

Bottom Ash WTD Conversion Alternatives

UCC R-SFC & Clarifier System

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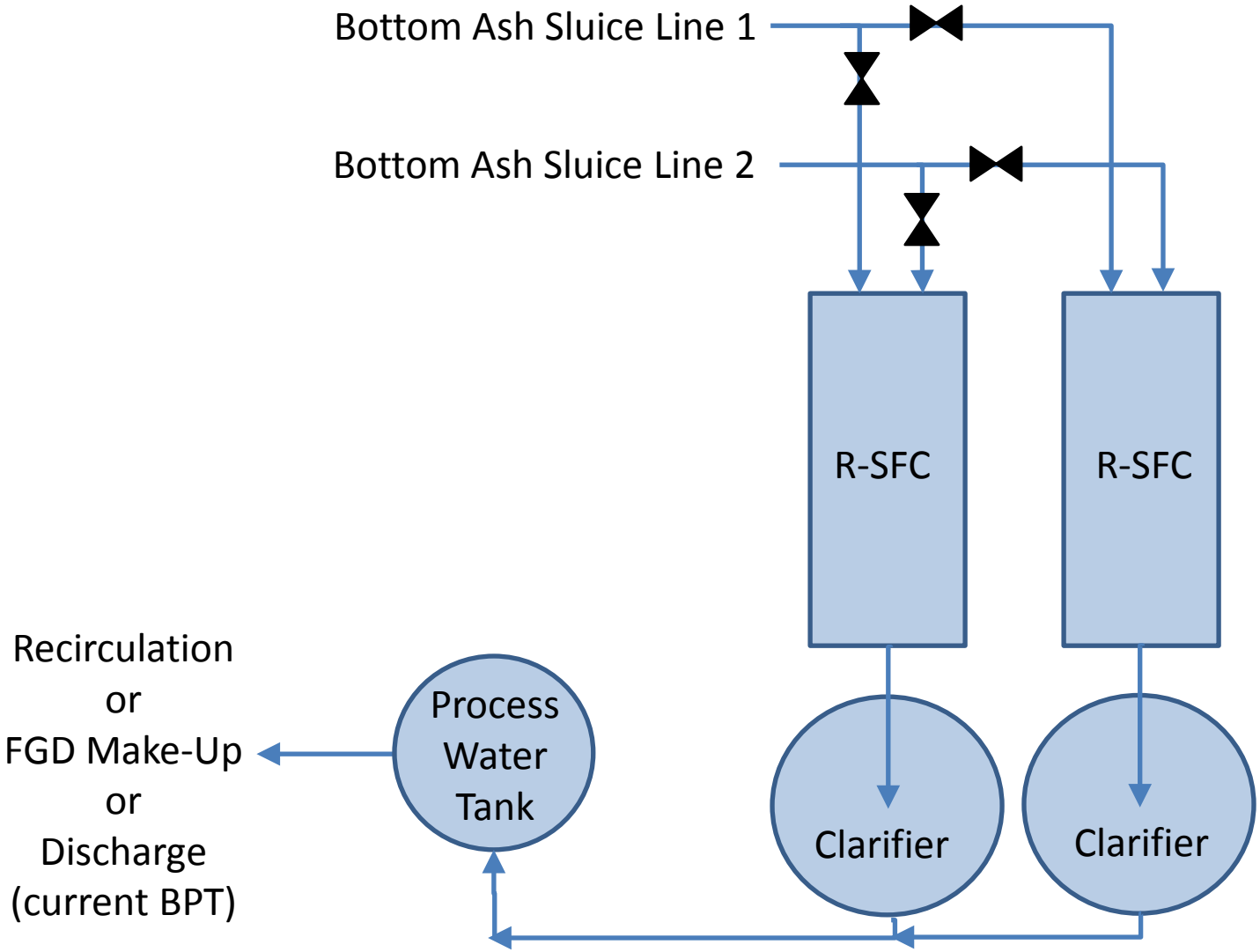

UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

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UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

Technical Design Features

- Optimized 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 R-SFC Incline Section
  - Dewaters Bottom Ash to Moisture Levels Suitable for Landfill Disposal or Beneficial Use

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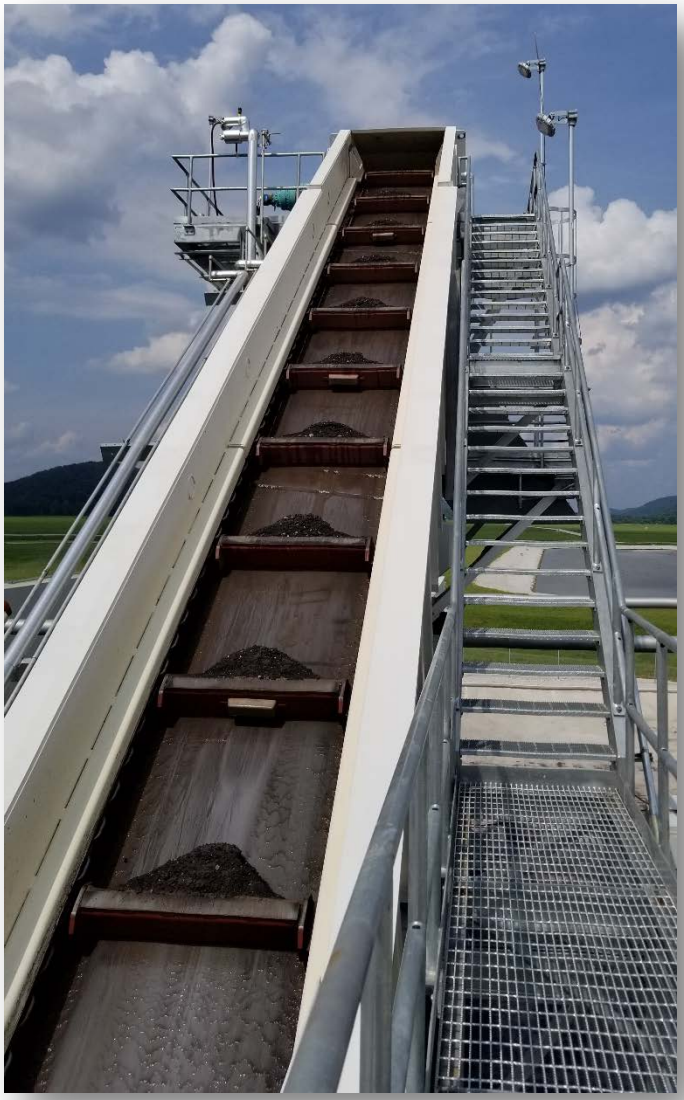

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UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

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UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

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 a make-up water source for FGD System (per Effluent Limitations Guidelines)
- Can be designed for TSS levels suitable for Recirculation Pumps

UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

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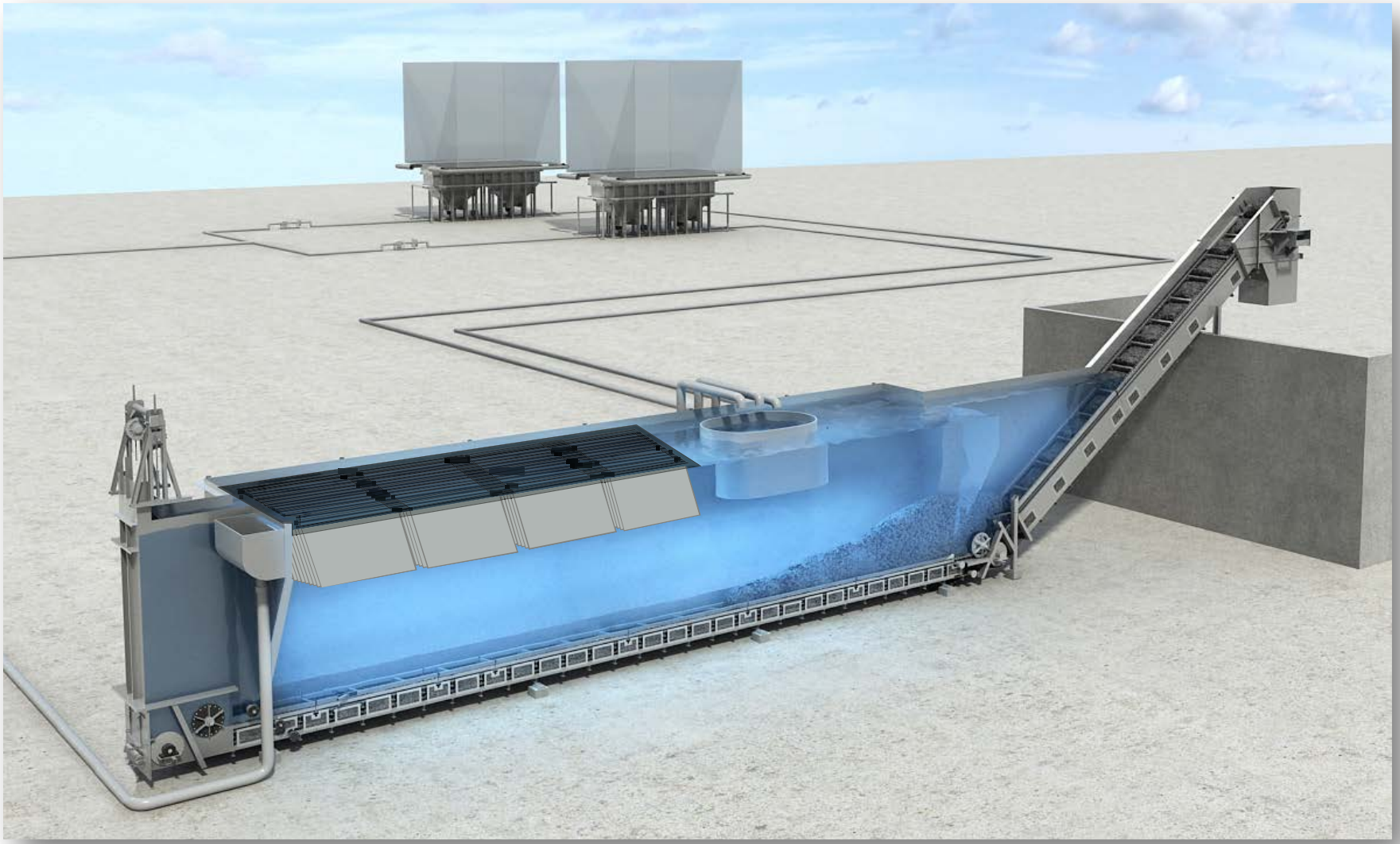

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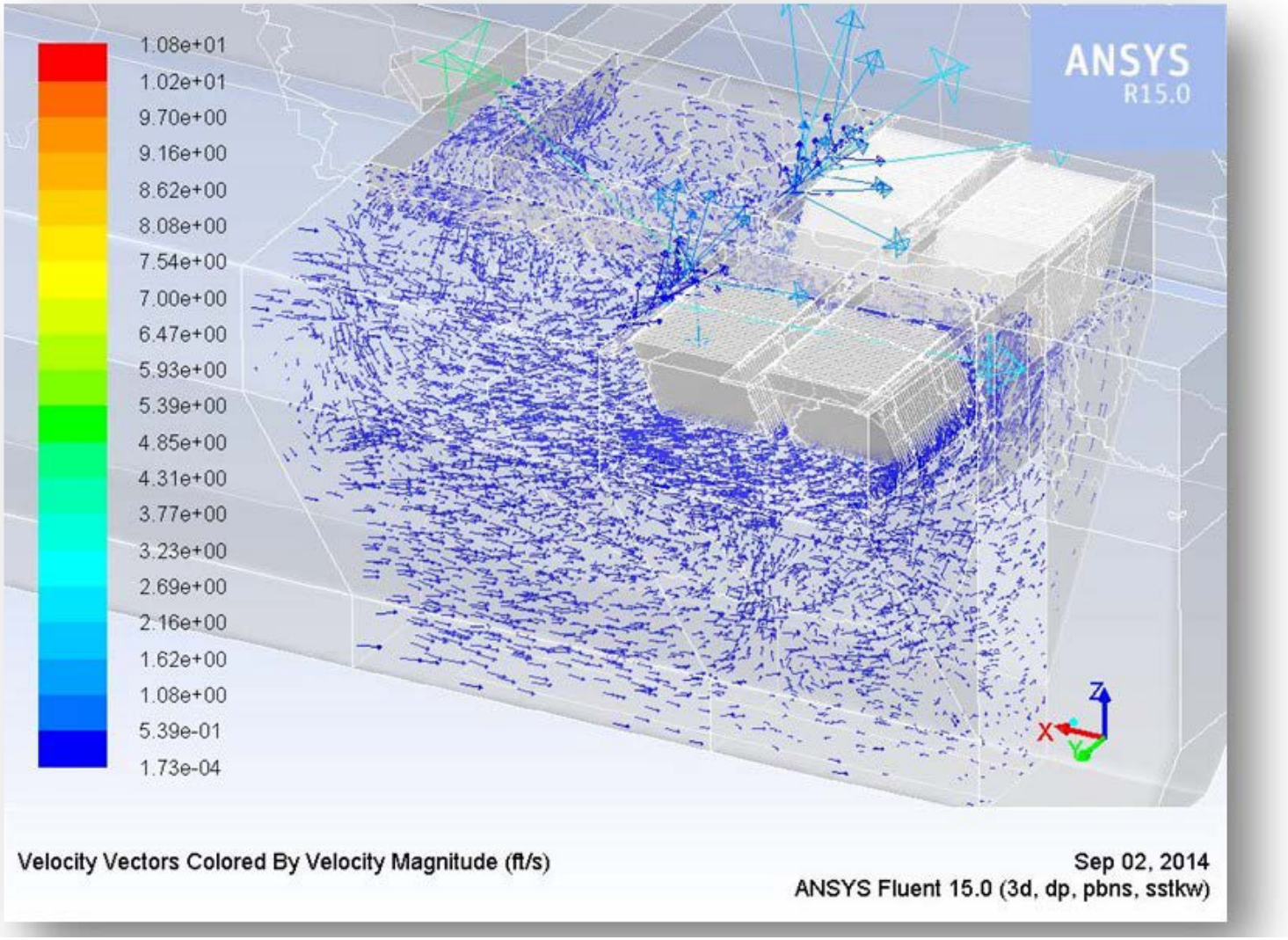
UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design



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TSS Control: UCC Lamella Design

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UCC R-SFC & Clarifier System

TSS Control: UCC Lamella Design

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Design Basis Requirements

Bottom Ash Sluice Water Demands for R-SFC & Clarifier Systems

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

Design Basis Requirements

Typical Performance Guarantees

Parameter	Performance Requirement
TSS (in R-SFC Overflow)	400 ppm (24-hour average)
TSS (in Clarifier Overflow)	100 ppm (daily maximum) 30 ppm (monthly average)
Moisture % (Bottom Ash)	20% in bunker after 24 hours or Paint Filter Test

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- **Design Approach and Performance Results**
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UCC Wastewater Treatment Design Approach

UCC Typical Approach Prior to System Design

- **Secure Solids Samples**
  - Test for Particle Size Distribution, Bulk Density, Specific Gravity, Chemical Constituency, Dewatering Potential
- **Secure Water Samples**
  - Test for Total Suspended Solids (TSS), Total Dissolved Solids (TDS) and pH
- **Confirmation of Incoming Flows**
  - Confirm all continuous flow sources and rates
  - Confirm all intermittent flow sources and rates
- **Laboratory Testing**
  - TSS and TDS Removal/Settling
- **Equipment Sizing**
  - Utilize sample testing data to confirm required size of clarifiers, tanks, filters, etc.
- **CFD Modeling**
  - Model performance of clarifiers with confirmed flow and particle data

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UCC R-SFC & Clarifier System

Design Requirements and Operating Results

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	Specified Design		Actual
	Maximum for any 1 day (mg/l)	Average of daily values for 30 consecutive days shall not exceed (mg/l)	Typical Daily Sample
TSS	100.0 ppm	30.0 ppm	<15ppm
Oil and Grease	20.0 ppm	15.0 ppm	<15ppm
pH	6-9		7.5

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- **Additional Water Management Considerations**

Existing System Outage Wash Capability

Current and Potential Arrangement

- **Typical Outage Wash Operations**
  - Non-Chemical and Chemical Water Outage Wash of Boiler, Air Preheater, and ESPs
  - Outage Wash Wastewater Stream Directed to Low Volume Waste or Pond Systems
- **Potential Arrangement for Outage Wash Water**
  - Provide WWT to Mitigate TSS, Iron, and Copper
  - Utilize Existing Bottom Ash Dewatering System Equipment
  - Leverage R-SFC / Clarifier to capture Fine Particulate from Outage Wash Operations
  - Minimize the Requirement for additional WWT Equipment
  - Augment with additional Chemical Injection Equipment if necessary

Existing System Outage Wash Capability

Review of Existing Equipment & Instrumentation

- **Existing Equipment Utilized in Wash Operations**
  - Remote Submerged Flight Conveyor (with Lamellas)
  - Clarifier
  - Clarifier Underflow Pumps
  - Process Water Tanks and Pumps
  - BA Hopper JETPULSION Pumps
  - Caustic, Coagulant, and Flocculant Skids at R-SFC Island
  - Clarifier Discharge Flow, pH, and Turbidity Meters

Existing System Outage Wash Capability

Key Considerations and Likely Discharge Requirements

- **Key Design Considerations**
  - Fully Understand Outage Wash Flow Rates
  - Sludge Management
  - R-SFC Conveyance Capabilities
  - Chemical Injection Locations and Rates
  - pH Adjustment Requirements

- **Likely Outage Wash Wastewater Treatment Targets**

pH	Copper (mg/L)	Iron (mg/L)	TSS (mg/L)
6-9	Less than 30	Less than 30	Less than 30 Monthly Average Less than 100 Daily Max

Existing System Outage Wash Capability

Pre-Outage Wash Preparation Considerations

- **Remote Submerged Flight Conveyor (R-SFC)**
  - Adjust Shimming to Lower Head Shaft Centerline for improved fines sludge removal
  - Turn Off R-SFC Chain Wash Nozzles
  - Ensure Proper R-SFC and HPU Settings
  - Water in R-SFC should be at a pH of 8
- **Other Items**
  - Ensure Ash Hoppers are Emptied as much as Possible
  - Ensure Proper Clarifier Rake Torque Settings
  - Complete Piping Tie-Ins

Existing System Outage Wash Capability

Potential Flow Rates (Typical Example)

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Outage Wash Water Flows (per Unit)									
Area to be Washed	**Wash Time (Hrs)**	**Flow per Hose (GPM)**	**Number of Hoses**	**Number of Flush Nozzles used**	**Flush Nozzle Flow per Nozzle (GPM)**	**Push Water Pump Type**	**Push Water flow (GPM)**	**Total Flow (GPM)**	**Total Wash Volume (Gallons)**
Boiler Wash Internal	72	95	2	-	-	Jetpump	1,770	1,960	8,467,200
Boiler Wash External	12	95	6	-	-	Jetpump	1,770	2,340	1,684,800
Air Preheater	40	95	2	2	100	Jetpump	1,770	2,160	5,184,000
Precipitator Wash (Option)	96	95	6	-	-	Centrifugal	1,000	1,570	9,043,200

Existing System Outage Wash Capability

Potential Range of Water Influent Properties & Potential Sludge Loading

Boiler Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 20,000
pH	SU	3 - 8

Air Preheater Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 20,000
pH	SU	2 - 8

Precipitator Wash		
	Units	**Range**
Total Suspend Solids	mg/L	100 – 65,000
pH	SU	2- 7.5

- Calculated Maximum Solids Loading Rate at SFC based on 60,000 Assumed TSS (Preliminary):
  - 14 tons/hour (SFC rated for 30 ton/hour)

Existing System Outage Wash Capability

Suggested Chemical Treatment Plan

Chemical Addition Primer

- Caustic – pH Adjustment to Precipitate Dissolved Iron and Copper
- Coagulant – Particle Neutralization
- Flocculant – Polymer that Gather Particles Together and Aids in Settling

- High Density Sludge
- Dewaters More Readily
- Lower Carryover Rates

- Lower Density Sludge
- Runny, Harder to Dewater
- Fines/Floaters

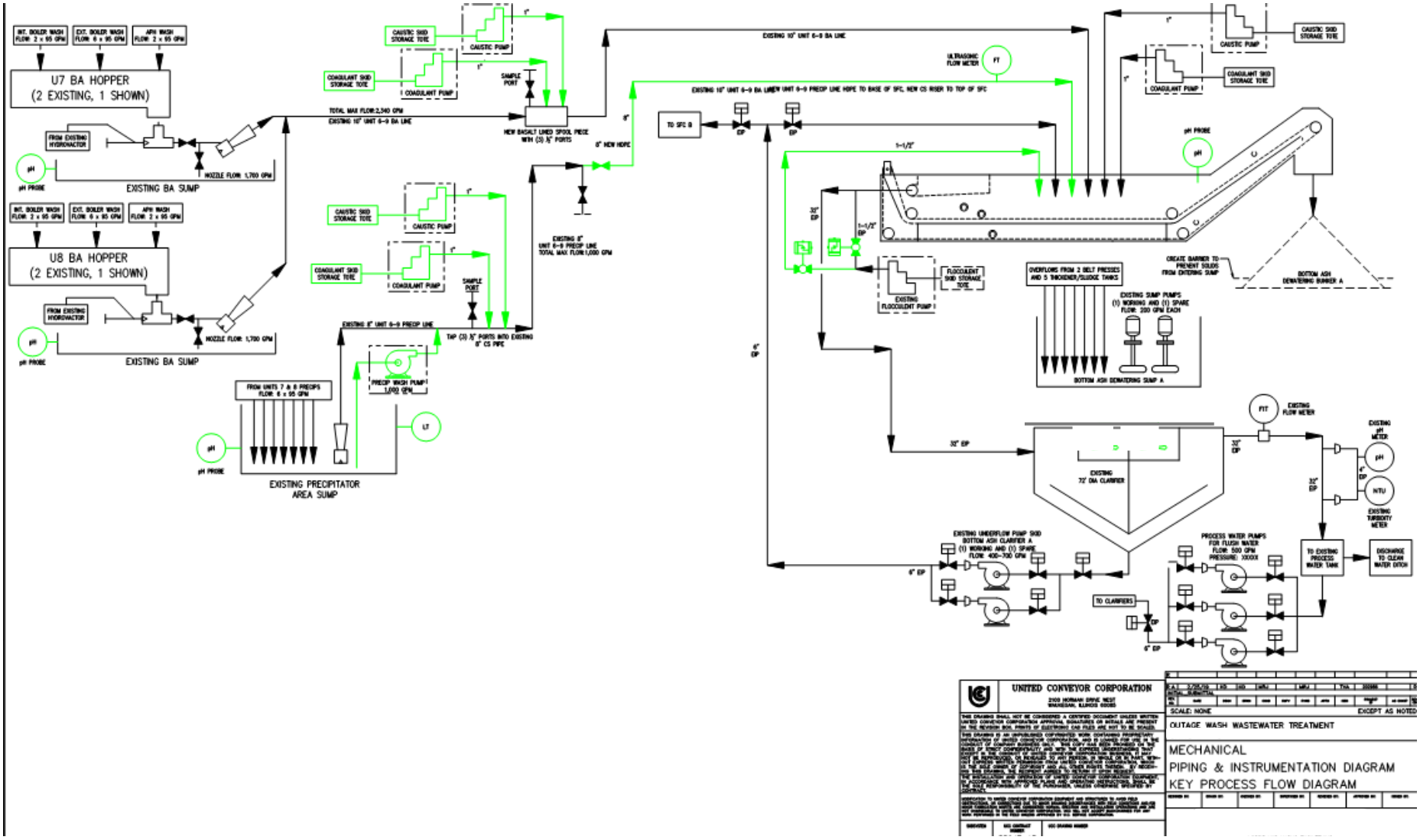
Existing System Outage Wash Capability

Chemical Injection Flexibility: Injection & pH Measurement Locations

- **Injection Locations**
  - Caustic Injection (pH Adjustment)
    - Upstream & at the SFC Inlet
  - Coagulant Injection
    - Upstream & at the SFC Inlet
  - Flocculant Injection
    - SFC Overflow to Clarifier & at the SFC
- **pH Measurement Locations**
  - Bottom Ash Hopper Sump
  - Precipitator Sump
  - Submerged Flight Conveyor
  - Clarifier Discharge (Effluent)

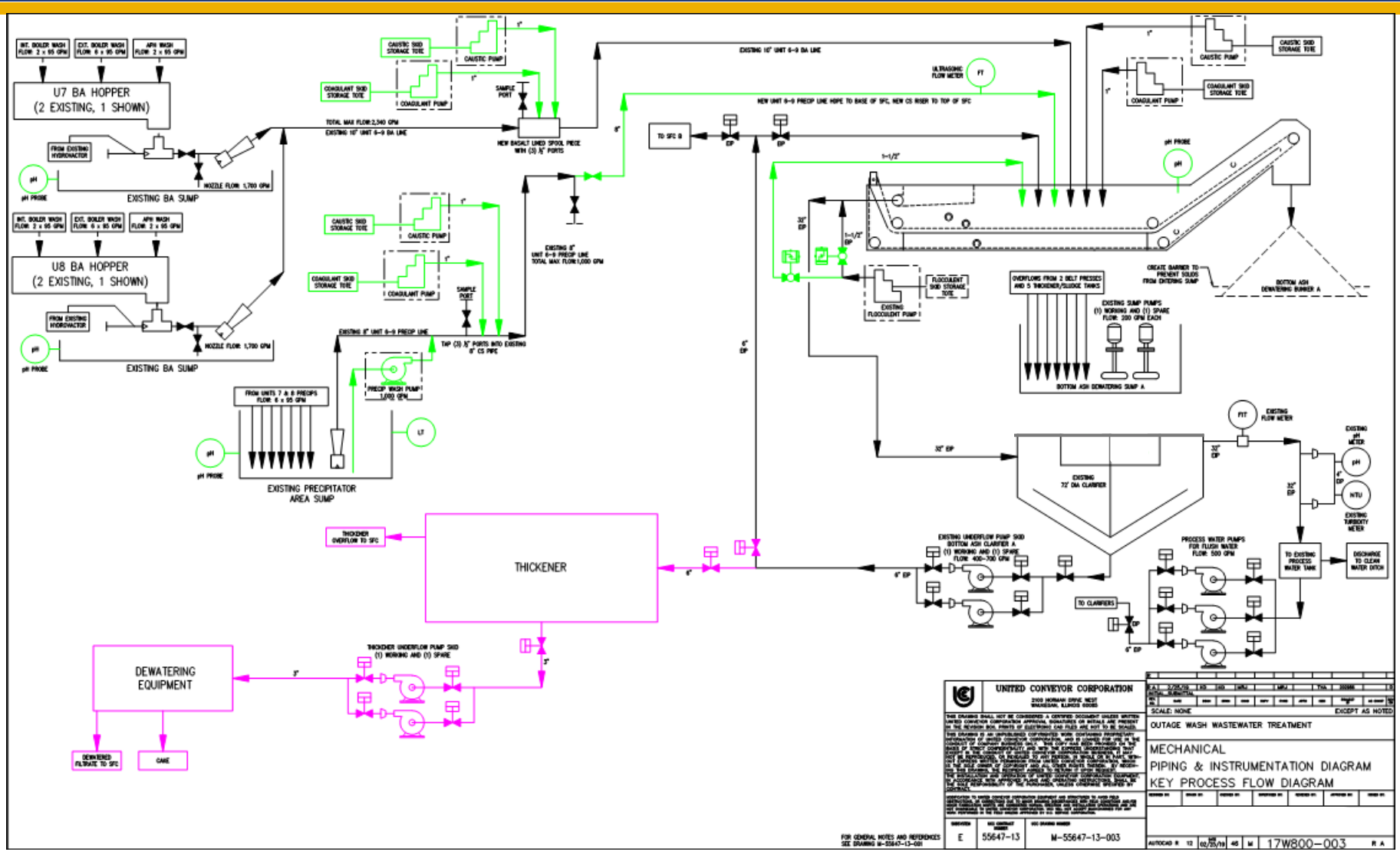
Existing System Outage Wash Capability

Equipment, Instrumentation, and System Operation Plan



Existing System Outage Wash Capability

Potential Sludge Removal Arrangement



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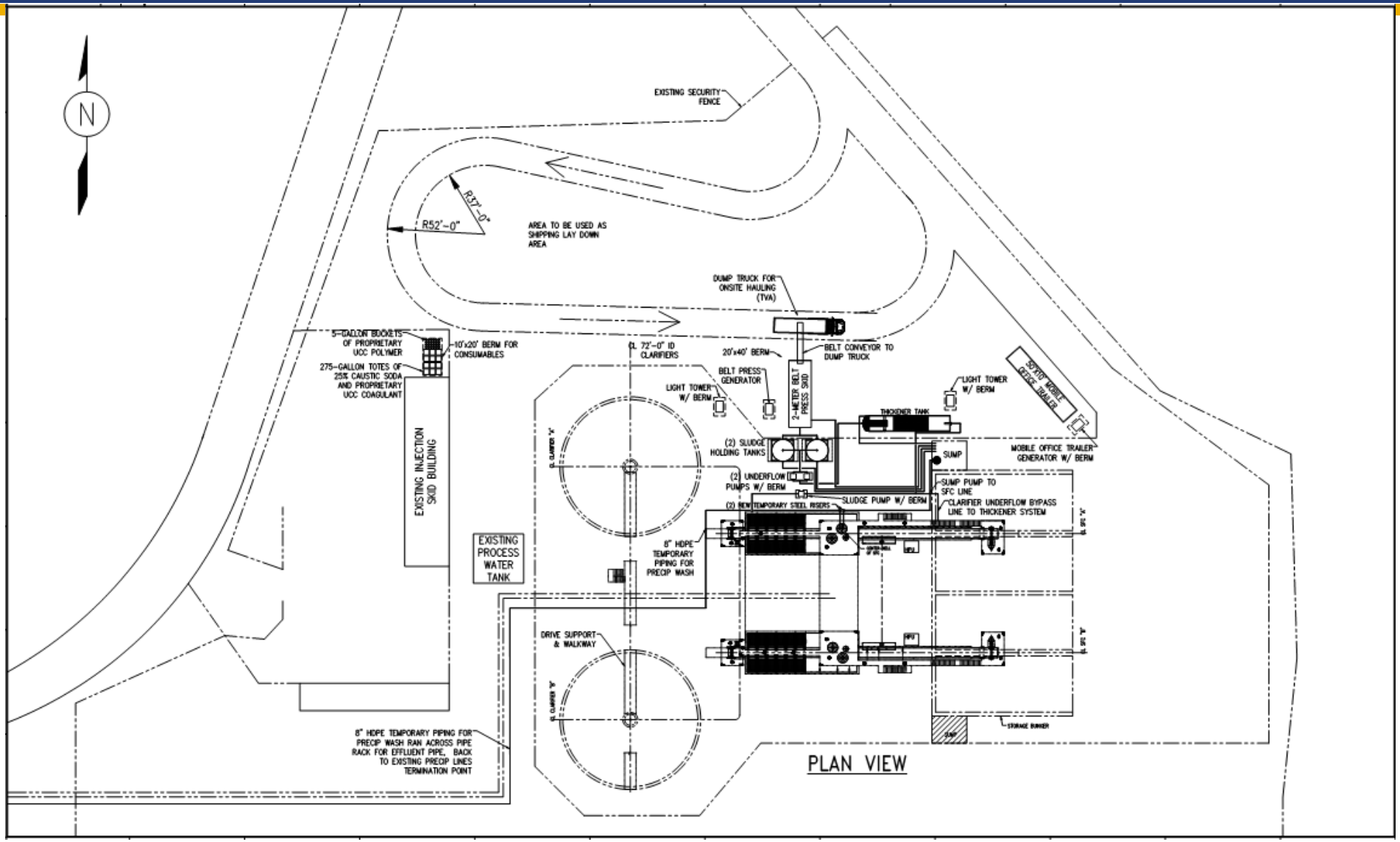
Existing System Outage Wash Capability

Equipment, Instrumentation, and System Operation Plan



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UCC R-SFC & Clarifier System

For Bottom Ash Transport Water Treatment

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 a make-up water source for FGD System (per Effluent Limitations Guidelines)
- Can be designed for TSS levels suitable for Recirculation Pumps

Outage Wash Capabilities

- Can be utilized (with minor modifications) to process Outage Wash Water during boiler cleanout operations

Existing System Retrofits for Outage Wash Operations

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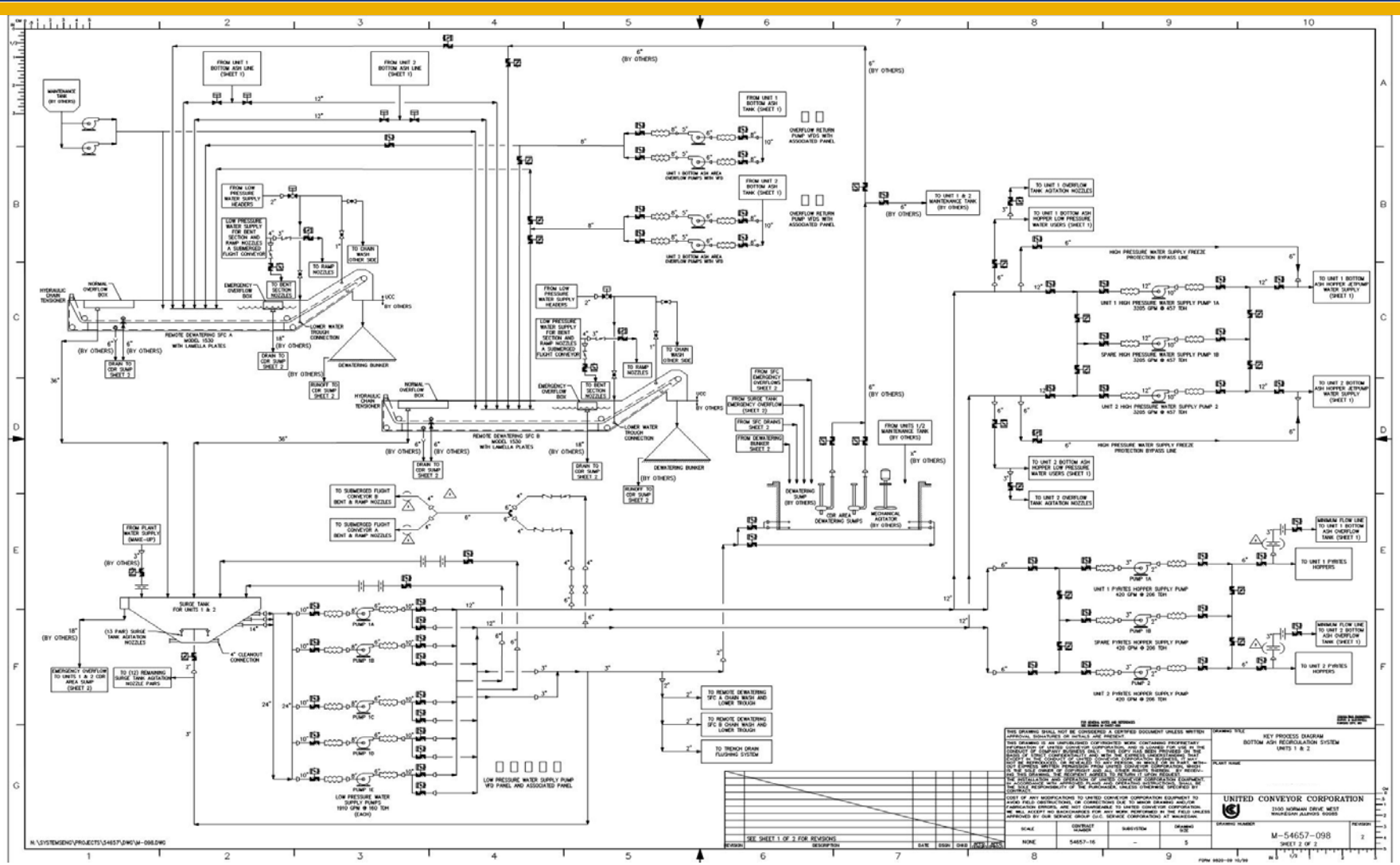

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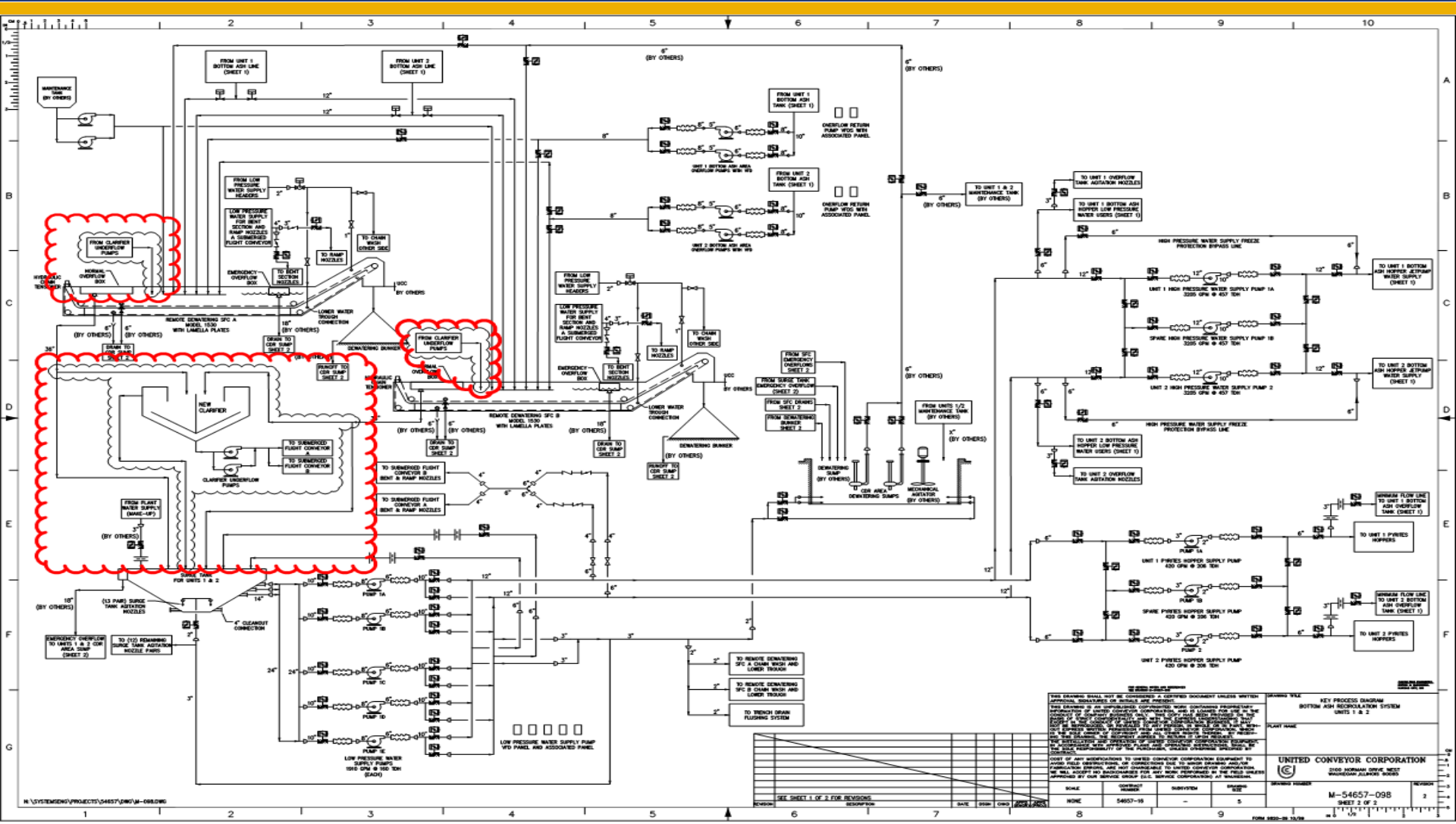

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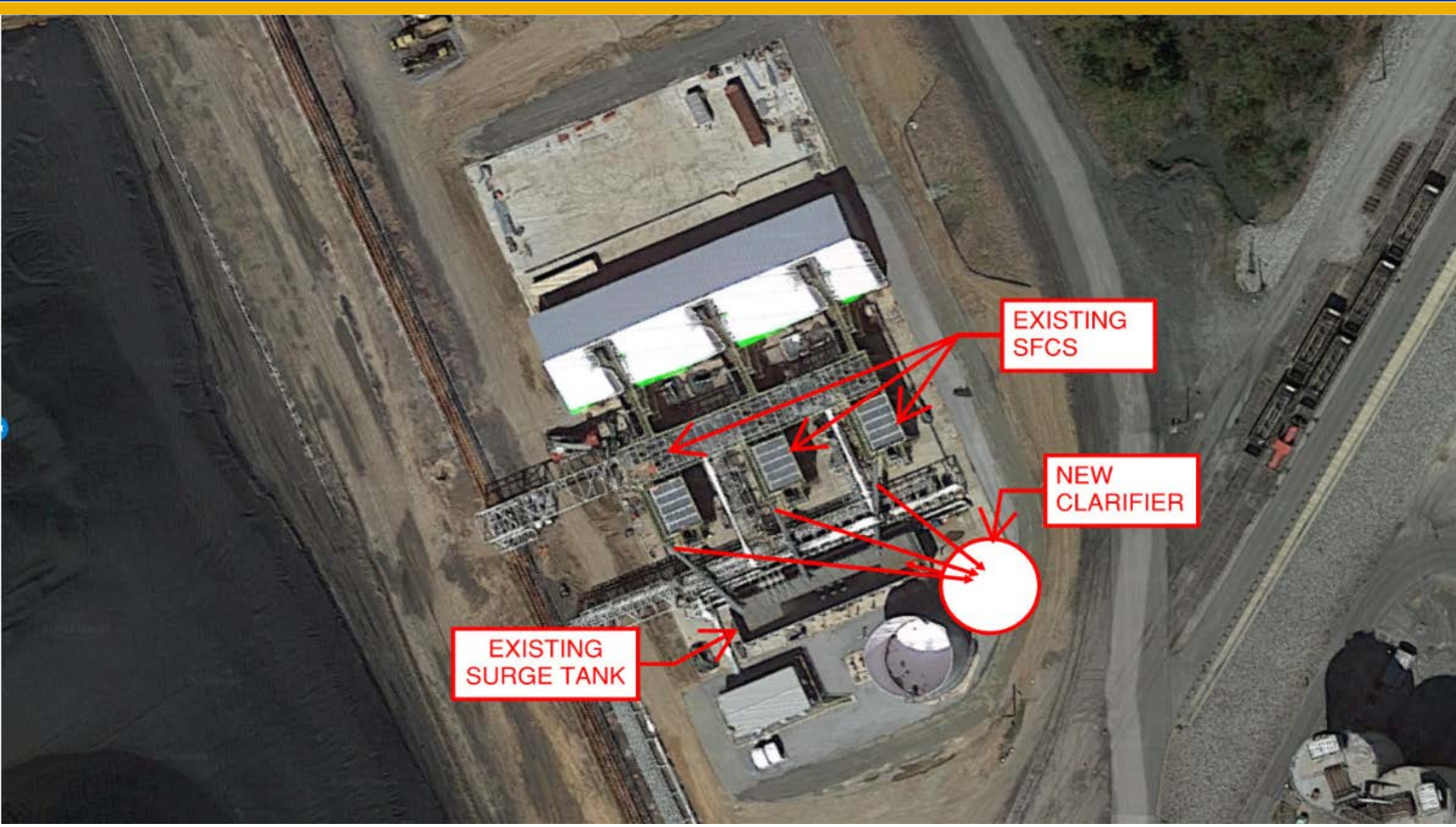

Clarifier addition augments existing assets for outage wash treatment

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Questions ?