Geosynthetic Products for CCR Applications

MDNR Solid Waste Forum

February, 2016

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DURABILITY RUNS DEEP

Coal Ash Applications

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Geosynthetic Barrier Materials and Regulations needed.

In December 2008 a levee containing coal ash failed at a TVA facility in Kingston TN.

Subsequent clean-up costs are in excess of 1.4 billion US dollars.

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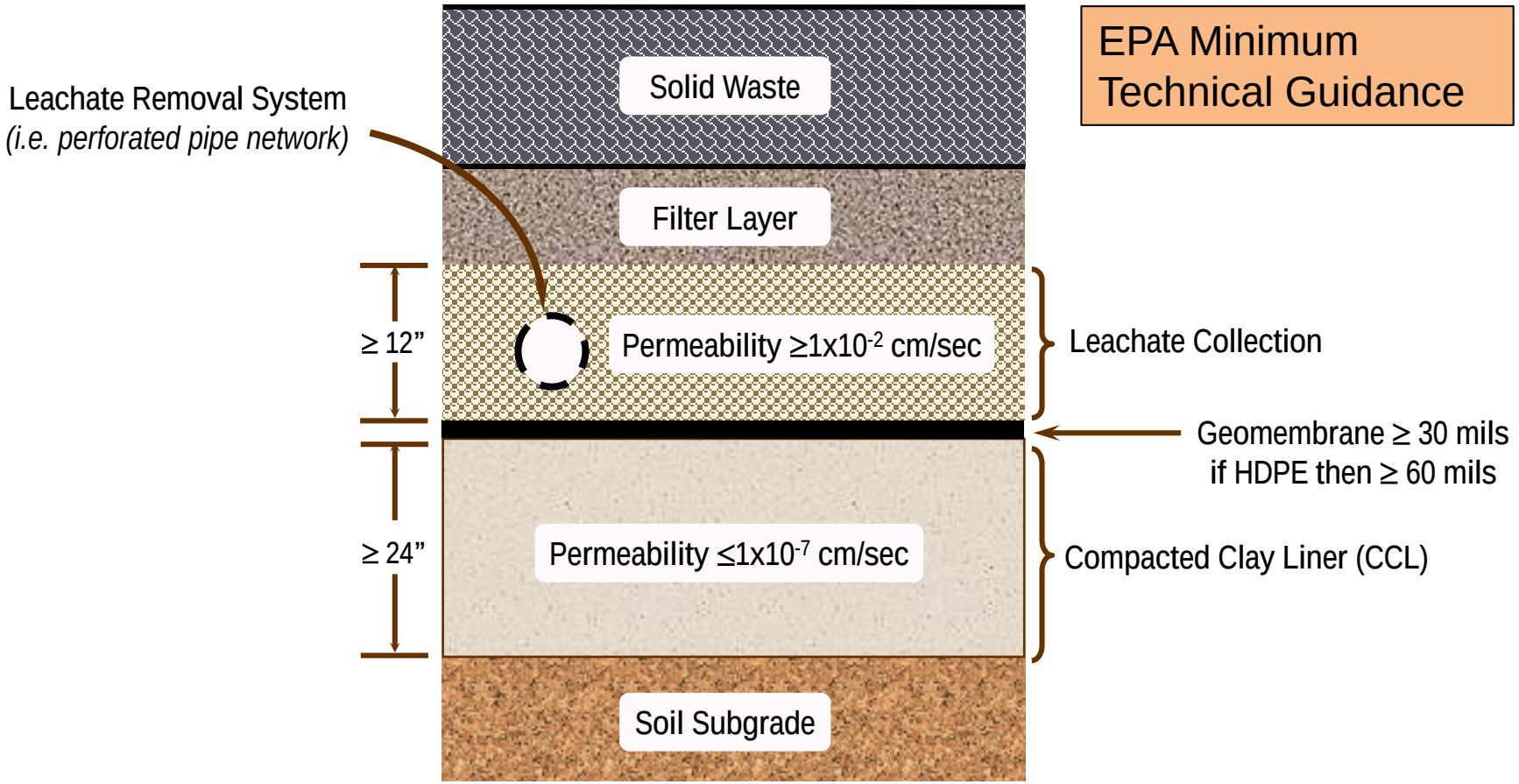
POLYMER ENHANCED GEOSYNTHETIC CLAY LINERS – CCR APPLICATIONS

Subtitle D liner system



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Hydraulic Performance

US EPA Technical Guidance Document - 2001

Major study conducted for USEPA (Bonaparte, Daniel, and Koerner - 1999)

Encompassed 91 Landfills and 287 double-lined cells

Cells monitored for 10 years

Leakage through primary liner (either GM, GM/CCL or GM/GCL) was evaluated by measuring flow into the underlying leachate detection system

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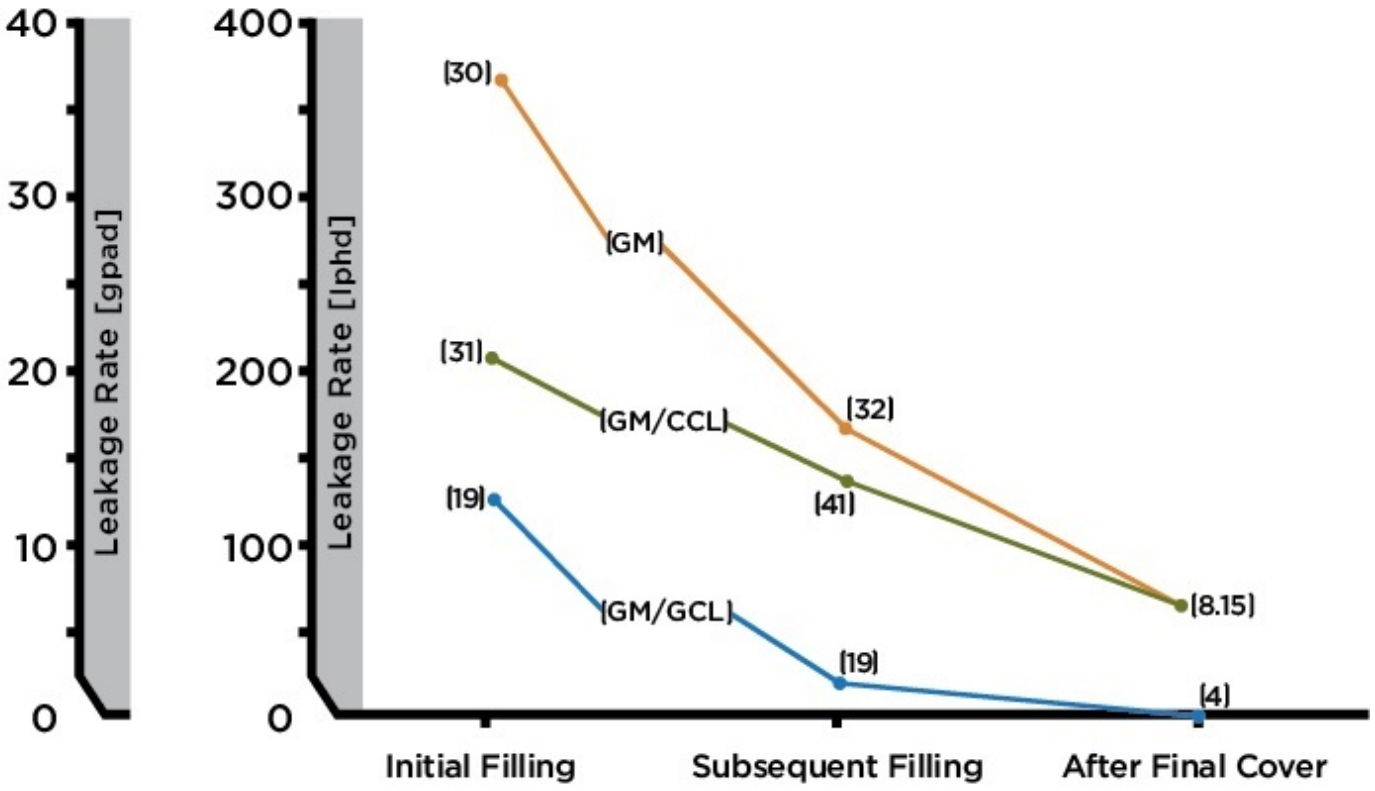
Part of a Composite Geosynthetic Liner

LANDFILL LINER SYSTEM PERFORMANCE



[Ref: 2002 Bonaparte, Daniel and Koerner, U.S. EPA]

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Geosynthetic Clay Liners (GCLs)

GSE BentoLiner

Fabric Encased GCL

GCL Product Types

Fabric Encased GCL

Geomembrane Supported GCL

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Fabric Encased GCL Modifications

Geosynthetic Clay Liner Product Options

1. EC – woven & 3 oz/SY non-woven
2. NSL – woven & 6 oz non-woven geotextiles
3. CNSL – nominal 5 mil thick PP-coated NSL
4. LNSL – 3 mil HD geo-film laminated onto NSL
5. NWLL – 3 oz scrim non-woven & 6 oz woven geotextiles
6. NWL – one 6 oz non-woven and one 6 oz scrim nonwoven geotextile
7. **CAR Series – Polymer Enhanced**

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Geosynthetic Clay Liners - Advantages

- Consistent Low Permeability Hydraulic Barrier
- Protects Geomembrane from Puncture
- Reduced Installation Cost and Time
- Saves Airspace
- Self-Sealing Properties
- Hydraulic Conductivity per ASTM D5887
  - Effective Confining Stress is 5 psi
  - Typical Value is 3 x 10^{-9} cm/sec
  - Equivalent to 2 feet of CCL Flux
- Superior Hydraulic Conductivity to CCLs
- Withstand Differential Settlement
- Resistance to Damaging Freeze/Thaw Effects

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Geosynthetic Clay Liners – Disadvantages

- **Bentonite Chemical Alterations –**
  - **Free available Calcium & Magnesium**
- Slope Stability When Hydrated
  - Low Bentonite Hydrated Shear Strength
  - Internal reinforcement
  - Peel Strength
- Hydraulic Conductivity influenced by effective stress – 12” minimum overburden
- Thickness
  - ~10 mm Thick
  - Vulnerable to puncture

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Coal Ash Resistant GCL

Polymer Enhanced Coal Ash Resistant GCL

- High Quality Wyoming Sodium Bentonite
  - High Free Swell
  - Low Fluid Loss
- Blended with Proprietary Long Chain Polymers
  - Expanding of the polymers reduces the space for water to travel around the sodium bentonite platelets
  - The polymers absorb components responsible for cation exchange, allowing fresh water to hydrate the sodium bentonite
  - Polymers are currently used in NSF Certified applications

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Federal CCR Rule – GCL Encouraged

CCR Rule language encourages composite liner with GCL and geomembrane.

To qualify as an alternative lower element of a composite liner the GCL must have:

- Appropriate chemical properties
- Sufficient strength and thickness
- Shear resistance between components
- Appropriate foundation
- Certification by PE of alternate secondary liner equivalence
- ***Site specific testing necessary per ASTM D 6766 Sc 2***

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Polymer Retention GCL Modifications

- Tests per ASTM D 6766 Scenario 2
- Proper polymer / bentonite blend
  - Different leachates require different polymers
- Cap and Carrier non-woven geotextile weight
- Scrim Reinforced non-woven geotextile
- Coated geotextile

Polymer Enhanced GCL Index Testing

- Industry seeking repeatable index testing
  - Finished GCL product cut open to remove polymer and bentonite blend
  - Working with ASTM to determine best test
  - Goal not to achieve a minimum value, just prove polymer present
- Loss on Ignition (ASTM D 7626 mod)
  - Oven burns off water, then burns off polymer and compare
  - Different polymers and amounts cause variability
- Fluid Loss (ASTM D 5891)
  - Volume of filtrate (water/leachate) lost and measured
  - Performed with bentonite alone, then polymer enhanced
- FANN Viscosity (API 13A mod)
  - Variability in sample prep, equipment, blades, labs, etc

Leachate Analysis with High Ionic Strength

	Acid Mine Drainage Solution 1	Coal Ash Leachate Solution 2	Gypsum Leachate Solution 3	Fly Ash/ FGD Leachate Solution 4	Fly Ash/ Gypsum Leachate Solution 5
Cations	mg/L	mg/L	mg/L	mg/L	mg/L
Calcium	660	820	580	740	480
Magnesium	4,000	340	220	6	530
Potassium	660	30	14	410	93
Sodium	670	82	78	240	2200
Anions					
Chloride	8,600	1,300	250	1,200	980
Sulfate	10,000	1,900	2,200	1,600	7600

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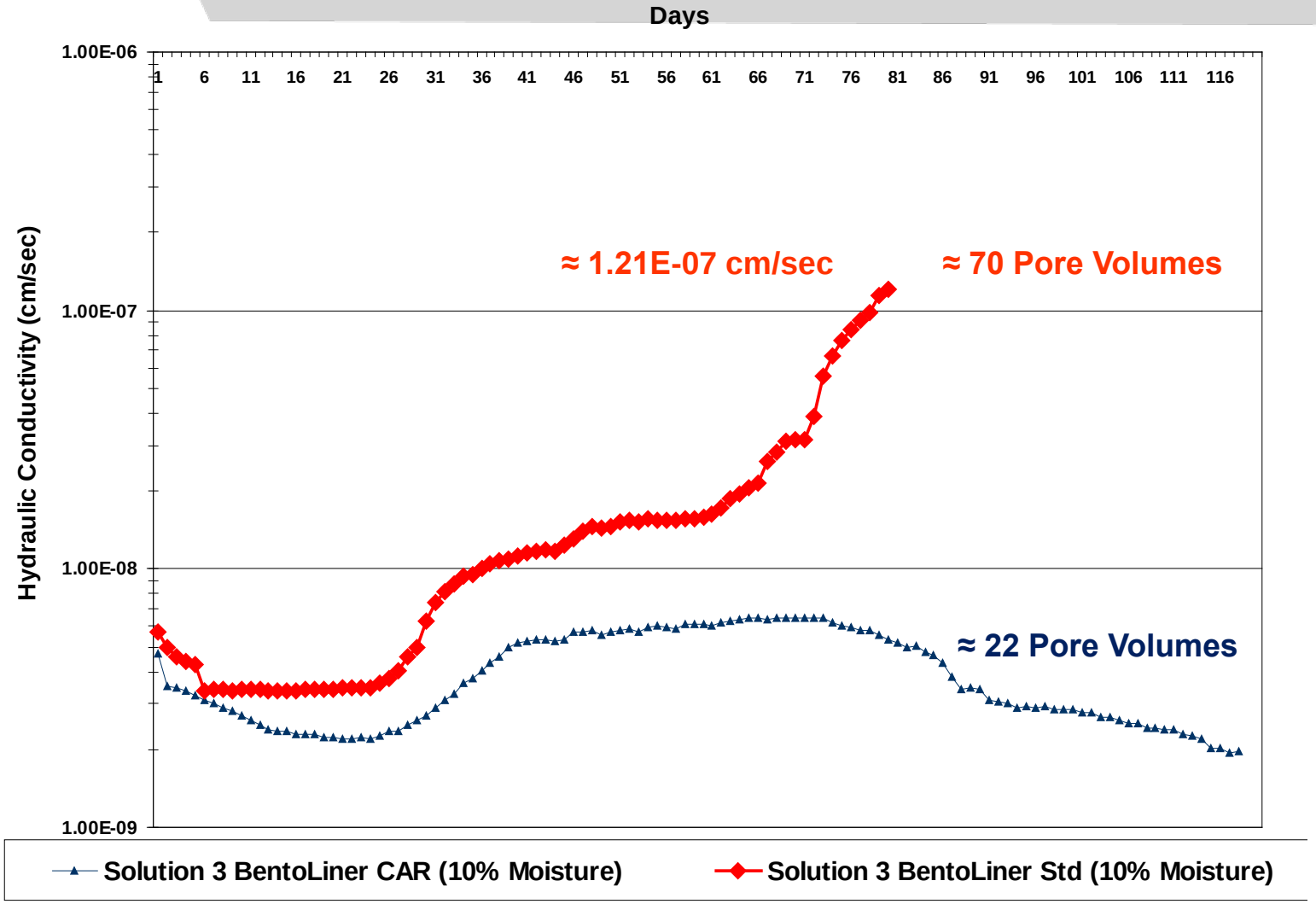
Solution 3 – Gypsum Leachate



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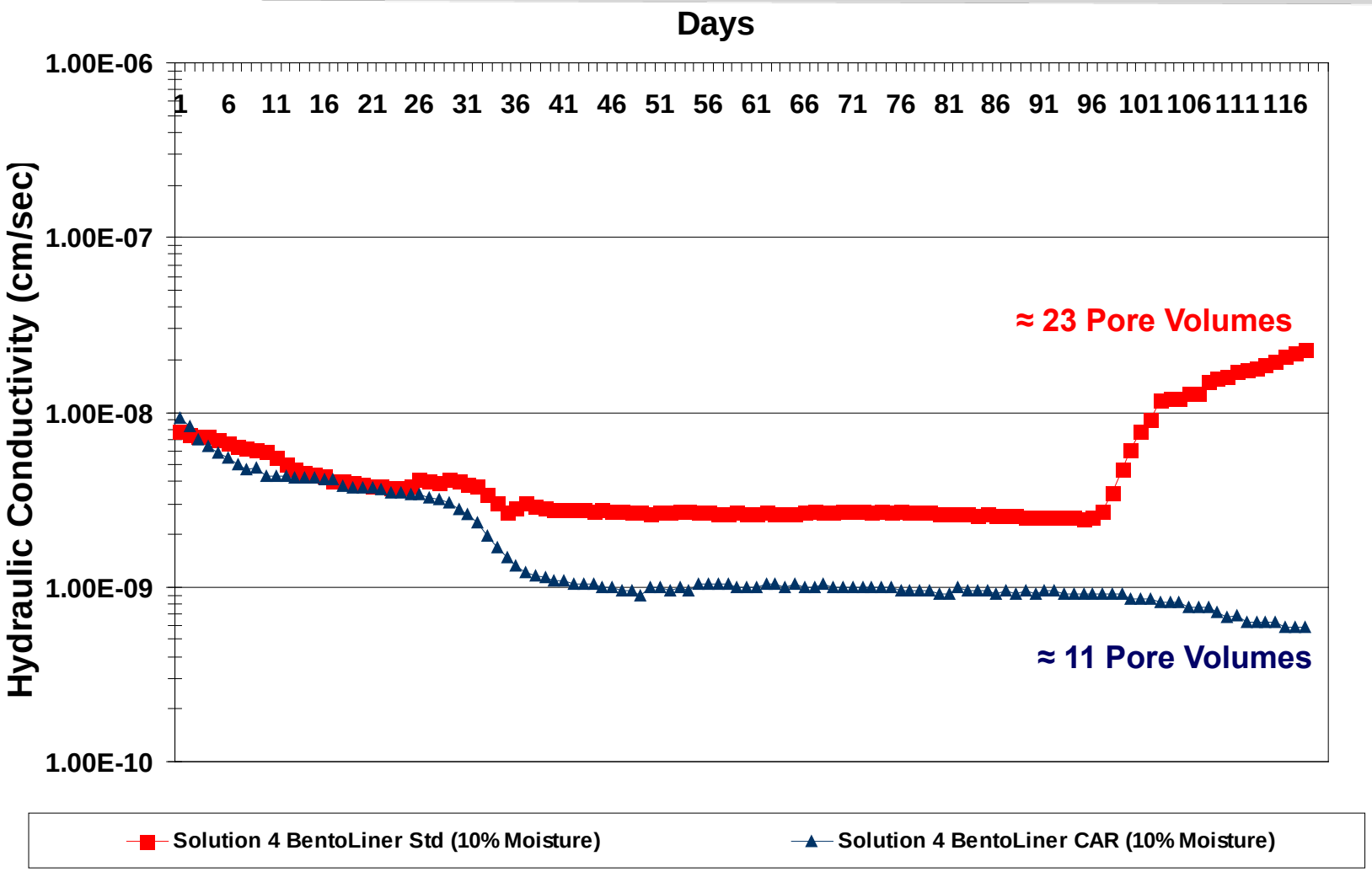
Solution 4 – Fly Ash/FGD Leachate



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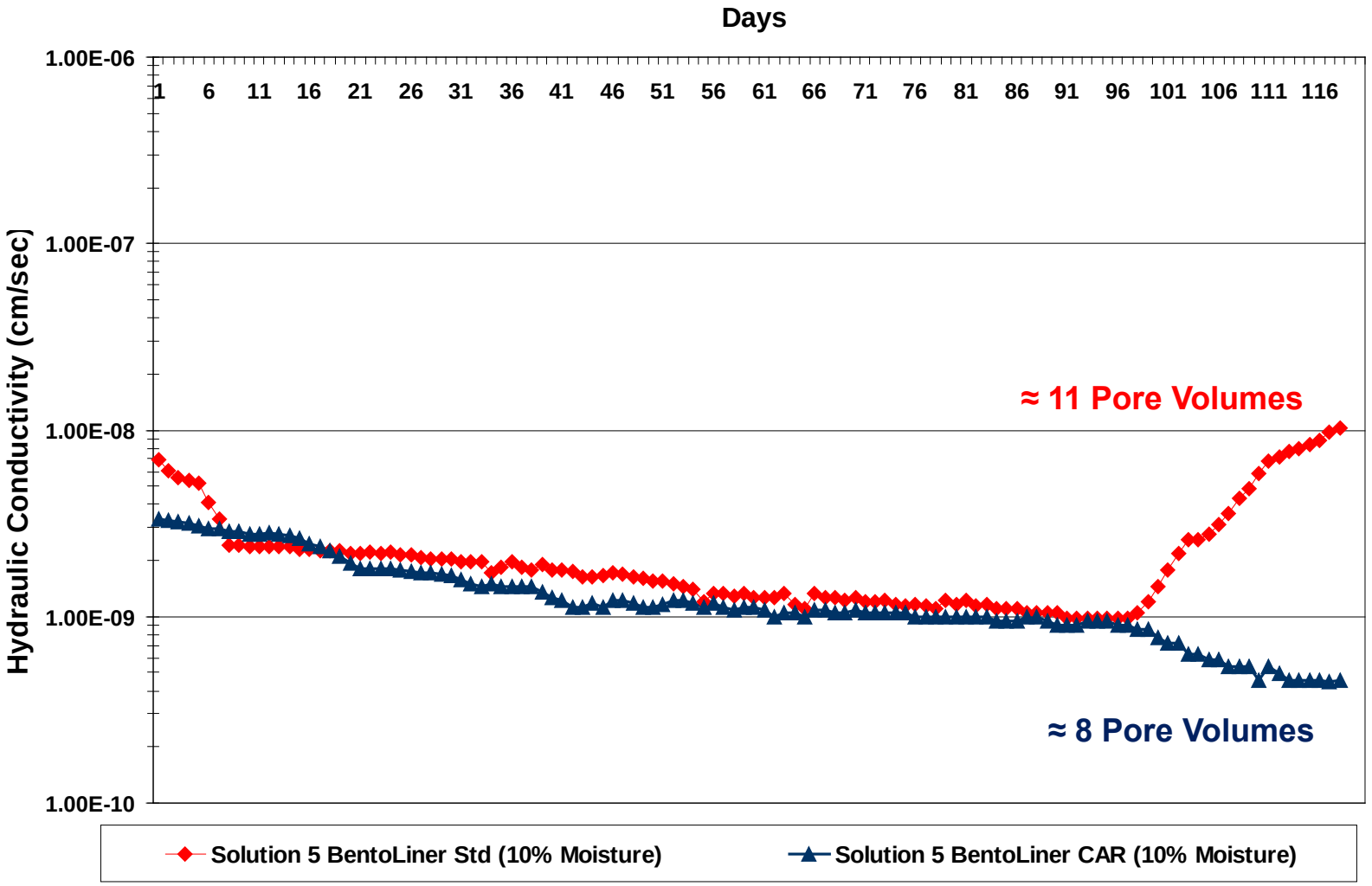
Solution 5 – Fly Ash/Gypsum Leachate



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GCL Consideration

- Chemical Compatibility Testing (ASTM D 6766 Sc 2)
- Clay Source
- EPA Recommended Composite Liner
- Missouri DNR Discussion

WET ASH SURFACE IMPOUNDMENTS

Wet Ash Surface Impoundment Closure

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Existing Wet Ash Surface Impoundment Closure

- Surface Water Removal in pond corner

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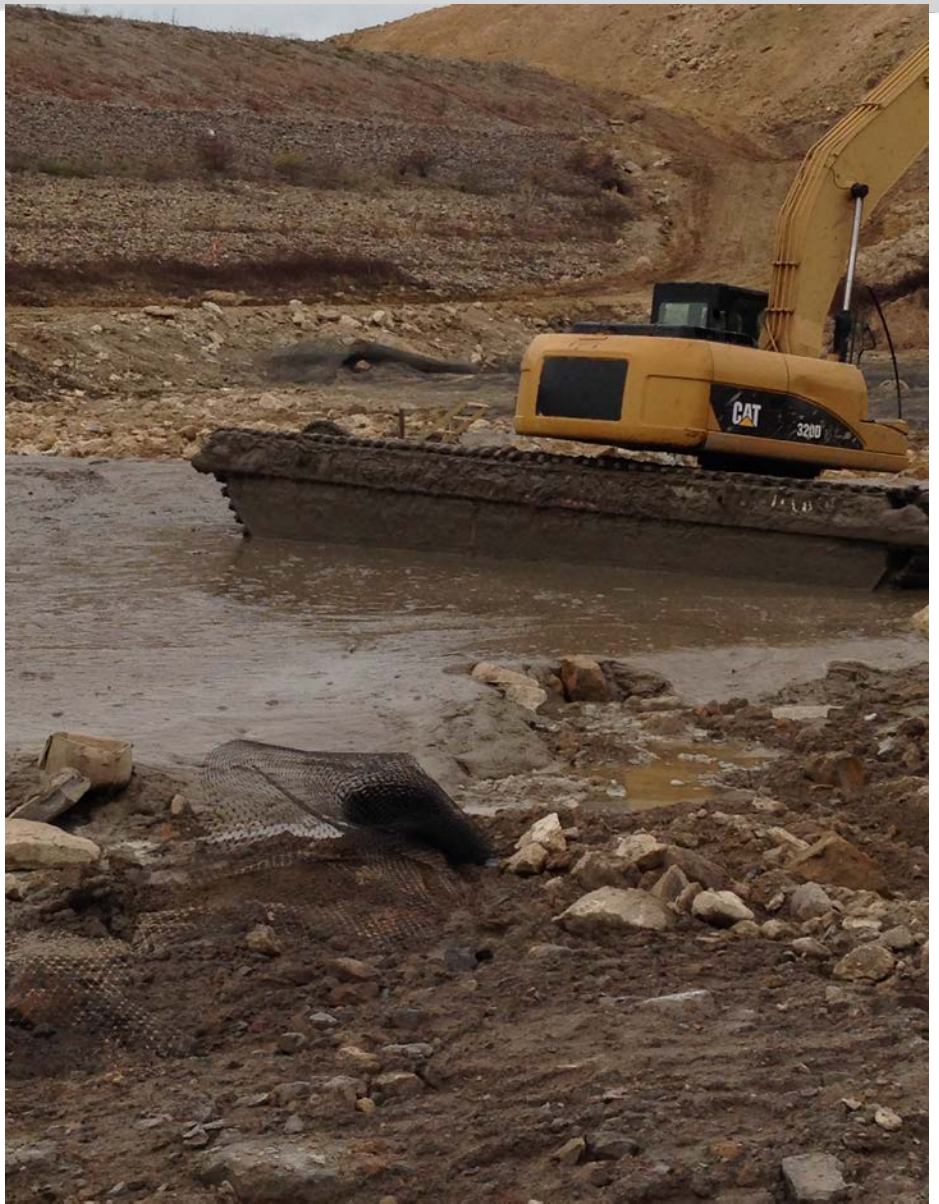
Existing Wet Ash Surface Impoundment Closure

- Seepage from ash agitation below
- Amphibious excavator to place fill and bridging material



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Existing Wet Ash Surface Impoundment Closure

- Tensar TriAx Geogrid
- On-site fill material above and below, no import
- Geomembrane closure with vegetative soil

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SURFACE IMPOUNDMENT STABILIZATION TEST PLOT

Objectives for Coal Ash Surface Impoundment Stabilization Test

- Test response of wet ash under various stabilization methods
  - Grade over top of exposed ash
  - Bridge with bottom ash
  - One layer of Geogrid with bottom ash fill
  - One layer of Geocomposite with bottom ash fill
- Determine most stable method
- Equipment loss a scary recurring theme

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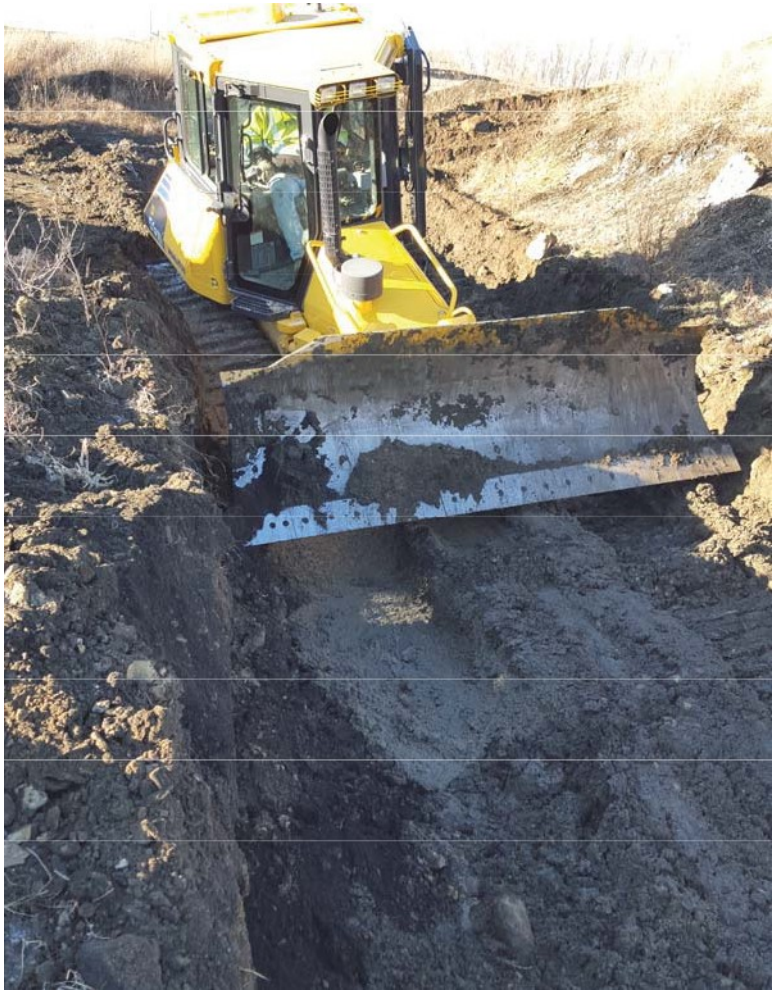
Test Plot Setup



- No Geogrid – bottom ash bridging under CCL

Test Plot Setup

- TriAx Geogrid anchored in perimeter and onto wet pond

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Test Plot Setup

- TriAx Geogrid with bottom ash fill

Test Plot Setup

- Several passes with full bucket loader show minimal rutting

Test Plot Benefits

- Test at location with lowest shear strength ash
- Better understand CCR waste reaction to compaction
- Relieve contractor concern / risk (i.e. – dollars)
- Prove a solution

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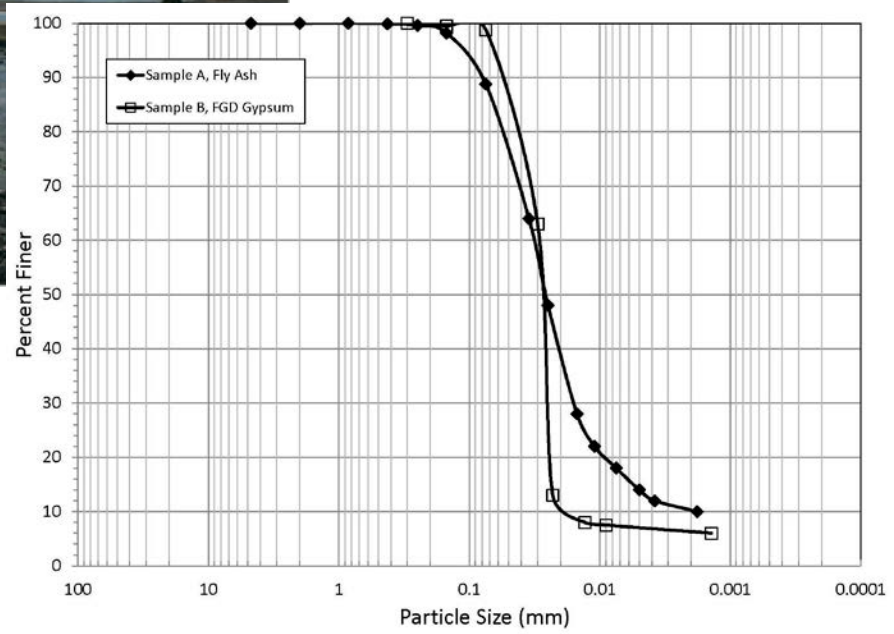
GEOCOMPOSITE FOR CCR WASTE FILTRATION AND DRAINAGE

Coal Ash Properties



- Wet and Dry Placement
- Not Easily Filtered
- 85% to 100% finer than silt
- Uniformly graded by-product

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Performance Challenge – Filtration Compatibility

Conventional Geotextiles do not filter non-cohesive fine-grained soils such as fly ash and gypsum.

"… the fines excessively clog the geotextile filter thereby blocking flow and in others the upstream fines move through the geotextile (i.e., lack of retention) thereby clogging the downstream drain."

"Inadequate Performance of Geotextile Filters Under Difficult & Challenging Field Conditions;" R.M. Koerner and G.R. Koerner; GRI Report No. 30; October 15, 2008.

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GeoAmericas April 2016

- Regarding soil problems, Cohesionless fine grained soils like rock flour, Cohesionless silts, and fly ash, represent a design dilemma in that very open geotextiles allow excessive soil to pass downstream (with subsequent upstream cavitation and piping) and very tight geotextiles that can result in excessive clogging. This balance requires site-specific soil properaties as well as product-specific geotextile properties.

"Significance of Proper Geotextile Filter Selection on the Hydraulic Performance of Drainage Geocomposite" Koerner, G.R.; GeoAmericas; April 2016

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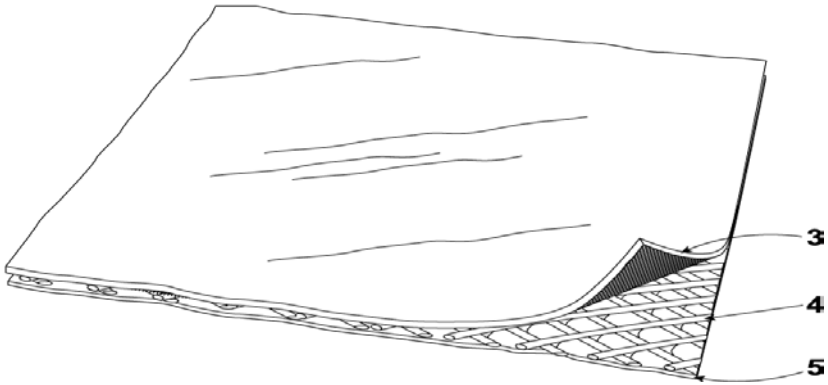
[ ]

CoalDrain Benefits

- Drain and filter in one geocomposite
- Retains fly ash, FGD, and other fine grained particles
- Cover material can be fly ash, FGD, or any CCR waste
- No need for expensive graded sand filter
- Easy installation on slopes



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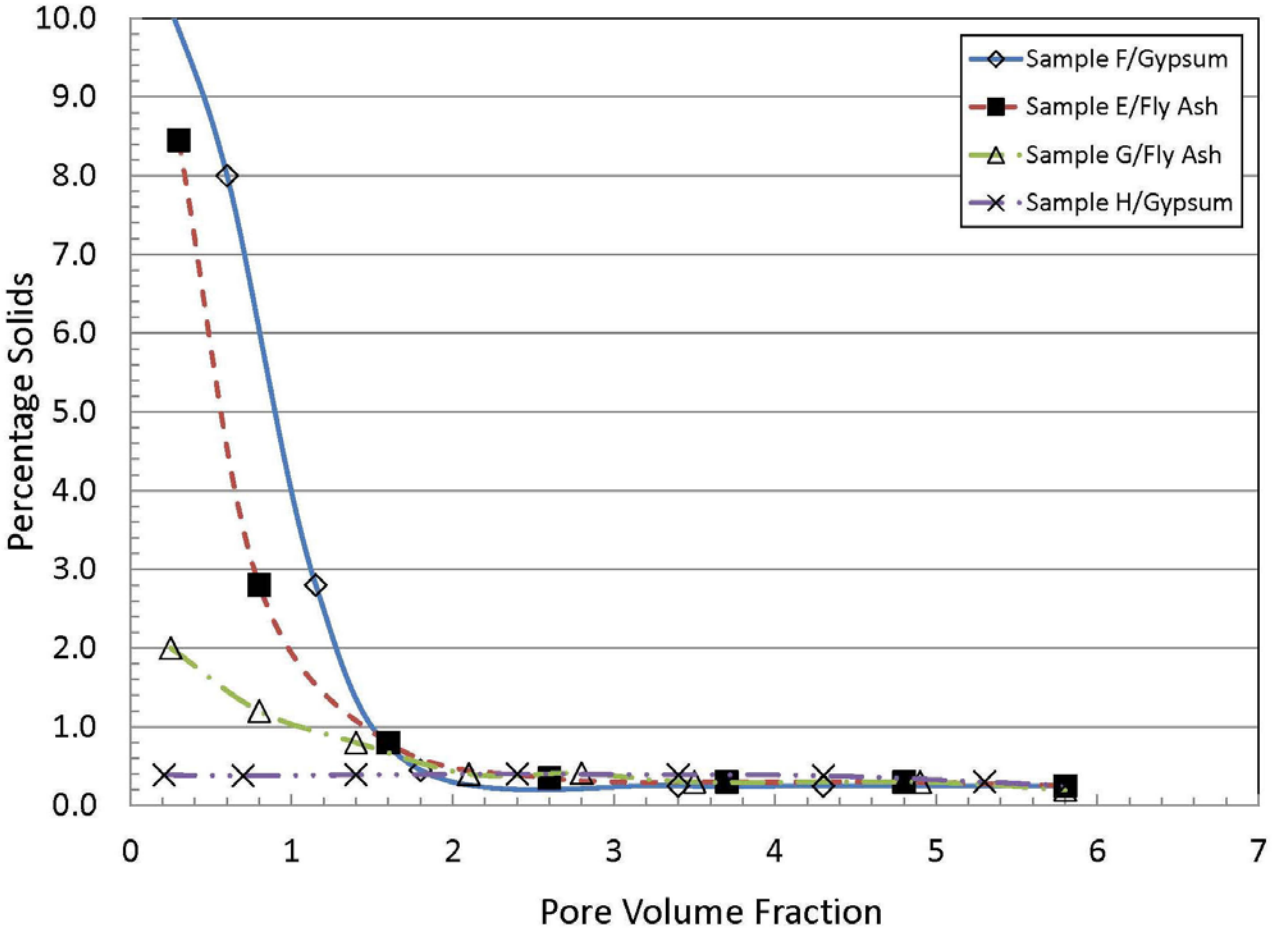
What Do We Find from Lab Tests?

- Within two pore volumes fines passing stabilize at a very low value
- CoalTex does not clog



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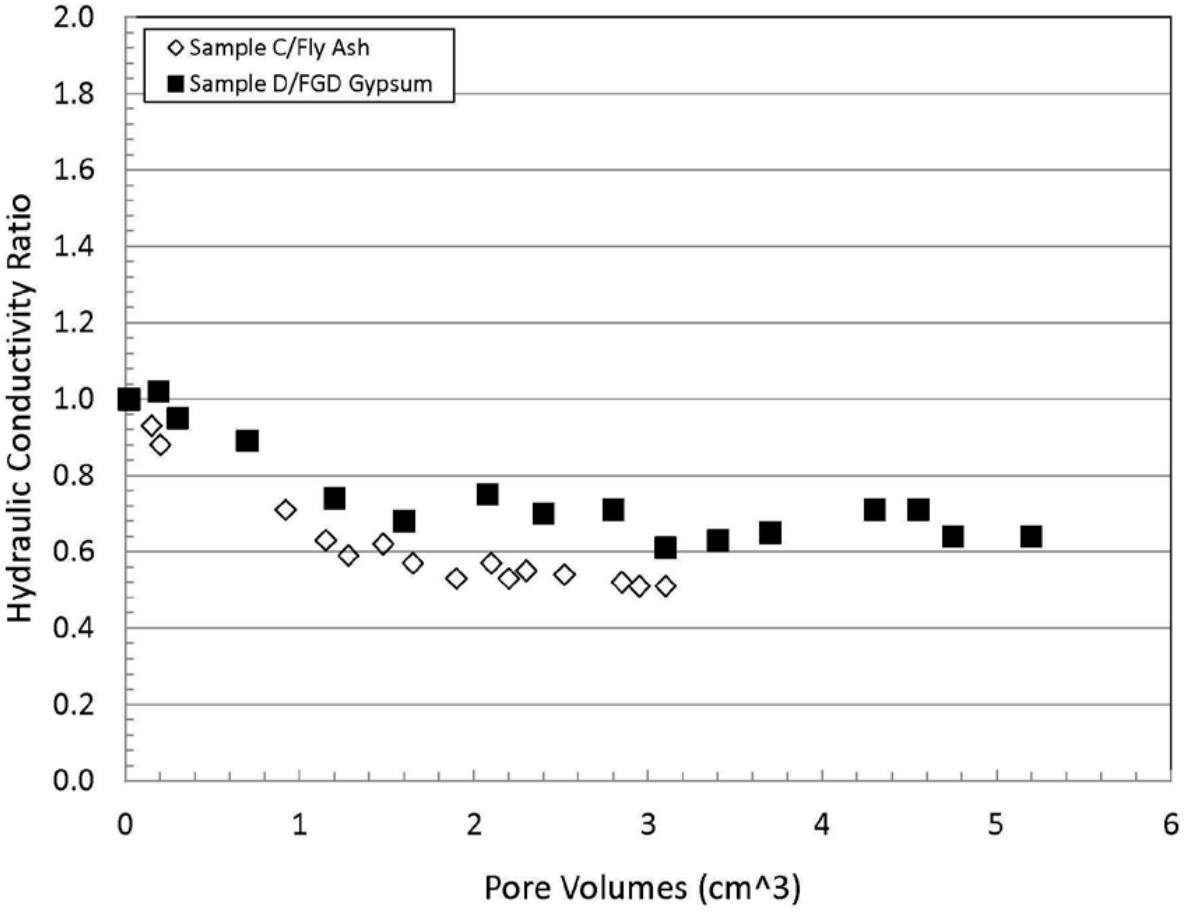
Lab Results for HCR Test Per ASTM D 5567

- CoalDrain tested with fly ash and FGD gypsum
- HCR value stabilized within two pore volumes with no further decrease
- The Coaltex forms a stable filter indicating no further decrease in hydraulic conductivity over time



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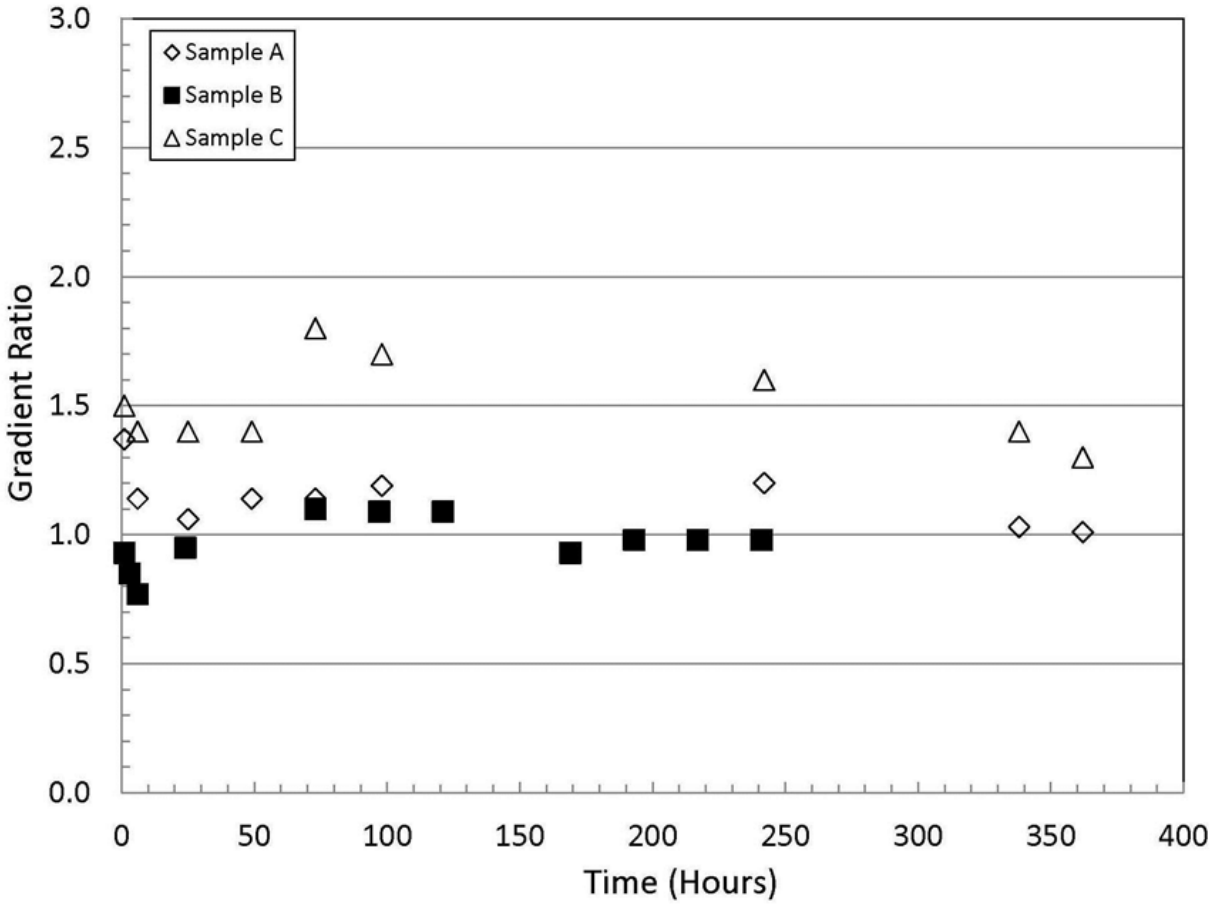
Resistance to Clogging, Gradient Ratio Tests

- All tests show a gradient ratio of less than 2
- Tests have been performed with different CCR materials
- The Coaltex found to be compatible with fly ash and FGD gypsum



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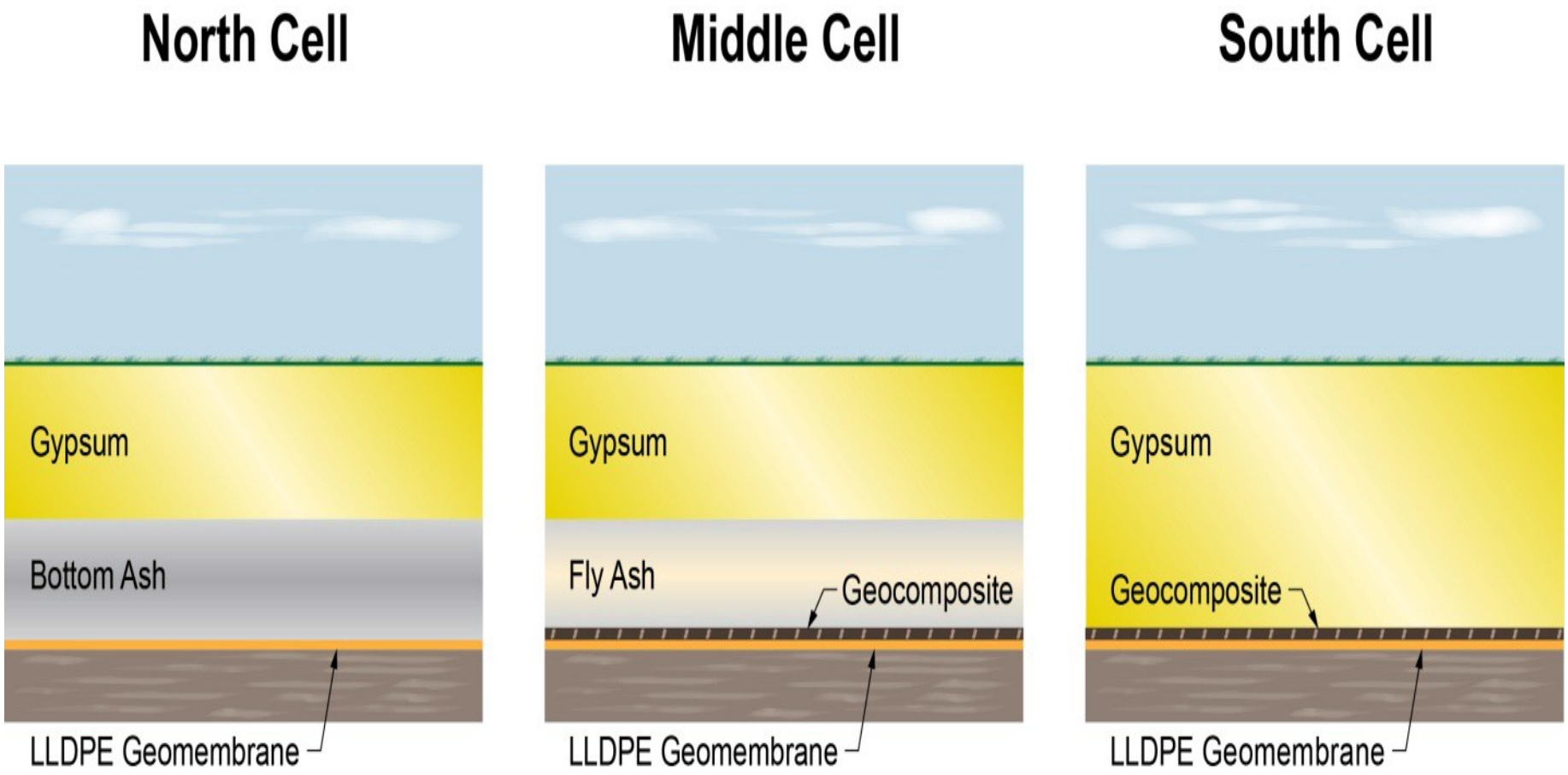
Cross Sections of Each Test Pad Cell



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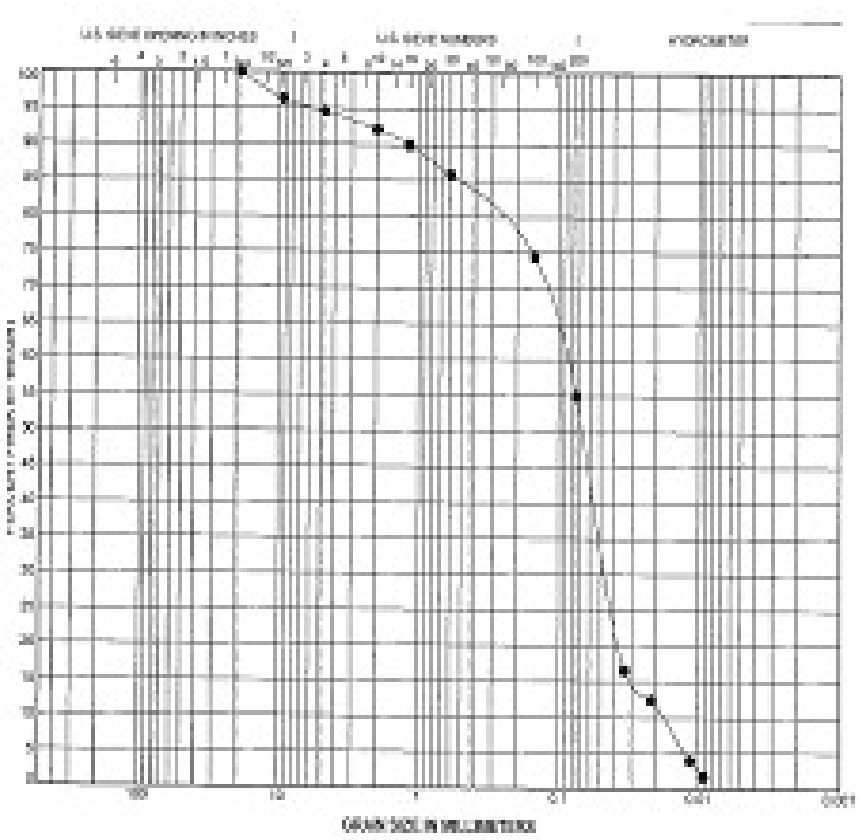
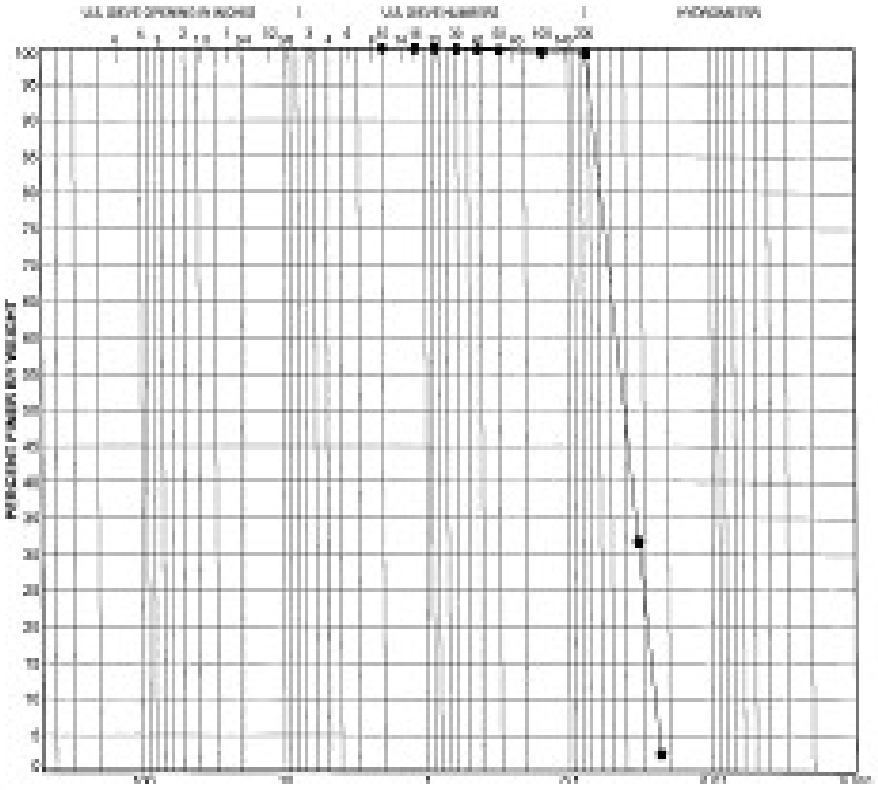
Gradations of fly ash and gypsum

Similar permeabilities (10^{-6} cm/sec), differing gradations



Fly Ash Gradation, k = 10^{-6} cm/sec



Gypsum Gradation, k = 10^{-6} cm/sec

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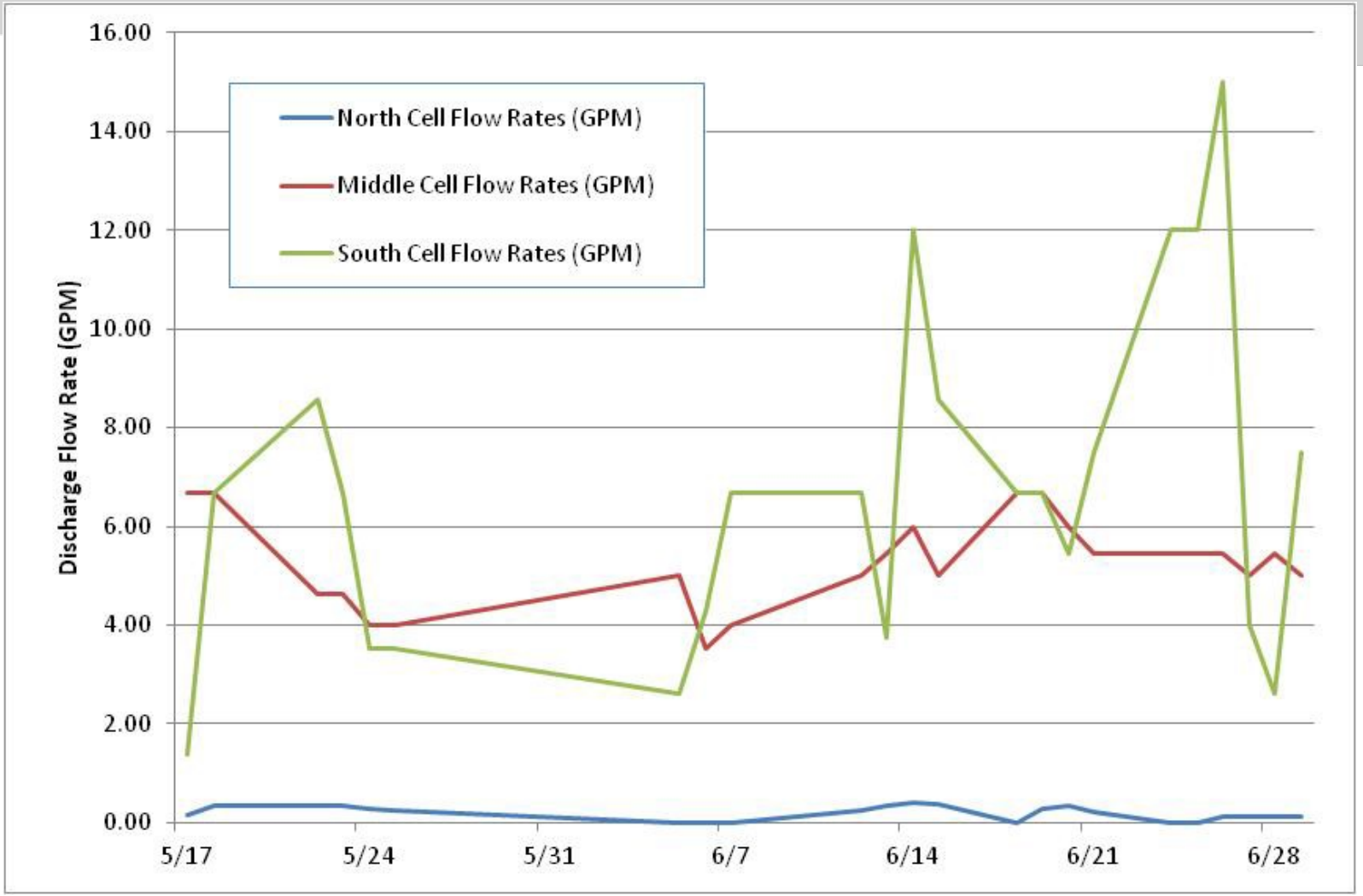
Variation of Flow Over Time



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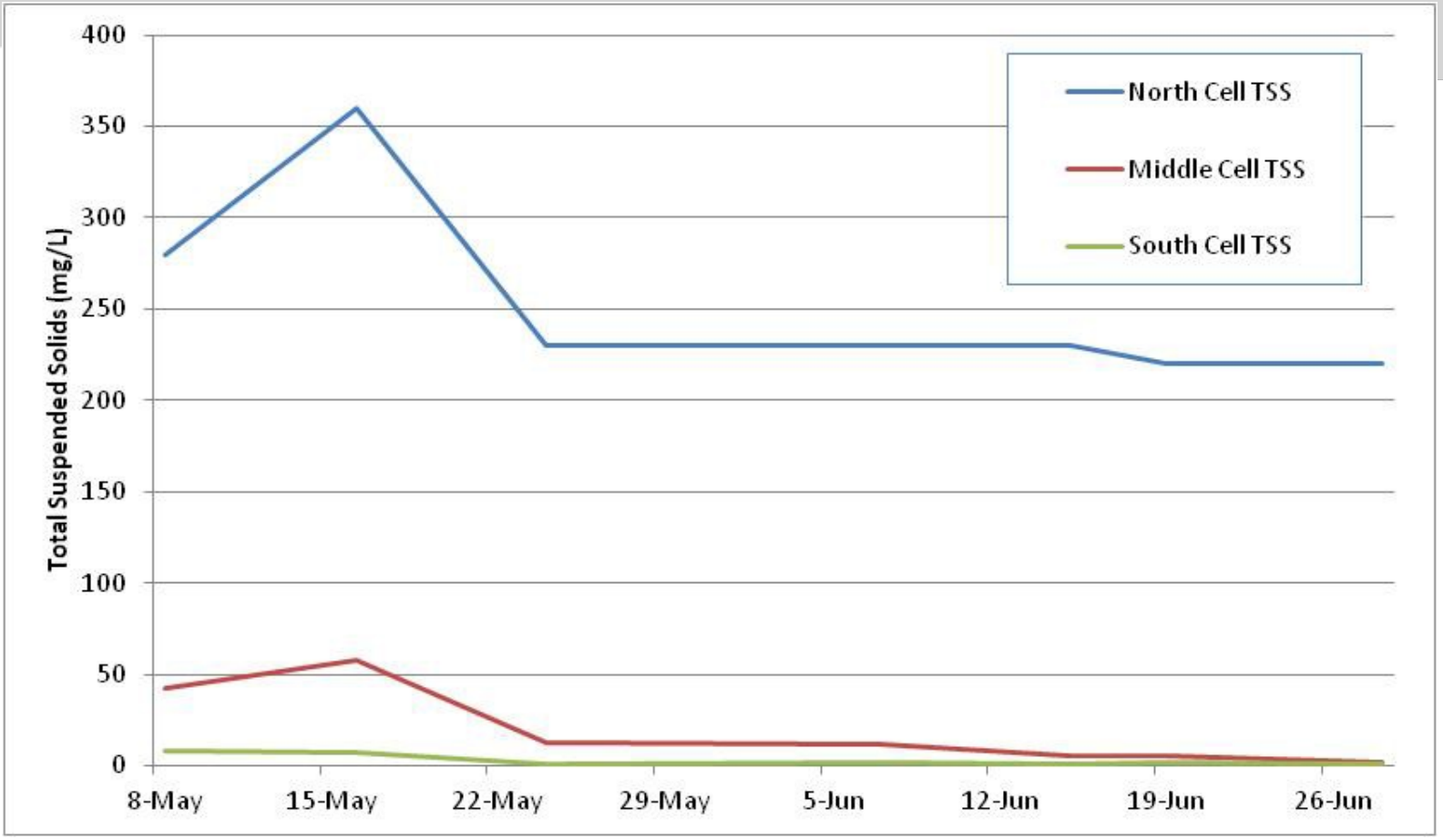
Variation of TSS Over Time



Measured TSS for sections with CoalDrain are all significantly less than 20 mg/L, can be considered clean

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DEWATERING BAG FILTRATION PILOT TEST

Ash Pond with Thin Crust

- Dewatering hose in ash pond pumping fly ash slurry

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Ash Pond with Thin Crust

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CoalTex Dewatering Bag – Filling

- Fly ash slurry filling bag, seepage evident

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CoalTex Dewatering Bag

- CoalTex Dewatering bag full of fly ash slurry
  - Conventional bags experience blinding of geotextile
  - Polymer additives block seepage

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Filter barrier near Decant Tower

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CoalTex Dewatering Bag Closure Applications

- Erosion control for rain events on large ponds
- Filter control near decant towers & discharge weirs
- Water Quality Control by placing bags near sensitive areas and NPDES discharge points with no chemical treatment
- Bank Stabilization
- Transport of dewatered ash on flatbeds
- Use as a ‘bridging bag’ to build a floating road or stabilize soft area
- Avoid importing soil to meet grades of closure, use existing fly ash within pond closure
- ***Potential with ELG / NPDES / TSS Control***

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