REINHOLD ENVIRONMENTAL Ltd.

# 2016 APC-Wastewater Round Table & Expo Presentation

July 18 & 19, 2016 in Dearborn, MI / Hosted by DTE Energy

# Integrated Compliance Strategies for the CCR Rule and ELGs

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July 18, 2016

# Outline

- Our Energy Mix – Driving Factors
  - CCR Rule
  - ELGs
  - CPP Implications
- Multimedia Approach to Compliance
  - Case Studies:
    - Beneficial Use
    - Solids Stabilization
    - Integrated Master Planning
- Innovative Solutions
  - Biological Process to Transform Waste to Marketable Material
  - Landfill Leachate Treatment
  - Impoundments and Landfills
- Thoughts for Moving Forward

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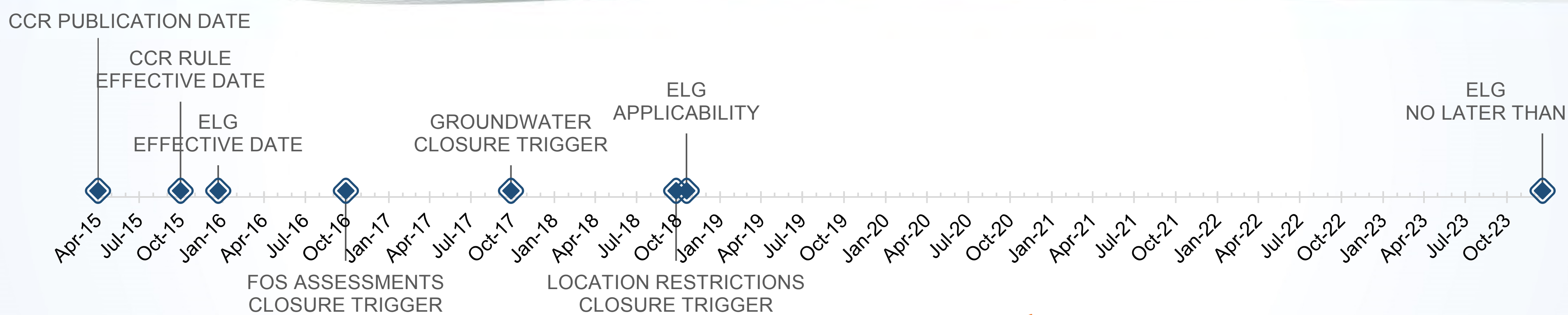
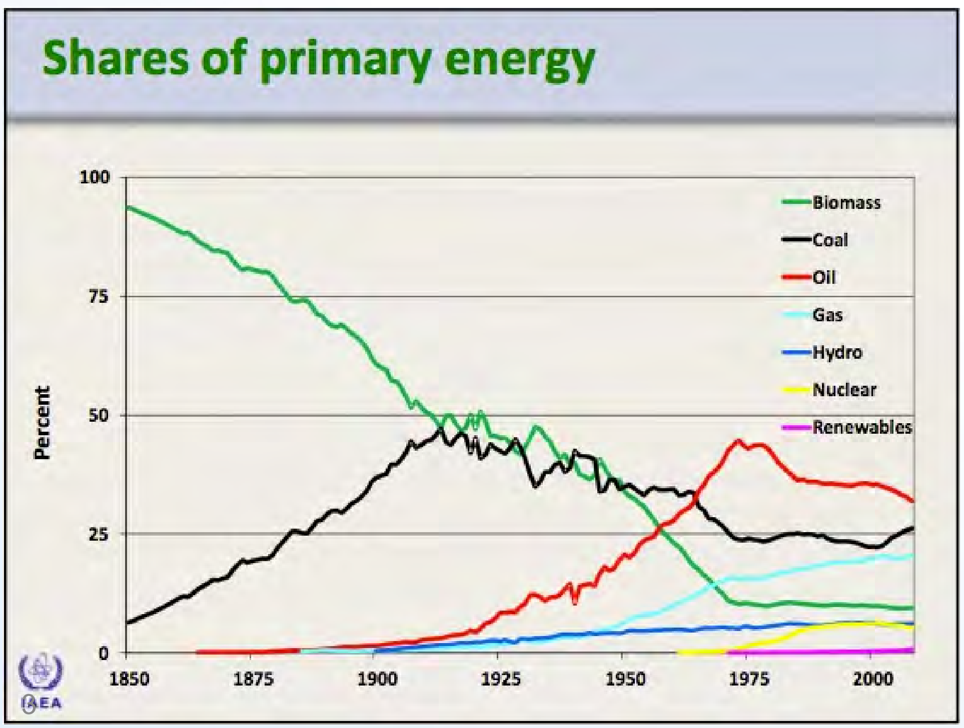
# Our Energy Mix and Regulatory Drivers




On the current energy transition….

*"Neither its pace nor its compositional and operational details are yet clear."–* Vaclav Smil, 2010

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# Where we've been….

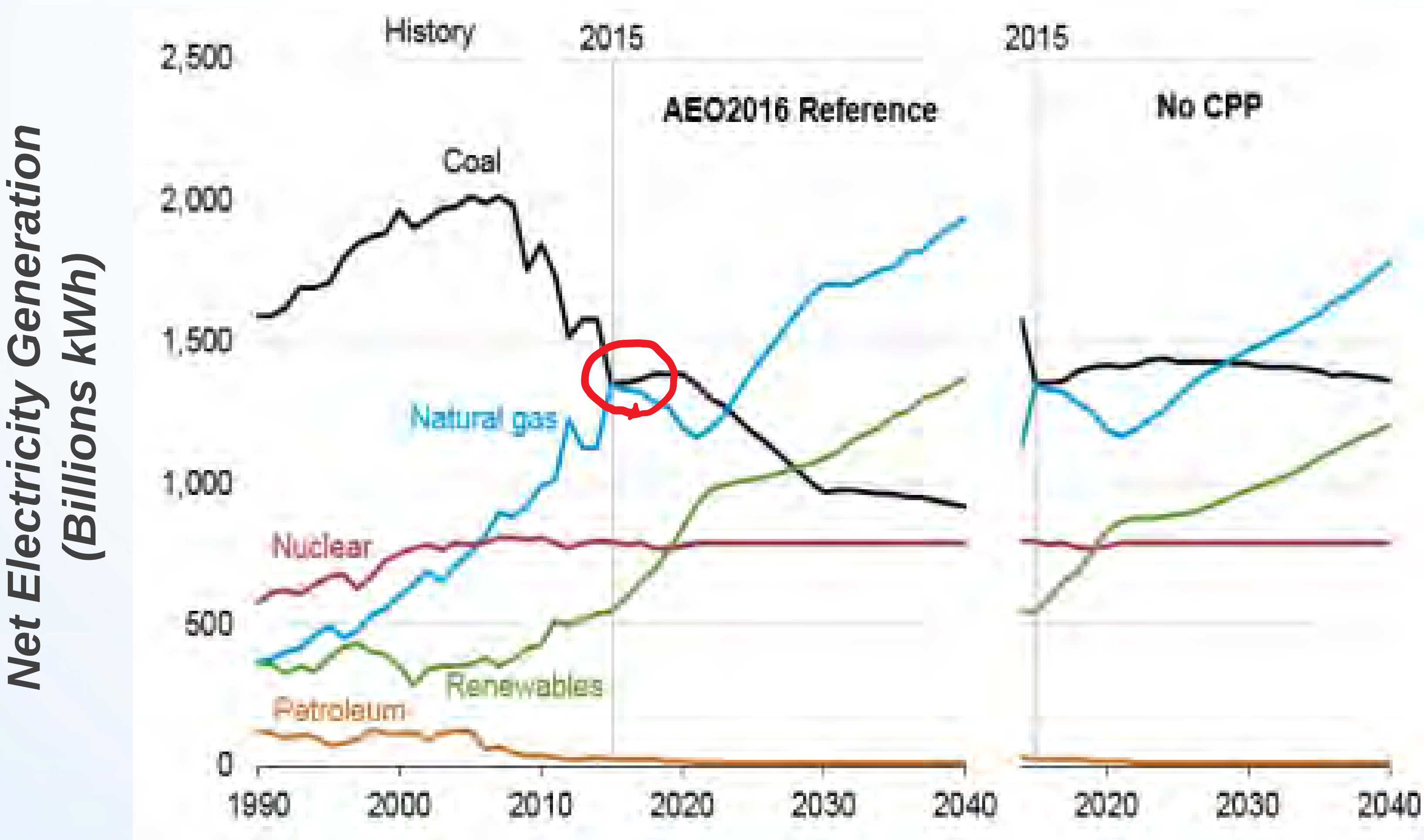
- Shift away from coal
- Shift toward production and supply of natural gas
- Growth in renewables
- More competitive transmission sector and movement toward distributed energy resources

**National Power Generation Mix**

| | COAL | NATURAL GAS | NUCLEAR | HYDRO AND OTHER RENEWABLES | OTHER |
|---|---|---|---|---|---|
| **2005** | 49.6% | 18.8% | 19.3% | 8.8% | 3.7% |
| **TODAY** | 38.6% | 27.5% | 19.5% | 13.2% | 1.4% |

*Source: EIA Annual Energy Outlook Early Release 2016*

# Where we' going….




*Source: EIA Annual Energy Outlook Early Release 2016*

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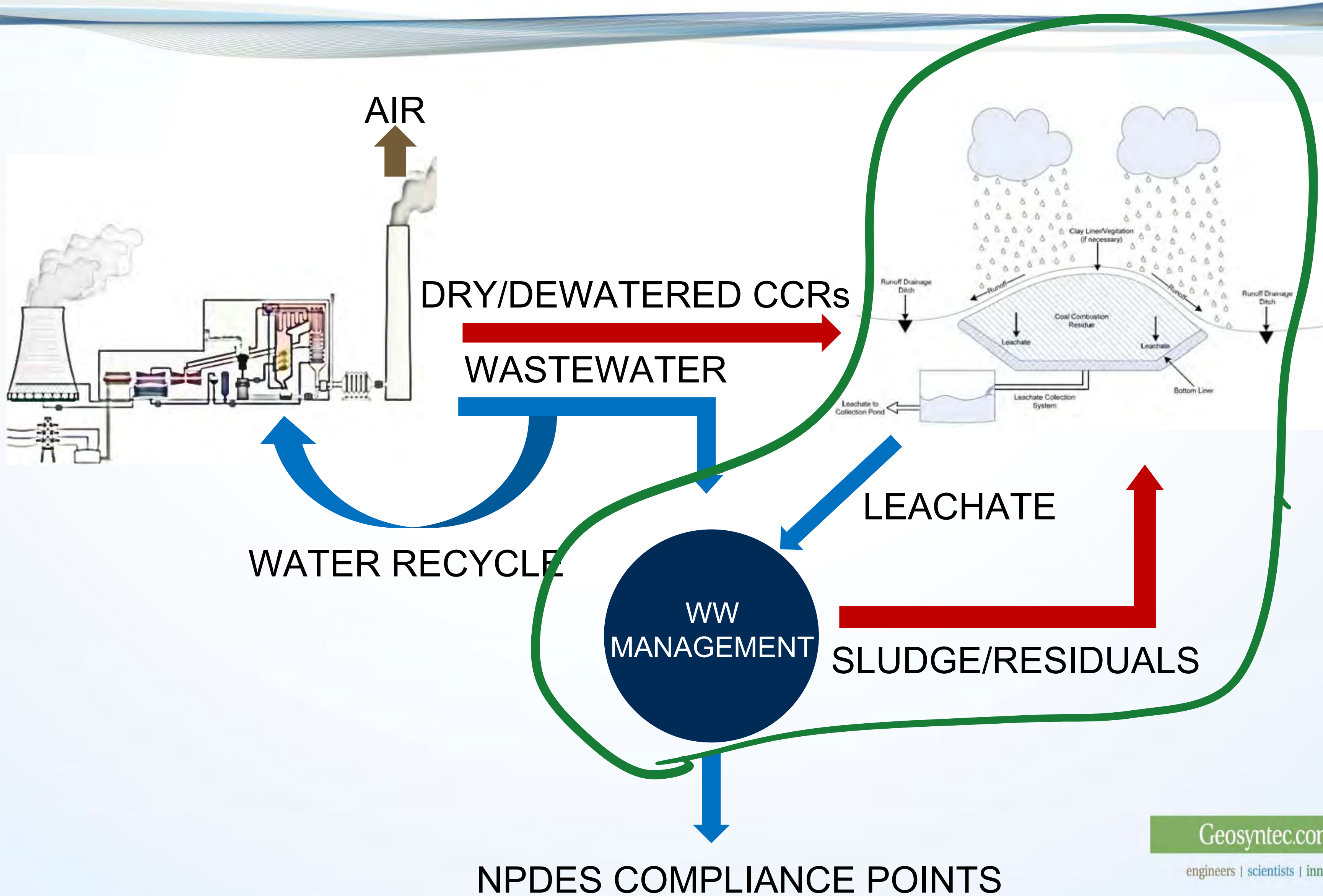
# Multimedia Approach to Compliance

- Air Regulations – CAA, CAIR, MATS
  - Improved air quality
  - Contaminants transferred to solid or aqueous state (e.g., EPS particulates, FGD wastewater)
- CCR Rule
  - Contaminants “contained” in lined units but transferrable to leachate
  - Improved groundwater quality
  - ELGs minimize use of water for transport, more dry solids to handle
- ELGs
  - Improved surface water quality
  - Contaminants precipitated to solid or gaseous state

(Walt Unks/Winston-Salem Journal)


# Multimedia Approach to Compliance



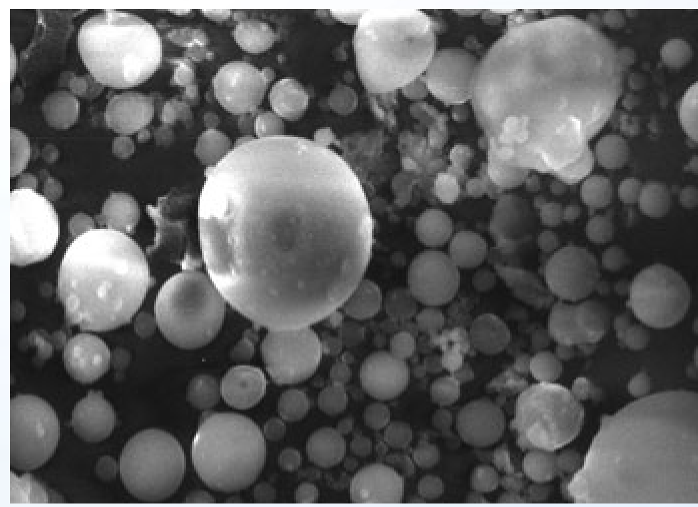
# Breaking the Cycle

- Contaminants cannot be “destroyed”
- Stabilizing solids provides the lowest risk long-term solution

Encapsulate/ stabilize

Modify geochemistry to treat/enhance stability

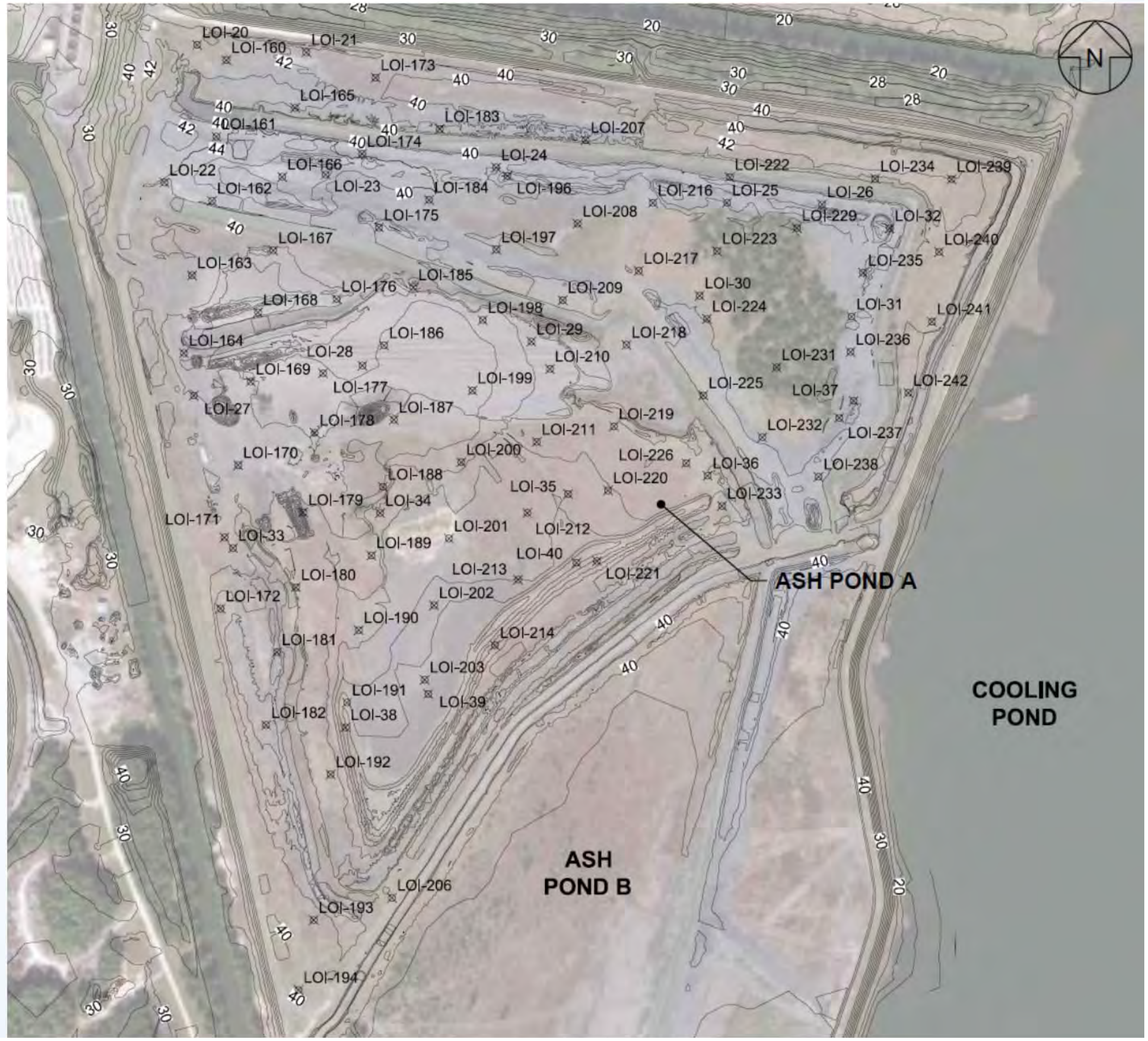
Beneficial Use



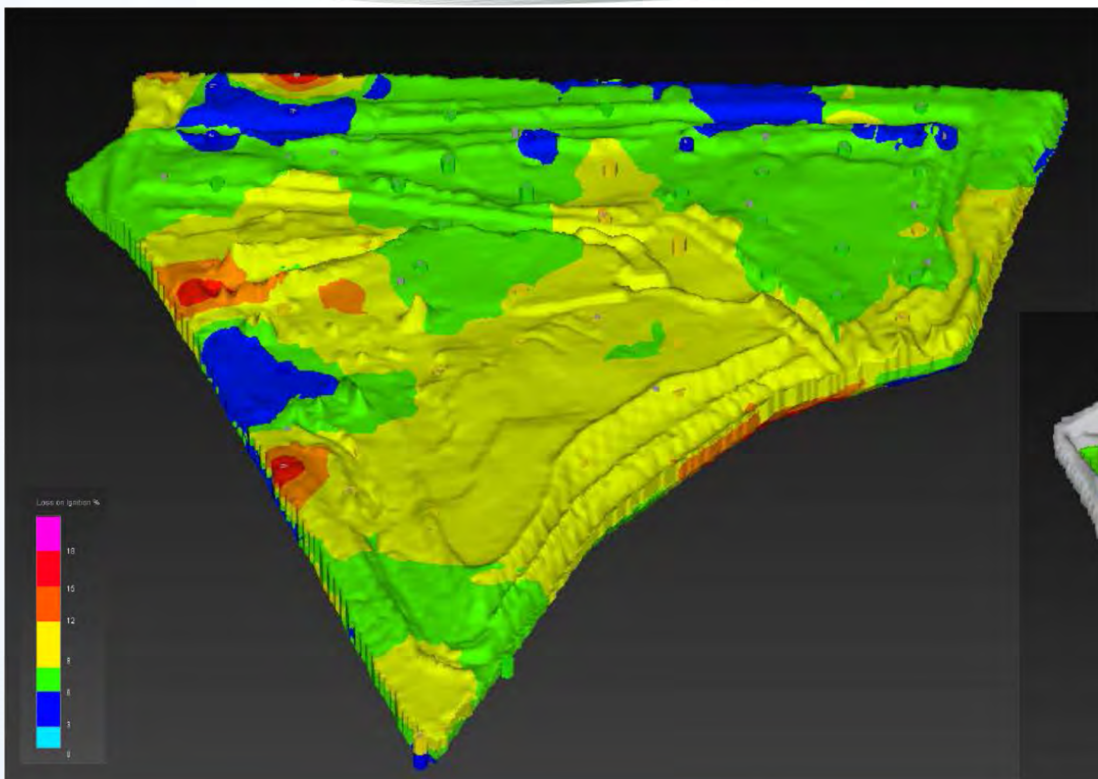
# Ponded Fly Ash – Beneficial Use Project

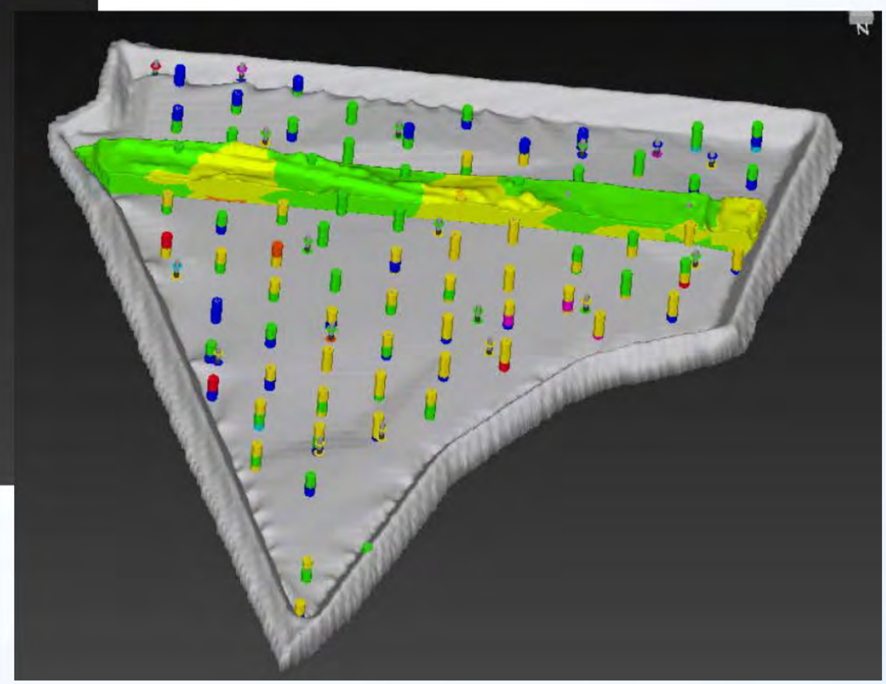
## Sampling Program

- Continuous cores from approximately 60 borings via Geoprobe
- 200 ft spacing
- Composite samples collected every 3 ft
- Results modeled using EVS with sediment deposition module

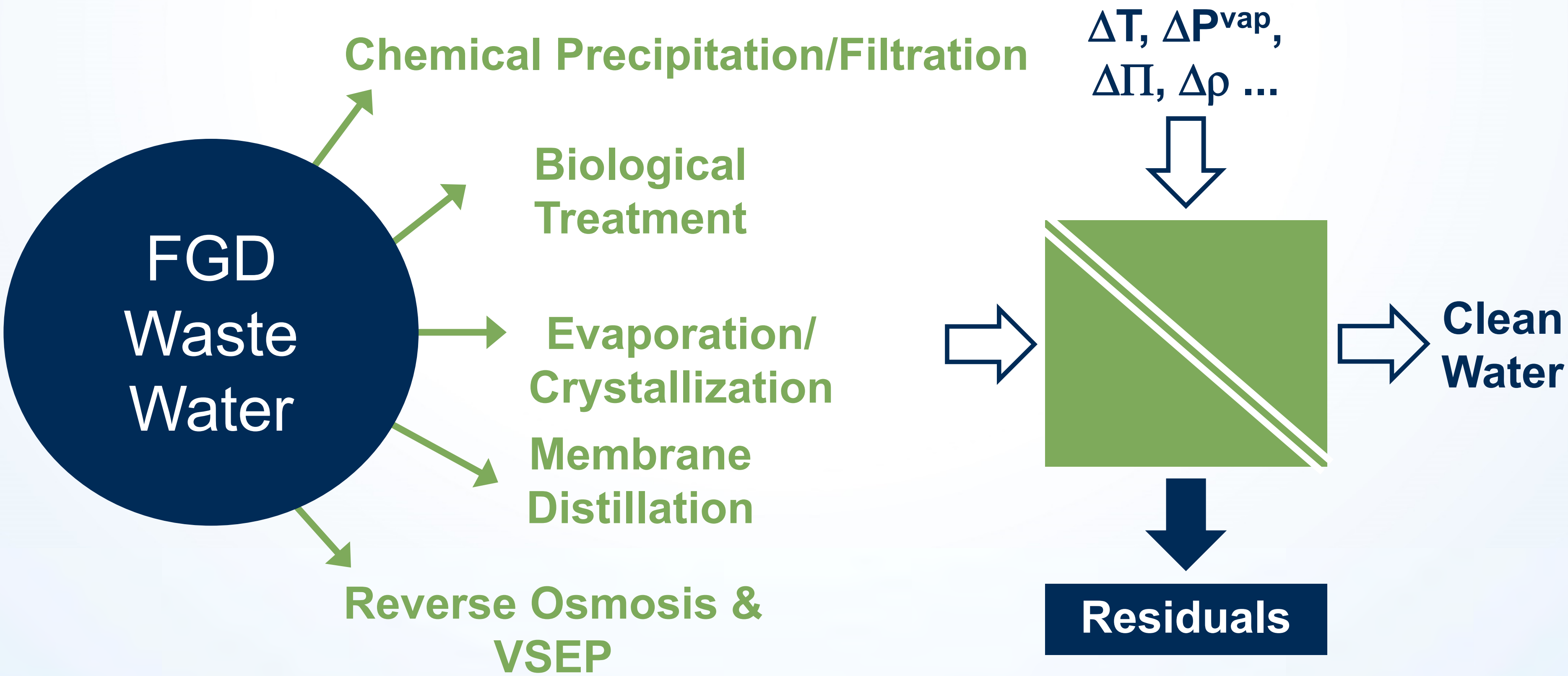


# Ponded Fly Ash – Beneficial Use Project

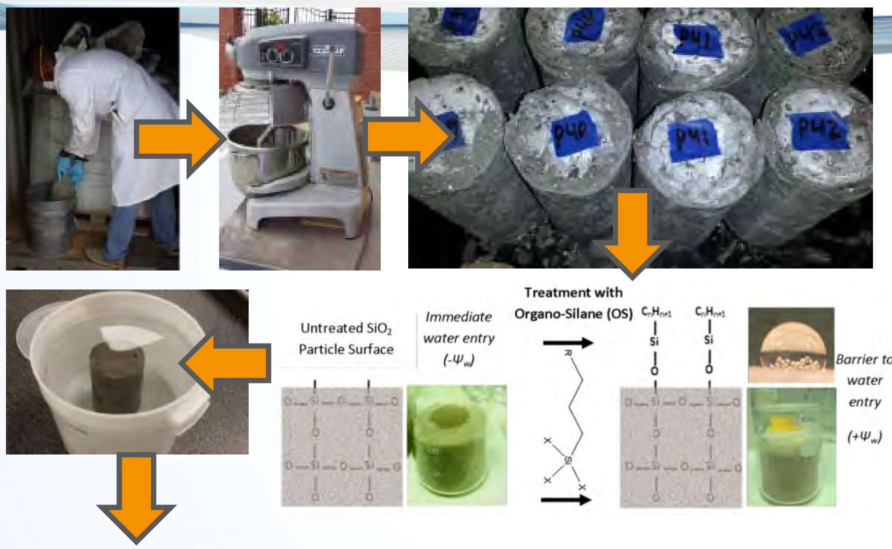


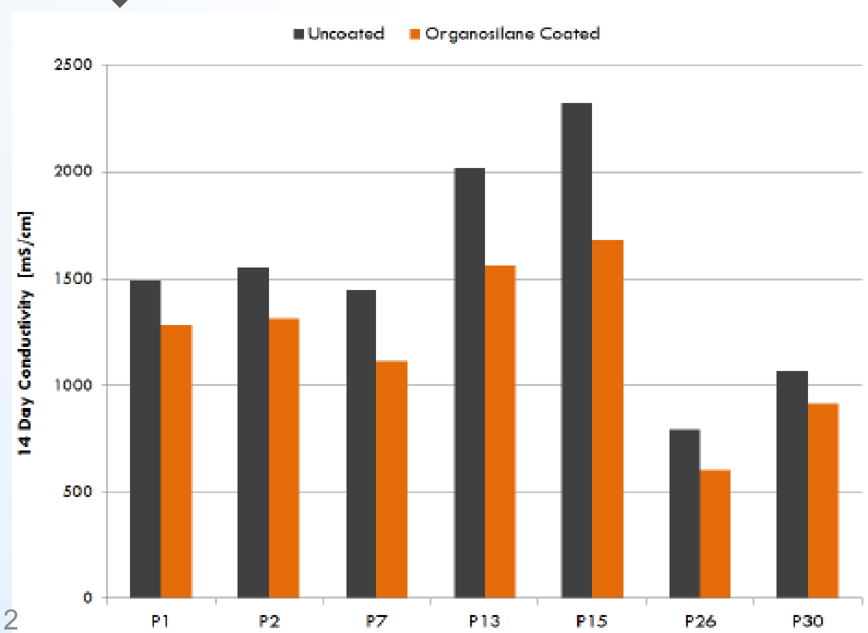



# FGD WW Residual Technology Development




# FGD WW Residual Technology Development




- Research and development at UNC Charlotte to develop treatment for scrubber wastewater to tie up halides (especially bromides) in non-leachable solid form for landfill disposal
- Mix scrubber wastewater with fly ash, gypsum, caustic (NaOH), hydrated lime ($Ca(OH)_2$) and other amendments; thin layer of organosilanes (water repellent); test for halide leachability
- Small scale: Reduced leachability
- 2016: Field tests at utility

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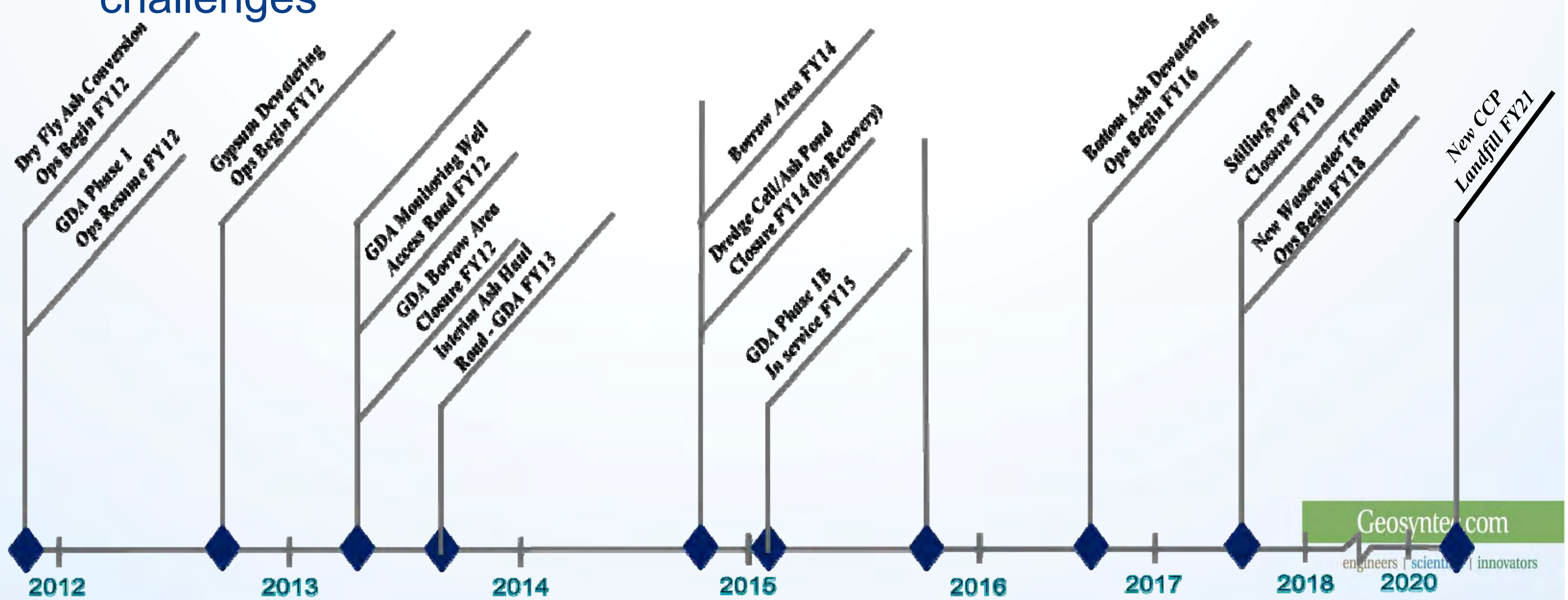
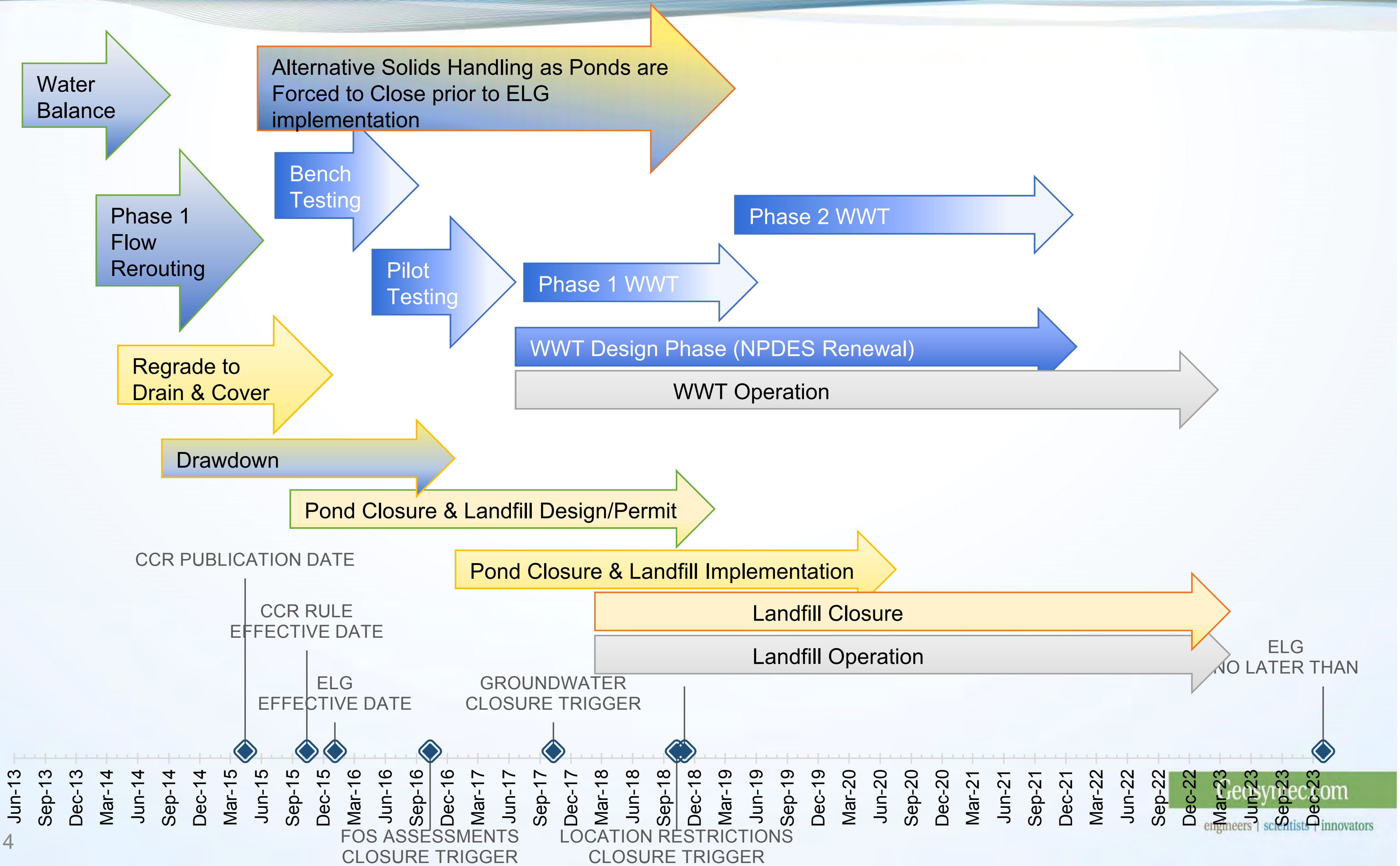
# Master Planning

- Strategic master planning for multimedia compliance is essential
- Identify critical first steps
  - Flow monitoring and wastewater characterization (Water Balance)
  - Expedited pond closure
- Balance programmatic approaches with each plant's unique challenges



# Case Study No. 1 – CCR and ELG Sequencing

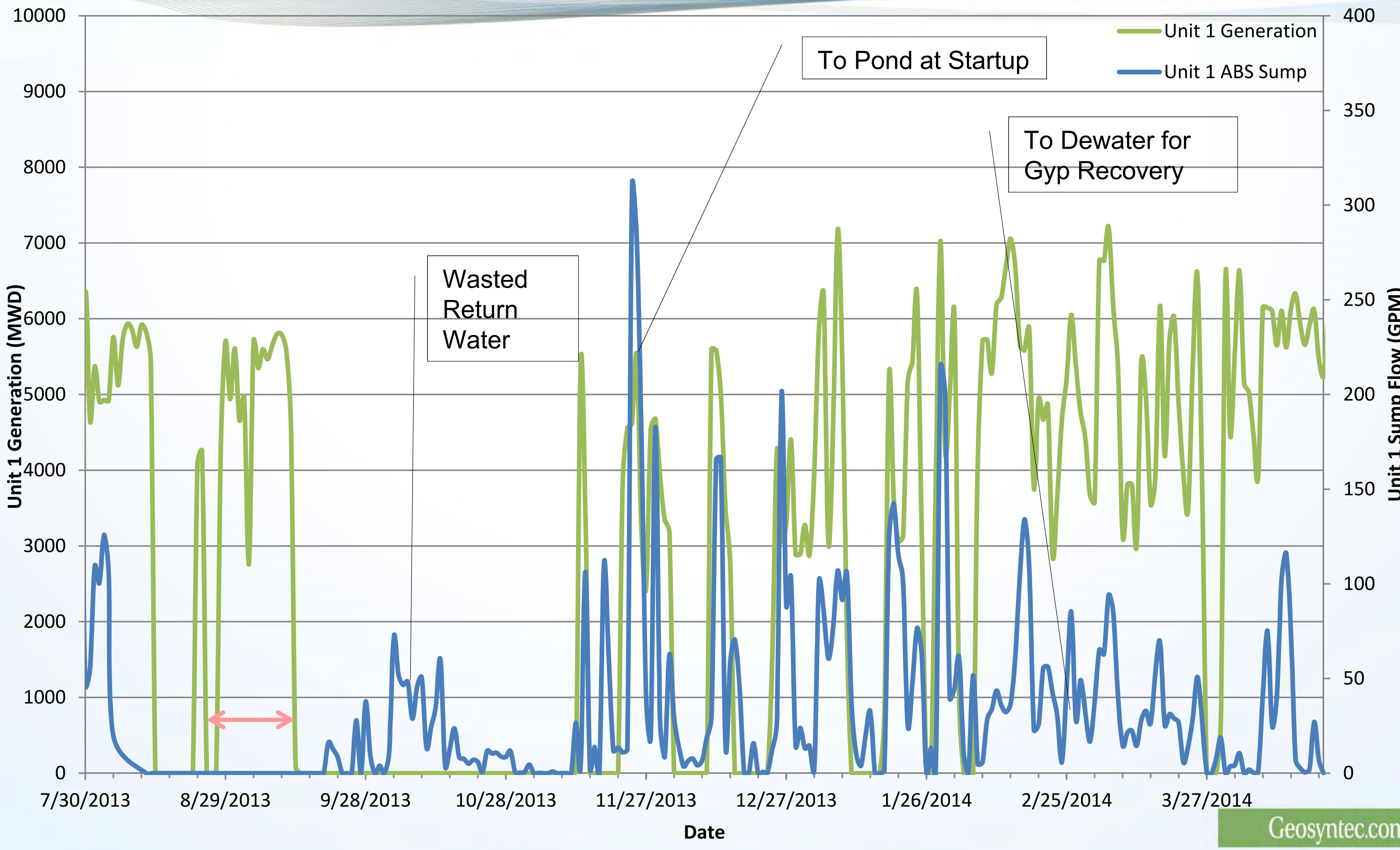


# Master Planning Case Study No. 1 – Starting Point

- Began with simplistic NPDES flow diagram
- Multiple changes to ww system over the years with missing record drawings
- Design basis quality PFD important component

# Water Balance – Select Monitoring Locations

# Findings – Opportunities for Flow Reduction and Recycle

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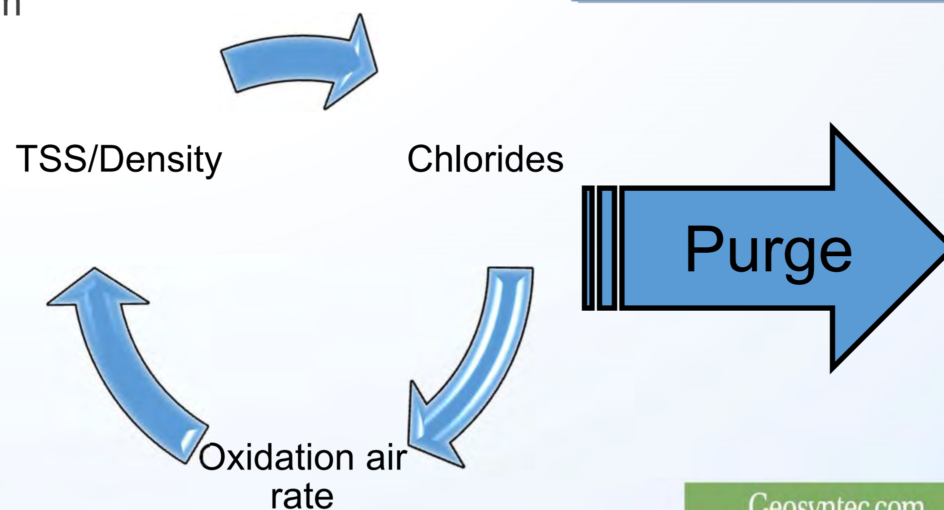
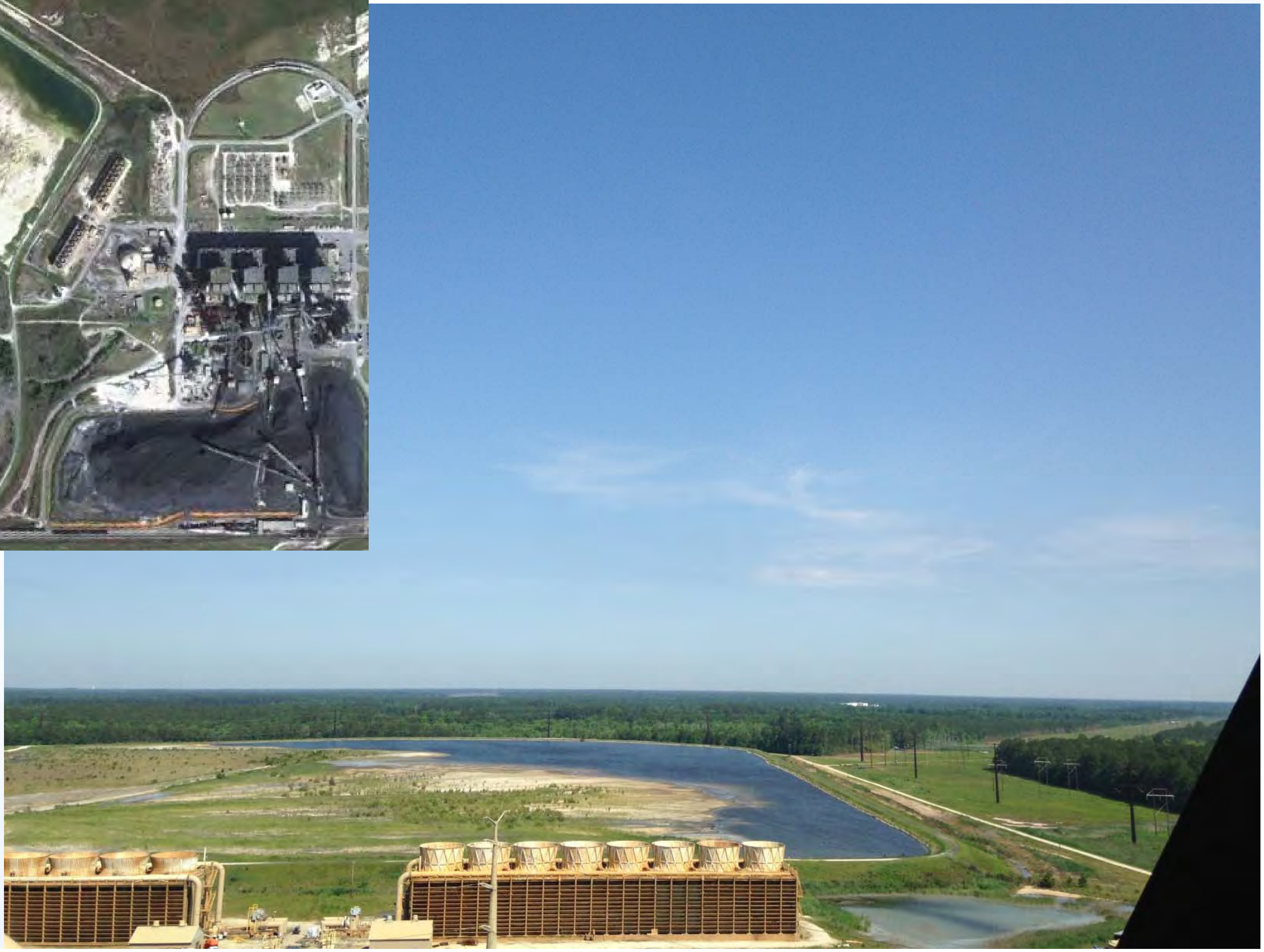
# Findings – Opportunities for Flow Reduction and Recycle

- Low Hanging Fruit
  - Operate secondary hydroclones
  - Fix faulty controls programming
  - Refine operational practices
  - Optimize flush cycle lengths
- Larger Endeavors
  - Add off-spec solids removal capacity
    - Just completed new, covered gypsum pad
    - Will add solids clarification capacity prior to ELG deadline
  - Optimize blowdown triggers, increase ww recycle



# Case Study No. 1 – Regulatory Integration



# Case Study No. 1 – Regulatory Integration

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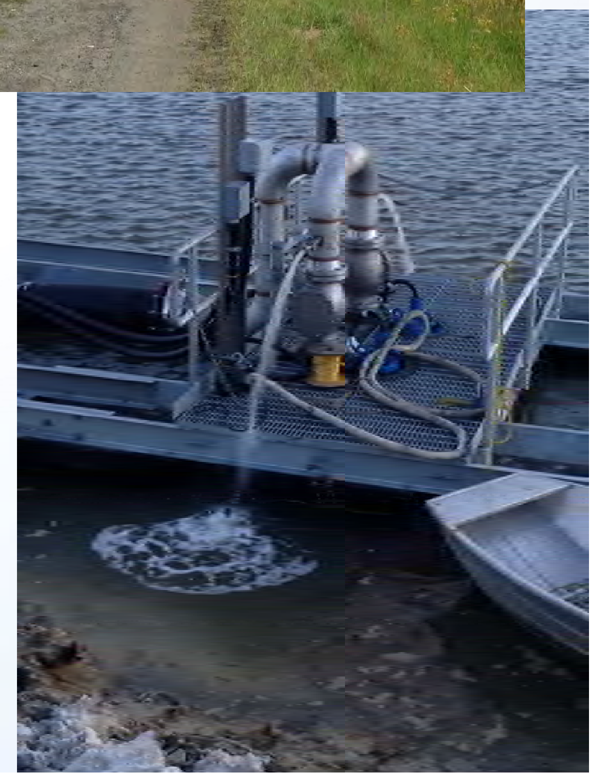
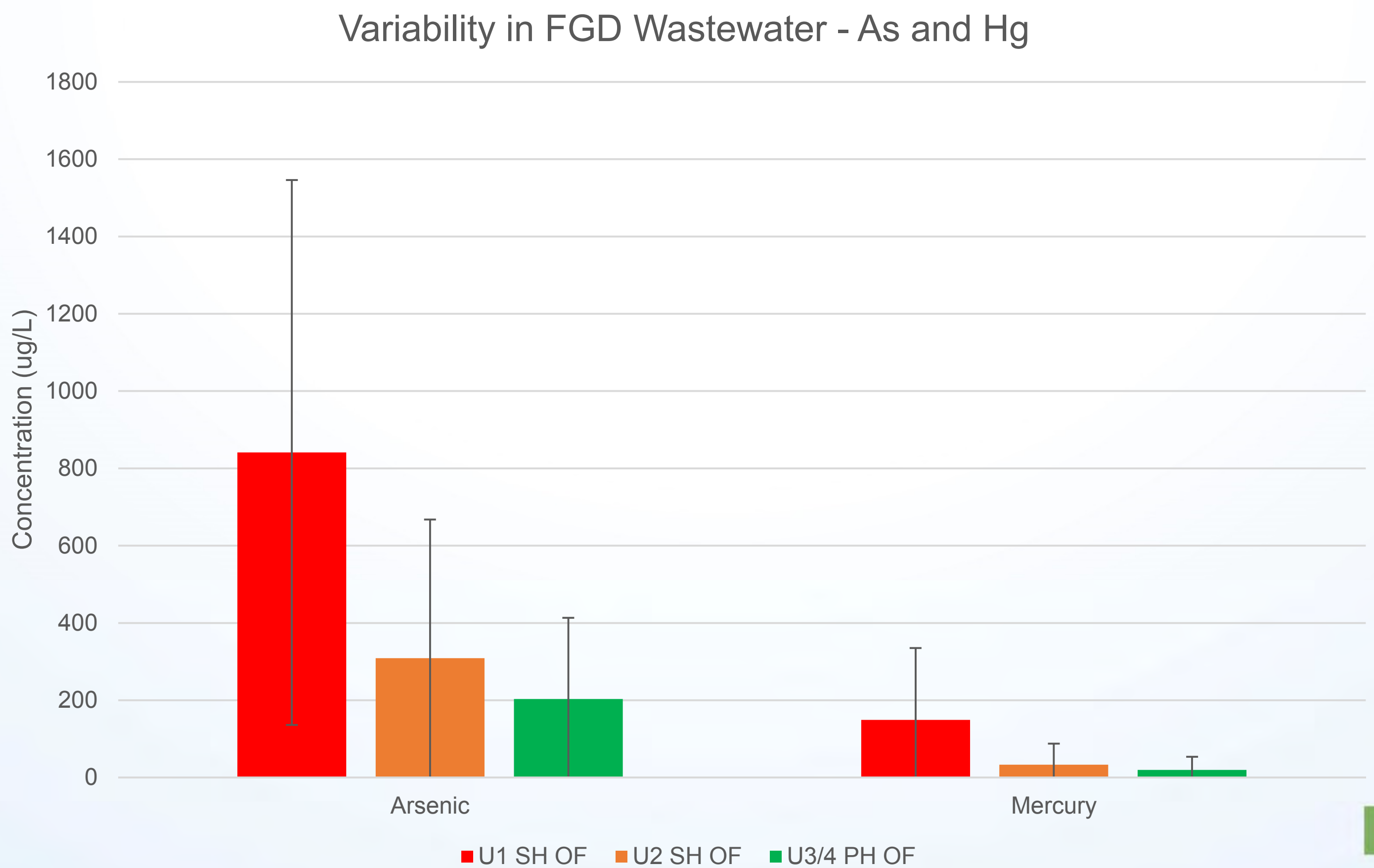


# Case Study No. 1 – Regulatory Integration

# Case Study No. 1 – Variability of FGD Wastewater

High degree of variability in FGD wastewater poses challenges

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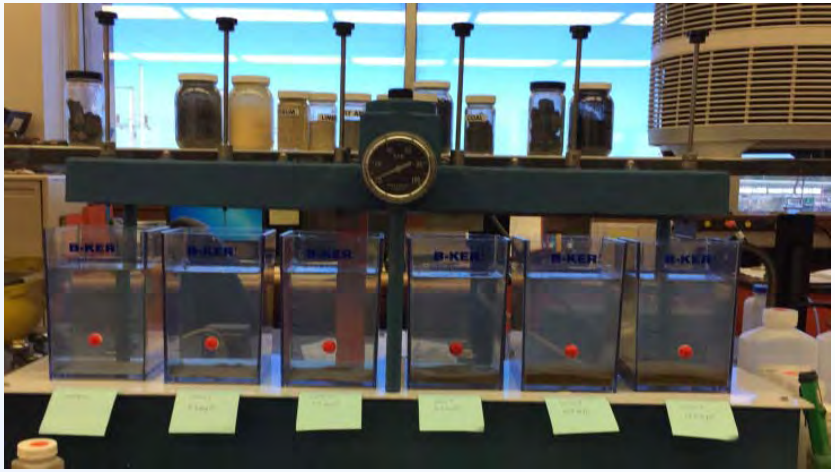
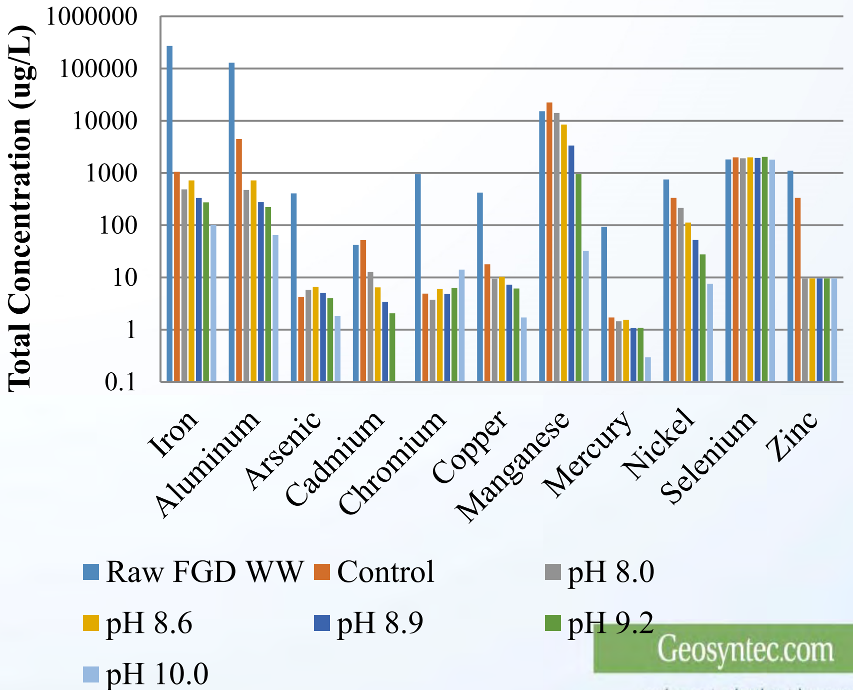
# Case Study No. 1 – Bench Testing Program

- To ensure bench testing results are representative and transferable  - experiments have to mimic the actual process.
- Interdependent variables make bench testing complex.



*Clarified FGD wastewater following chemical precipitation with lime, ferric chloride, and organosulfide*

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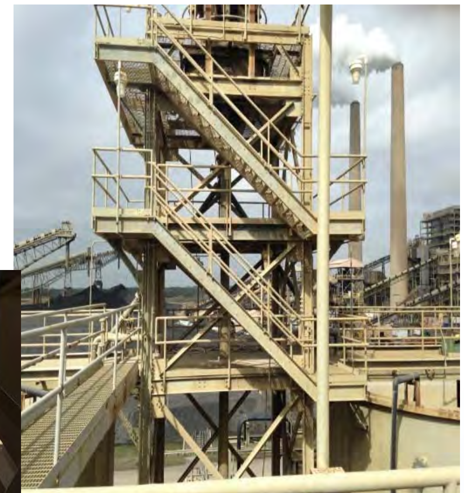
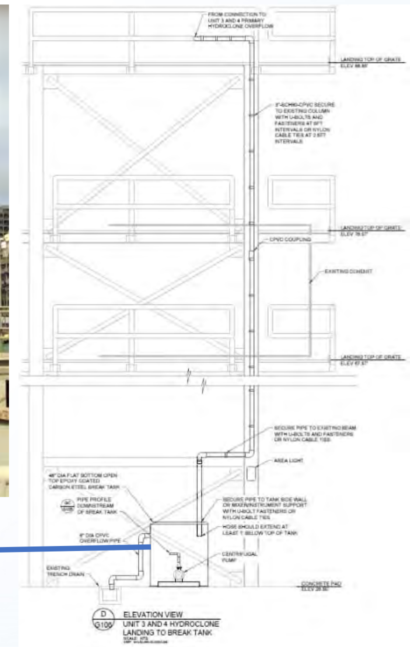
# FGD Treatment Pilot/Demonstration System

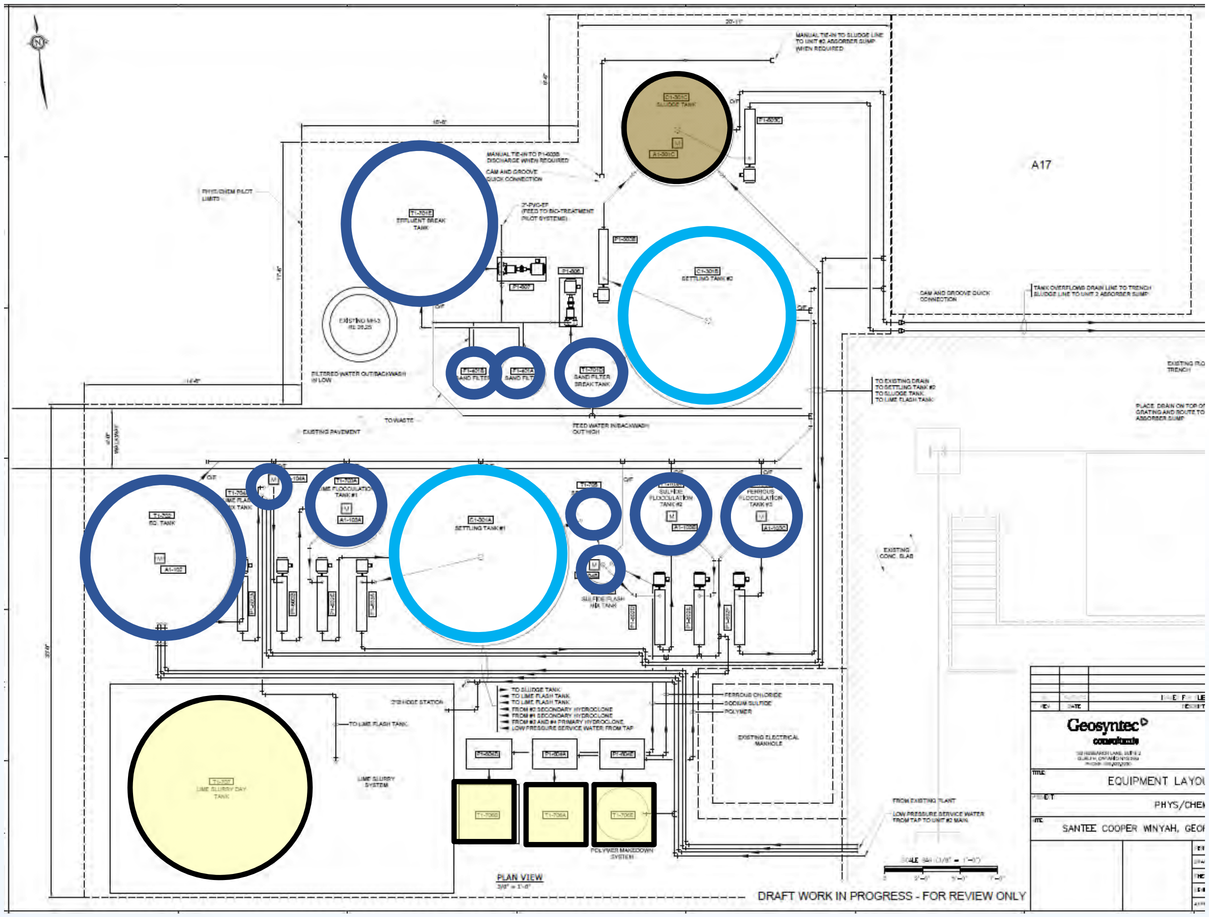




Iron hloride → Polymer Addition → Settling

- Multi-stage Bioreactor
- RO
- Conditioned ZVI

# FGD Treatment Phys Chem General Arrangement



# FGD Demonstration System – Construction Progress

# Master Planning Case Study No. 2 – Kingston (Post-Release)

- Immediate response actions and subsequent forensic investigations
- Wet to dry conversion of CCP material storage
- New facility design, detailed engineering and CQA
- Leachate treatment and management
- Water treatment/management
- Karst mitigation
- Inspection, analysis and evaluation of existing impoundment structures
- Monitoring using real-time techniques

TVA Kingston Facility

# Master Planning Case Study No. 2 – Kingston (Post-Release) Solid Waste

## Initial Steps (12 months)

### Selected Strategy

- Re-permit already permitted GDA for both Ash and Gypsum disposal

### Challenges

- Keep plant in production during interim
- Community relations
- Regulatory relations
- Construction "drop-outs" (karst) within GDA footprint

### Path Forward

- Use Ballfield for temporary ash storage
- Operate GDA initially for wet gypsum disposal
- Transition from wet- to dry disposal
- Obtain regulatory approval prior to completion of plant outage

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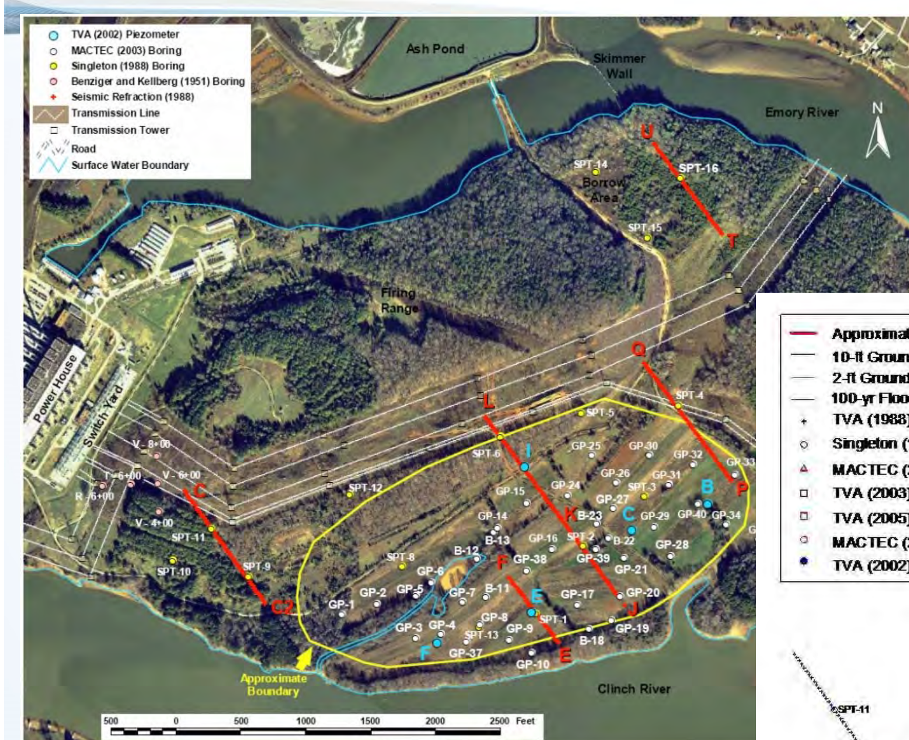
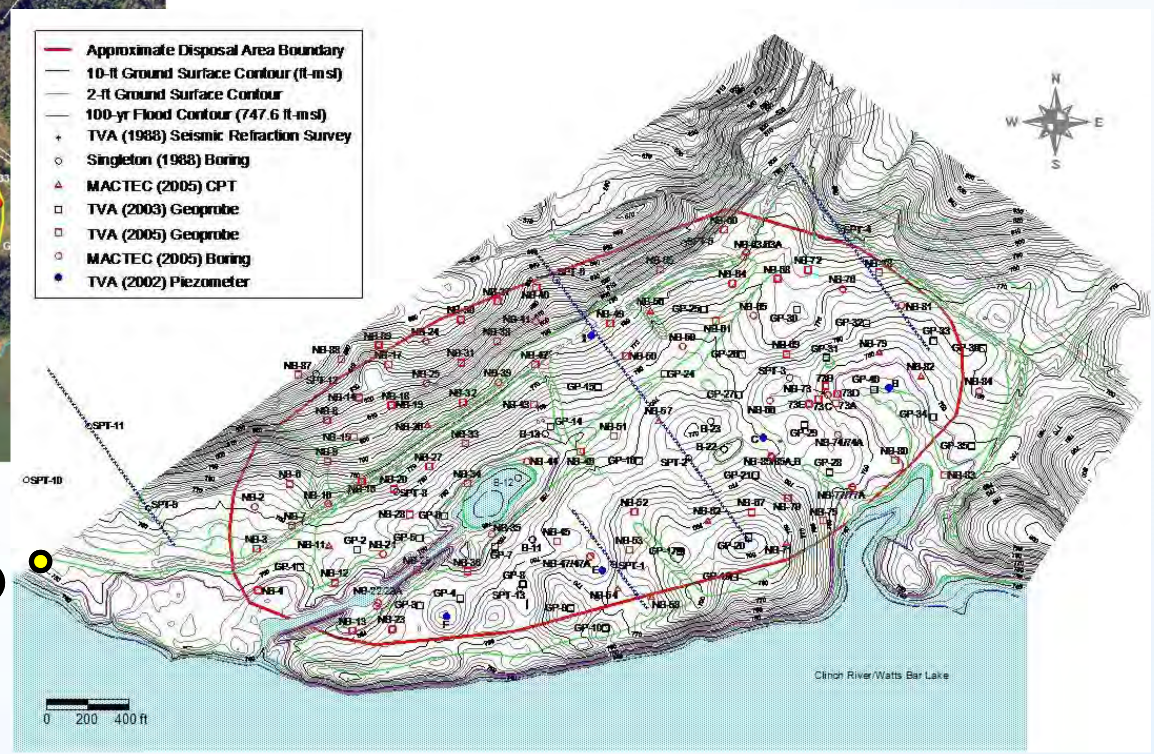
# Solid Waste Facility Siting




**Original Facility - designed, permitted, partly constructed for gypsum disposal**

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# Solid Waste Visualization Study

Public and
Regulatory Relations
1. Reduce height
2. Reduce visibility


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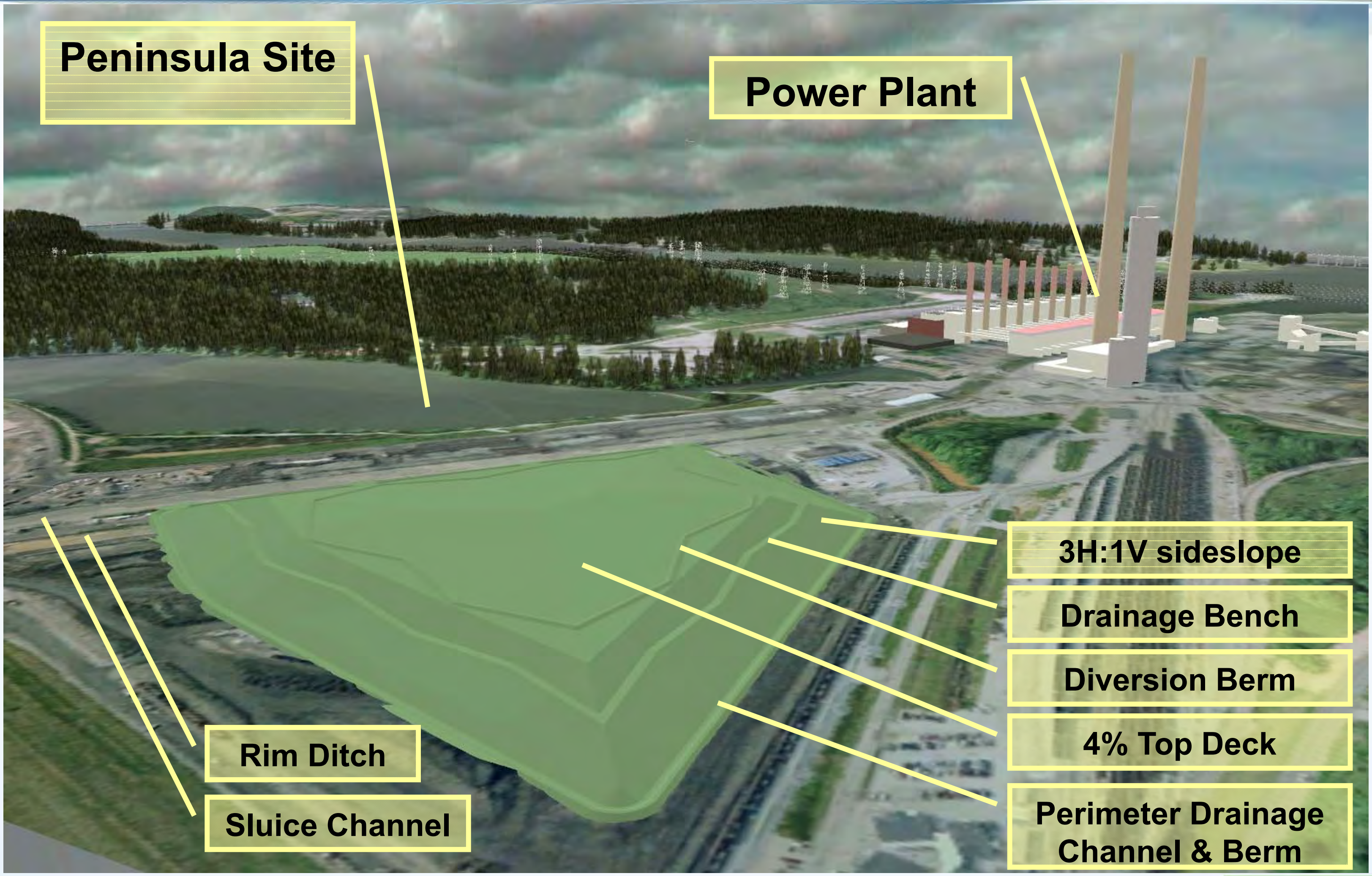
# Kingston – Solid Waste Ballfield Area Temporary Ash Disposal



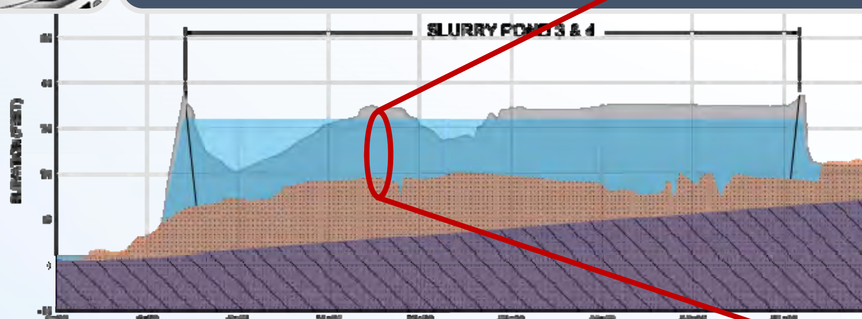
# Innovative Solutions – Off-spec FGD Beneficial Use?

## Objectives

To enrich the gypsum (CaSO4·2H2O) content in order to increase opportunities for beneficial use

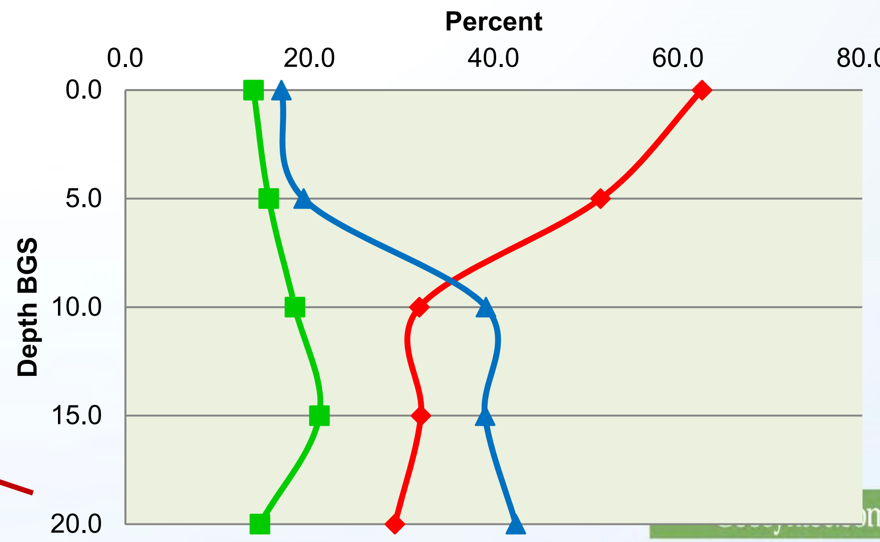
To separate from residual components
- Hannebachite (CaSO3 ·0.5H2O)
- Residual limestone, Fly ash…

To determine the feasibility of processing ponded FGD solids through a large-scale pilot system

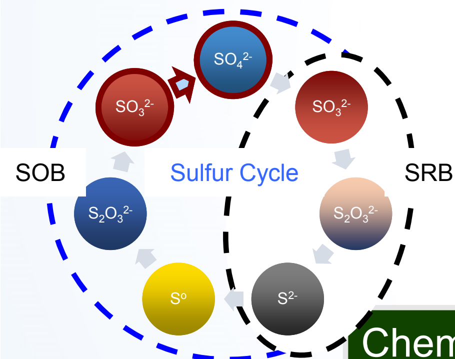



| Specification | Wallboard | Agricultural | Cement |
|---|---|---|---|
| $CaSO_4 \cdot 2H_2O$ | > 92% | > 85% | > 85%, < 95% |
| $CaSO_3 \cdot 0.5H_2O$ | < 1% | | |
| Moisture | < 15% | < 18% | < 18% |
| Other | < 7% | | |

**Average Composition of Borings**

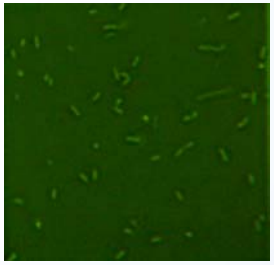



# Geosyntec's Novel Solution




$SO_3^{2-} + O_2 \rightarrow SO_4^{2-}$

$SO_3^{2-} + CO_2 + H_2O \rightarrow SO_4^{2-} + (CH_2O)_n + 0.5\ O_2$



- Chemolithotrophic sulfur oxidizing bacteria (SOB)
- Convert sulfite to sulfate
- Consume some carbonate
- Biostimulate and bioaugment
- Slurry reactor with 20-40% solids
- *Halothiobacillus sp*, others in bioaugmentation culture

# Experimental Design Utilizing SOBs

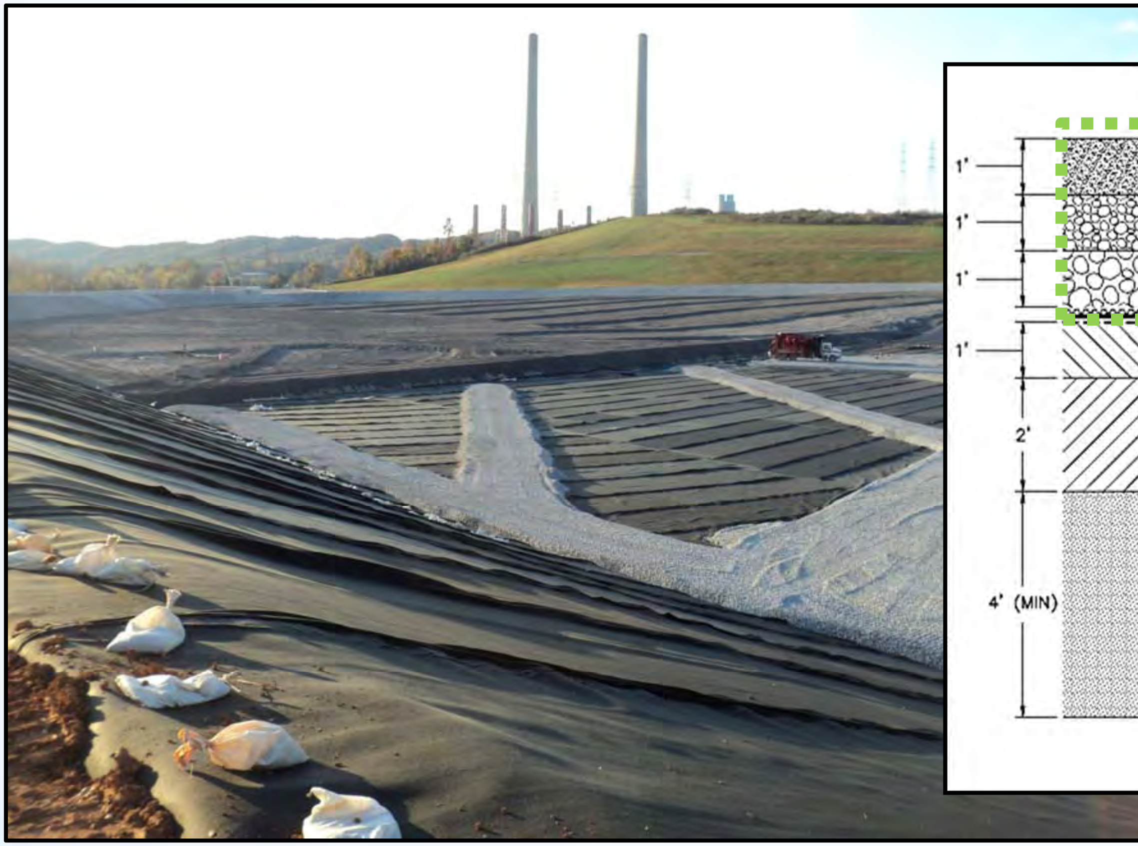

| | Wallboard Parameters | | Treated FGD |
|---|---|---|---|
| | **Minimum** | **Maximum** | |
| Gypsum | >92% | | 95.73% |
| Hannebachite | | 1% | 1.79% |
| pH | 6 | 8 | 7 |
| Particle size | 20 µm | 60 µm | 51.74 µm |
| Chloride | | 120 ppm | < 68 ppm |
| Acid insoluble matter | | 3.5% | 0.63% |

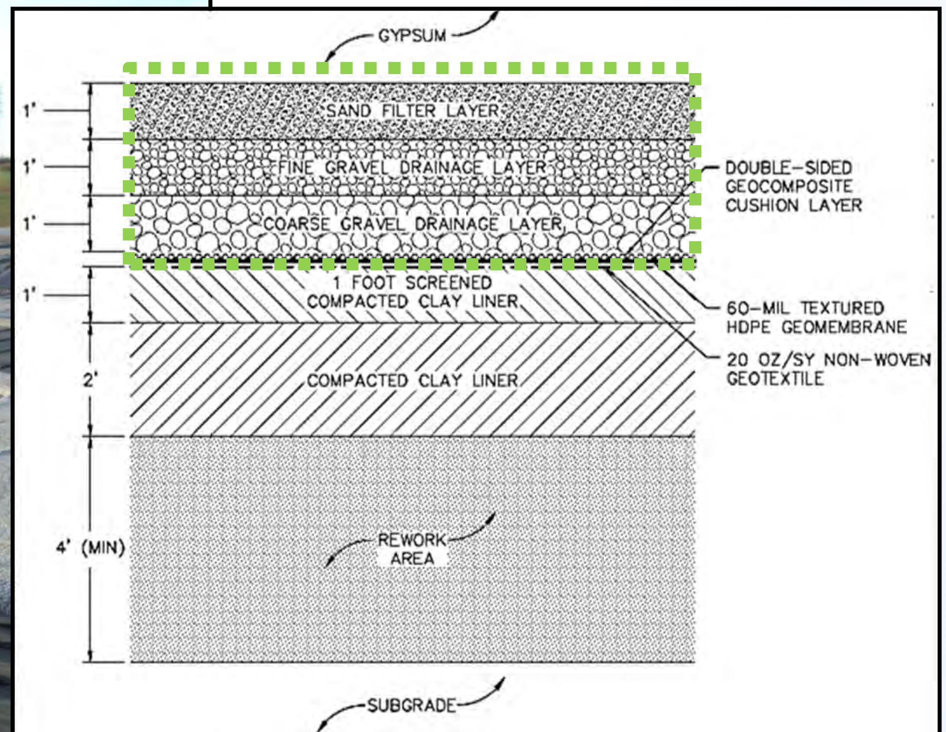
# Modify Geochemistry to Enhance Stability of Contaminants?

## Leachate Collection System

- Traditional Approach
  - Multi-layer system
  - Designed to filter (not clog)
  - Retain solids but filter/collect liquids for collection and treatment
  - Liquids typically treated (on-site or off-site) and discharged (NPDES)
- Alternative Approach
  - Multi-layer system
  - Designed to filter (not clog)
  - Develop in-situ bioreactor to treat contaminants or modify to a less soluble form (e.g., selanate to less soluble elemental selenium)
  - Partial re-circulation to optimize in-cell treatment
  - Secondary treatment and discharge (NPDES)

# Example Multi-layer Leachate Collection System





# Sand and Gravel LCS Test Column

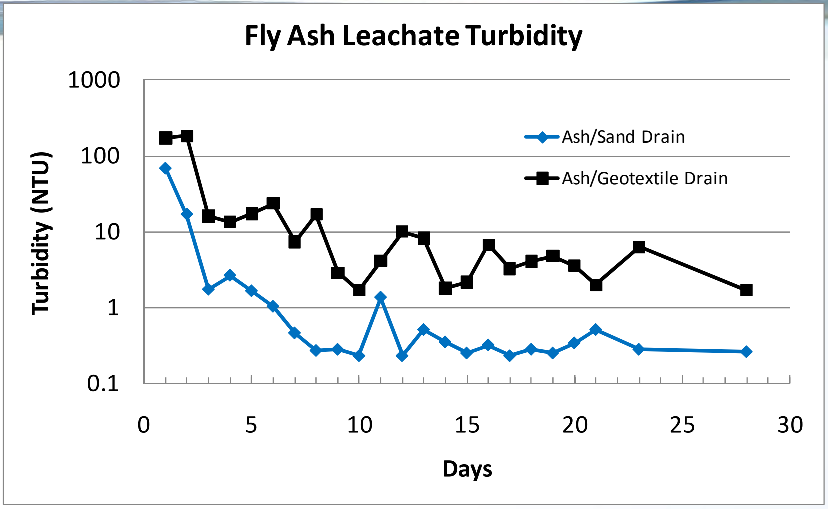
- 6.5 feet tall
- Gravel, sand, and ash loaded through a shallow layer of water to minimize channels
- Gravel and sand flushed to remove rock dust before adding ash
- Column filled with water from bottom up to expel trapped air
- 2 feet of water on top of ash, replenished daily by recirculating leachate

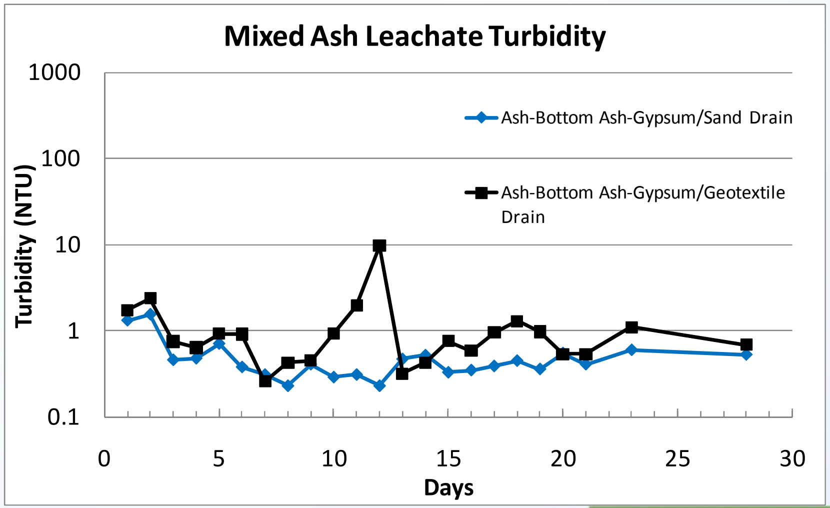

# Testing Schedule

- Daily flow rate and recirculation of leachate
  - Simulates flow through several feet of ash
  - Allows accumulation of TSS and TDS
- Daily pH, ORP, and turbidity
- Weekly sampling and analysis for carbonate, chloride, phosphate, sulfate, TSS, arsenic, and selenium
- Measurement of TDS at end of test
- Total test time, 28 days

# Leachate Turbidity

- NTU less than 2 or 3 looks clear
- Leachate turbidity declined over time
- Sand and gravel LCS had lower turbidity than the Geotextile LCS

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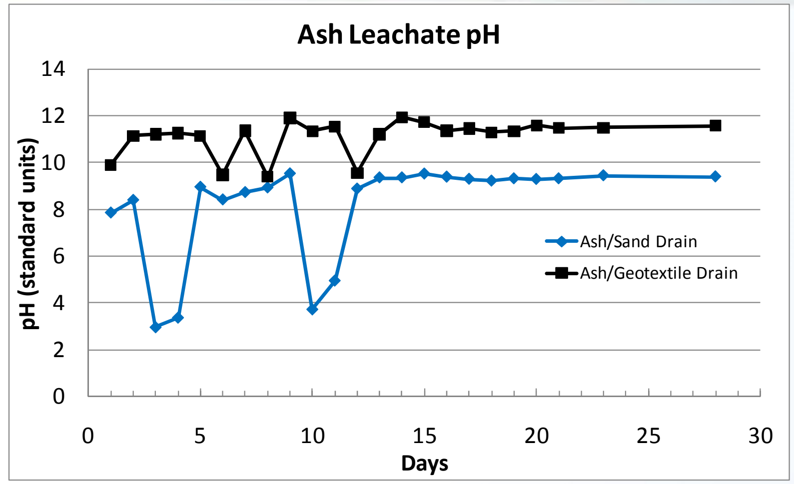
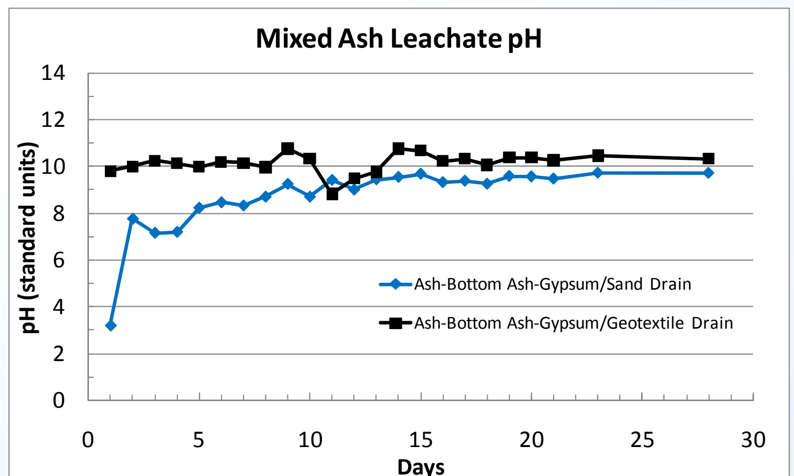
# Leachate pH

- Ash had a pH near 12
- Mixed ash was somewhat buffered by gypsum
- Sand and gravel had a significant buffering capacity




# Leachate Arsenic and Selenium

- Preliminary data suggests that granular media may promote in-cell treatment
- Can media and in-cell conditions be "engineered" to promote further treatment of leachate and immobilization of contaminants?
- More work needed

| Analyte | Days | Col A Ash/Gravel (mg/L) | Col C Ash/ Geotextile (mg/L) | Col B Ash Mixture/ Gravel (mg/L) | Col D Ash Mixture/ Geotextile (mg/L) |
|---|---|---|---|---|---|
| Arsenic | Tap Water | <0.0100 | <0.0100 | <0.0100 | <0.0100 |
| | 8 | 0.127 | <0.0100 | <0.0100 | 0.0167 |
| | 14 | <0.0100 | <0.0100 | <0.0100 | 0.136 |
| | 22 | <0.0100 | <0.0100 | <0.0100 | <0.0100 |
| Selenium | Tap Water | <0.0200 | <0.0200 | <0.0200 | <0.0200 |
| | 8 | 0.129 | 0.127 | 0.0796 | 0.0919 |
| | 14 | 0.0450 | 0.158 | 0.0766 | 0.0950 |
| | 22 | 0.0473 | 0.133 | 0.0814 | 0.0978 |

Although not currently regulated in existing landfill leachate, there may be long-term benefits to managing these and other contaminants in a secure landfill

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# Conclusions – Multi-layer Leachate Collection Systems

- LCS performance evaluated for
  - Flow
  - Clogging potential
  - effluent turbidity
  - pH
  - ORP
  - Dissolved solids content and composition
- Provided performance details for selecting a design—Sand and gravel design had better performance characteristics
- Unexpected finding on the value-added benefit of the sand and gravel design for pH buffering and potential treatment
- ***Could the LCS be used as a fixed film bioreactor for in-cell treatment?***

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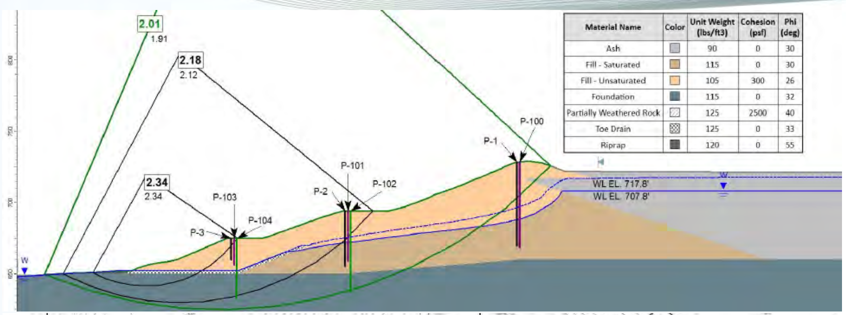
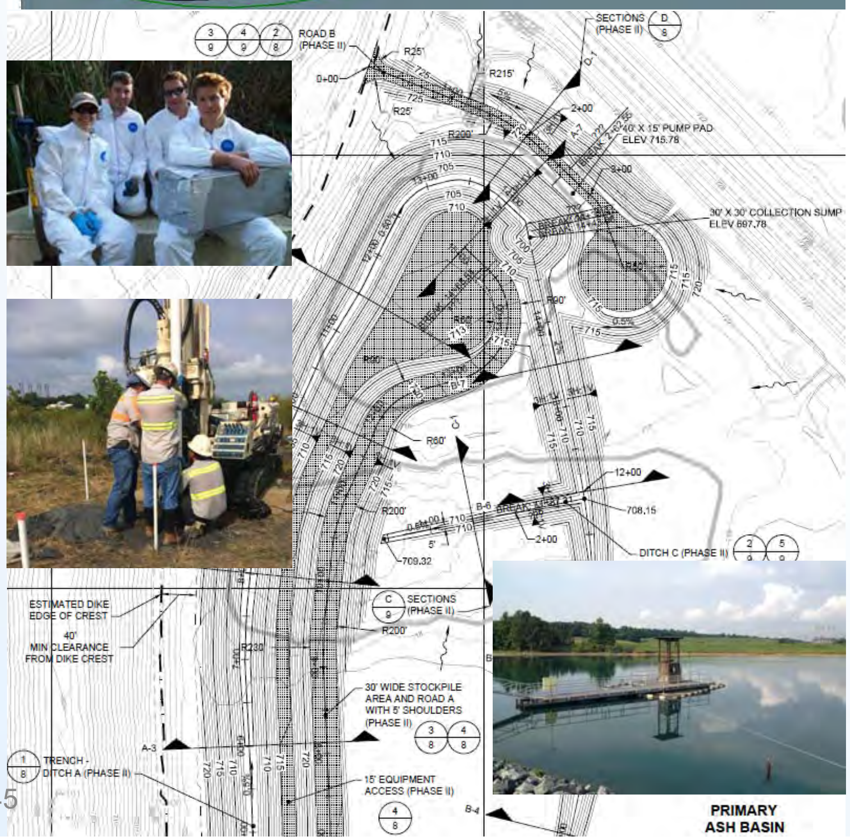
# Long-term CCR and Water Management

- Dewatering of CCR Units
  - Water management
  - Allows access for further action
  - Improved materials handling and stability
- CCR Unit Evaluation and Closure
  - Regulatory Evaluation (e.g., stability, location restrictions, etc.)
  - Closure options
  - Future CCR management options
  - Groundwater

# Ash Pond Dewatering




| Material Name | Color | Unit Weight (lbs/ft3) | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|
| Ash | | 90 | 0 | 30 |
| Fill - Saturated | | 115 | 0 | 30 |
| Fill - Unsaturated | | 105 | 300 | 26 |
| Foundation | | 115 | 0 | 32 |
| Partially Weathered Rock | | 125 | 2500 | 40 |
| Toe Drain | | 125 | 0 | 33 |
| Riprap | | 120 | 0 | 55 |




- May be multiple CCR ponds at each site
- Preparatory activity for other actions
- Pro-active approach may be good PR/Risk Mitigation measure
- Benefits to dewatering may include :
  - Improve short-term target Factors of Safety for dikes & dams
  - Remove free water and entrapped water as an advance activity
  - Develop ash excavation design approach
  - Dewatering system may need to incorporate water treatment to meet NPDES discharge limits
  - Integration with ELG approach – may be able to utilize treatment system legacy wastewater

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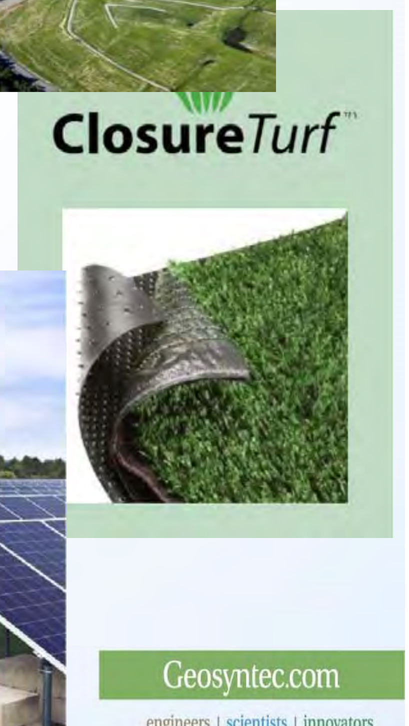
# Closure Options - What are the Trends?

## “Realistic” options tend to be limited

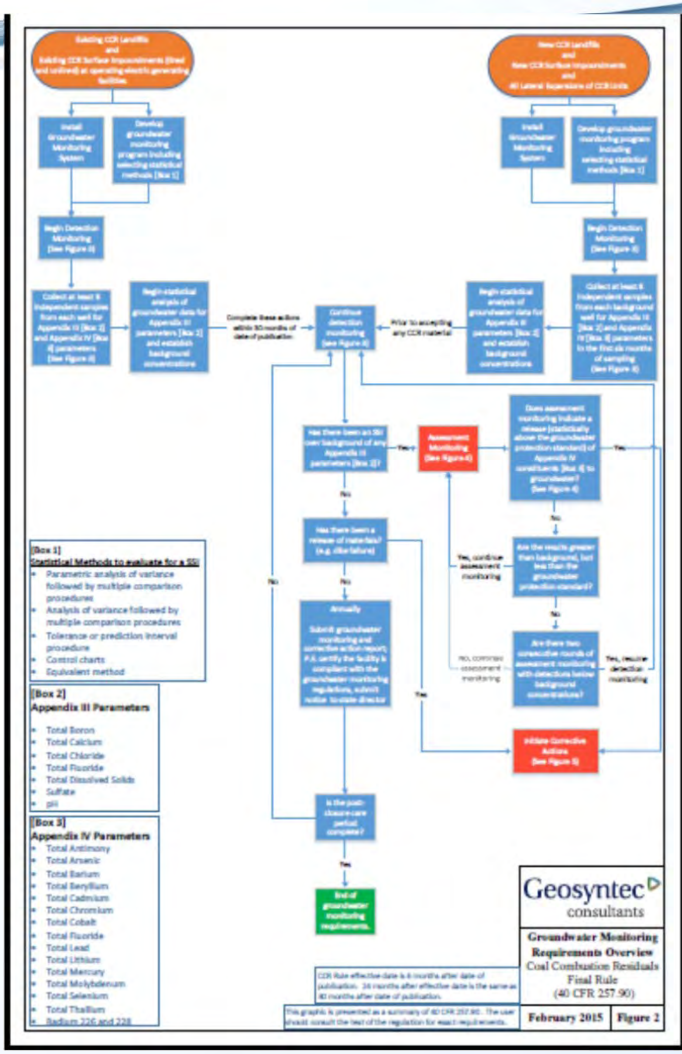
- Excavation
  - **Excavate and off-site**
  - Excavate and new on-site
- In-place closure/capping
  - **Conventional cover system**
  - Enhanced phyto-cover systems
  - **Exposed geomembranes (including synthetic turf)**
  - Solar covers
- Beneficial Re-use
  - **Direct re-use**
  - **Pre-processing and re-use**
- Hybrids
  - Combinations of the above




# Groundwater

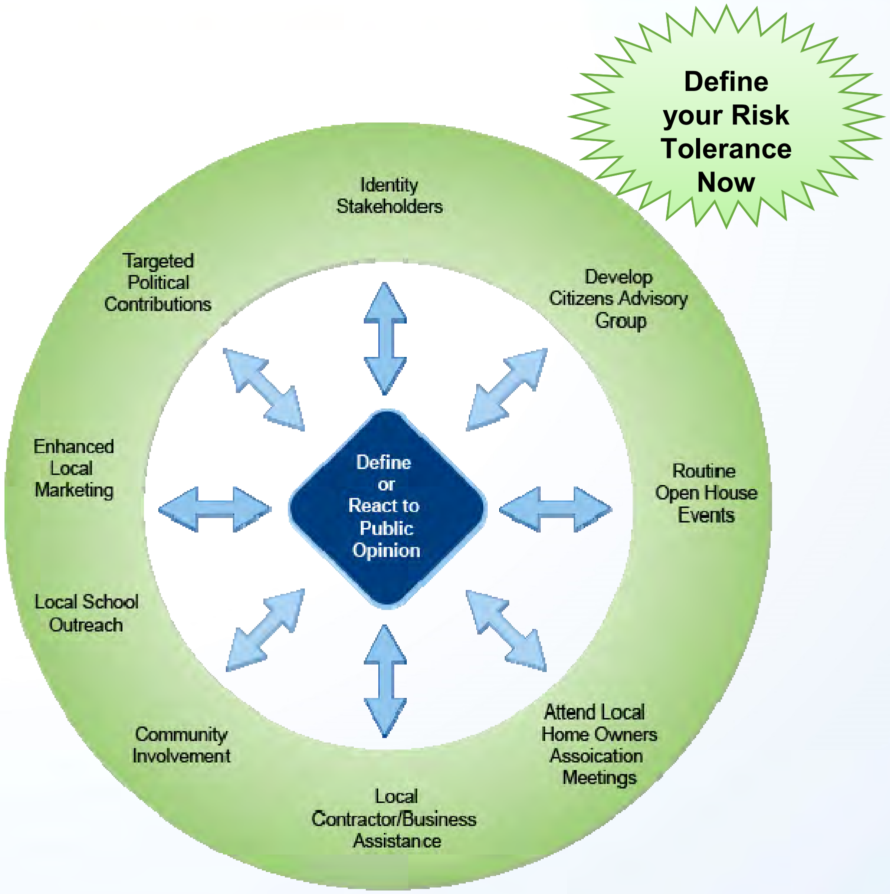
- Immediate action on groundwater (if not already initiated)
  - ( § 257.90 - § 257.98) - **Oct 17, 2017** Install the groundwater monitoring system; develop the groundwater sampling & analysis program; initiate the detection monitoring program; and begin evaluating the groundwater monitoring data for statistically significant increases over background levels

***[Groundwater work should be in progress in order to gather and synthesize available and background data]***



# Importance of Community Relations

- CCR information will be publically available on the internet
- Pro-active approach to Community Relations is usually beneficial



# Long-Term CCR and Wastewater Management Strategies

- Strategically master plan
  - Integrate the Rules (media) and programmatic and site-specific solutions
- Optimize opportunities for beneficial use& wastewater recycle
  - Wallboard, cement and related products
  - Install or upgrade wastewater recycle capability
  - Wastewater reduction/elimination by solidification
- State of Practice CCR Disposal Facility
  - On-site
  - Off-site
  - Regional
  - Aggressive residuals management

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## Potential Future Developments

When developing a holistic, multimedia approach, future regulatory trends and social trends should be considered.  These may include:

- General reduction in discharge limits for all waste streams
- Increased concern over emerging contaminants
- Increased societal pressure/trend towards "green power" and reduced carbon footprint

***In our introductory remarks, we identified how changes in generation mix tend to occur slowly due to size, complexity, and high capital investment needs.  New regulations and policy may accelerate this, but the rate of change is still uncertain.***