Geosynthetics for CCR Applications

Jason D. Ross, P.E.
Project Engineer
S&ME, Inc.
jdross@smeinc.com

Fabricated Geomembrane Institute
Webinar Series – 2019 Webinar #5

Outline of Presentation

- Review of CCR Rule Language
- Bottom Liner Systems
  - Design Scenarios
  - GCL Hydraulic Conductivity Testing
  - Additional Design Considerations
- Cover Systems
  - Design Scenarios
  - Design Considerations
- Constructability
  - Geocomposite Drainage Outlets
  - Tie-ins at Structures and Pipe Penetrations
  - Geomembrane Deployment
  - Electrical Leak Detection
- Questions

CCR – Federal Guidelines

- Published – Friday, April 17, 2015
  - Additional Documentation
  - Additional Analysis
  - Improvements
  - Design Changes

  - Both State and
    Federal Regulations

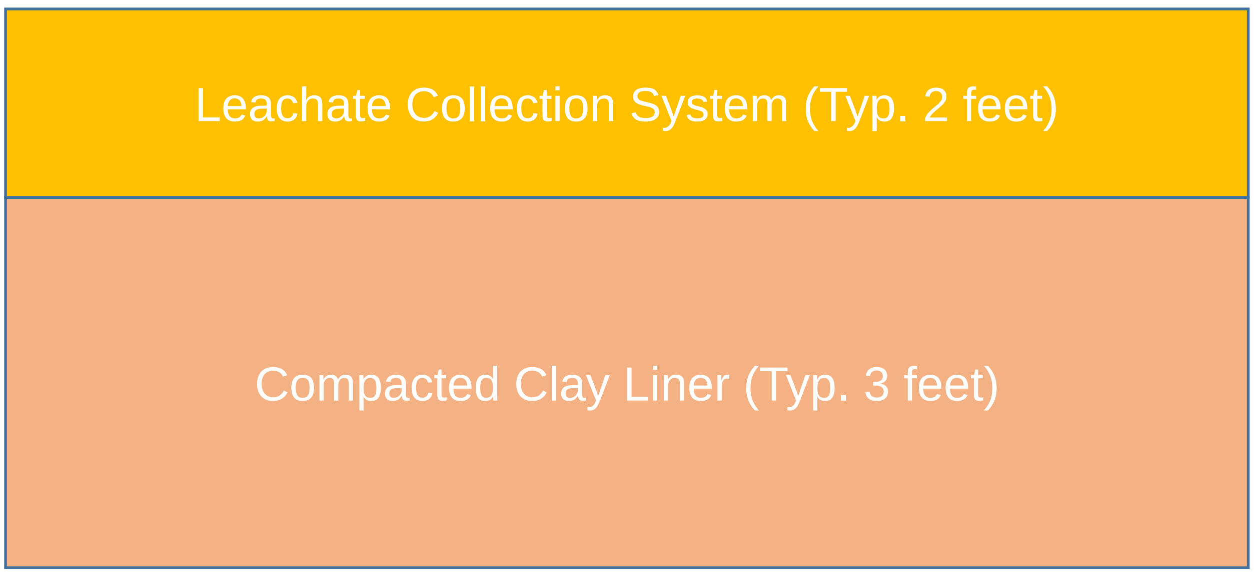
CCR – Federal Guidelines

- Result:
  - Closures of inactive/ not needed facilities.
  - Force reviews of existing facilities
  - Require regular inspections and annual review by Professional Engineer
  - Changes future construction and new designs
- 257.70 and 257.72:
  - Design Criteria for Bottom Liner System for Landfills and Surface Impoundments
- 257.102:
  - Design Criteria for closure of Landfills and Surface Impoundments

Bottom Liner System

- Bottom Liner System
- (257.70 – Landfills, 257.72 – Surface Impoundments)
  - Composite Liner:
    - Geomembrane (GM) / Compacted Clay Liner (CCL)

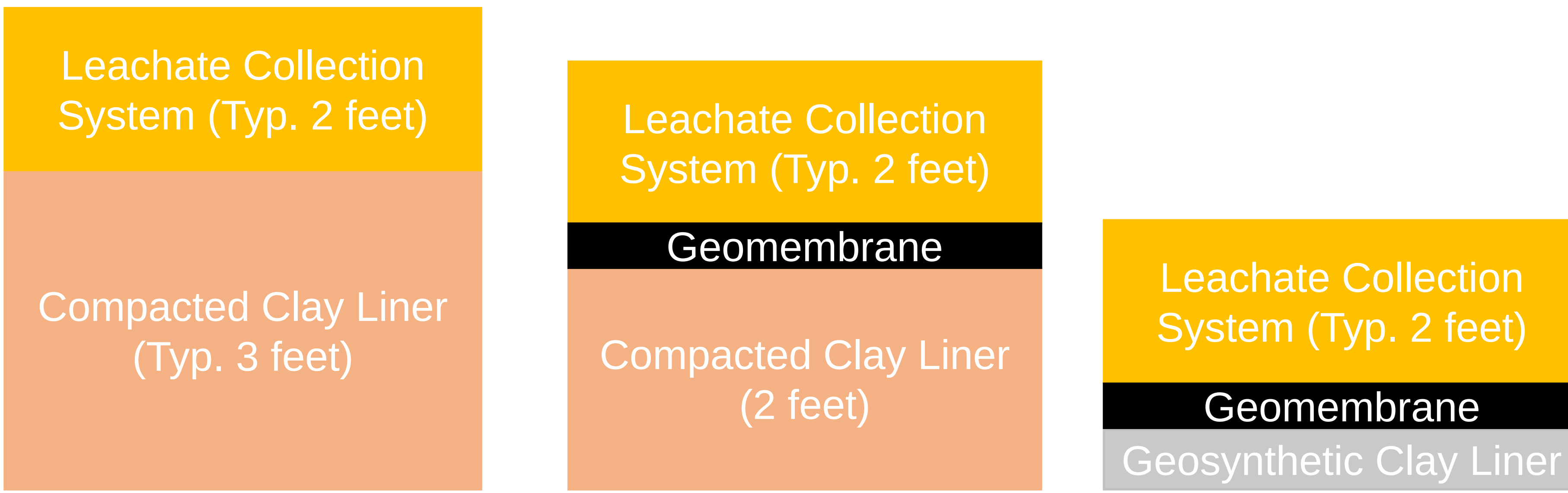
      OR
    - GM/equivalent liner to CCL (i.e. Geosynthetic Clay Liner)



<u>CCL Only (non-CCR Rule)</u>

Bottom Liner System

- Examples



CCL Only (non-CCR Rule) | Composite Liner | Alternative Composite Liner

Bottom Liner System

- Compacted Clay Liner (CCL)
  - 24 inches thick
  - Maximum permeability 1E-07cm/s
    - Lab testing
    - Test pads
    - In-situ Shelby tube sampling

Test Pad Preparation

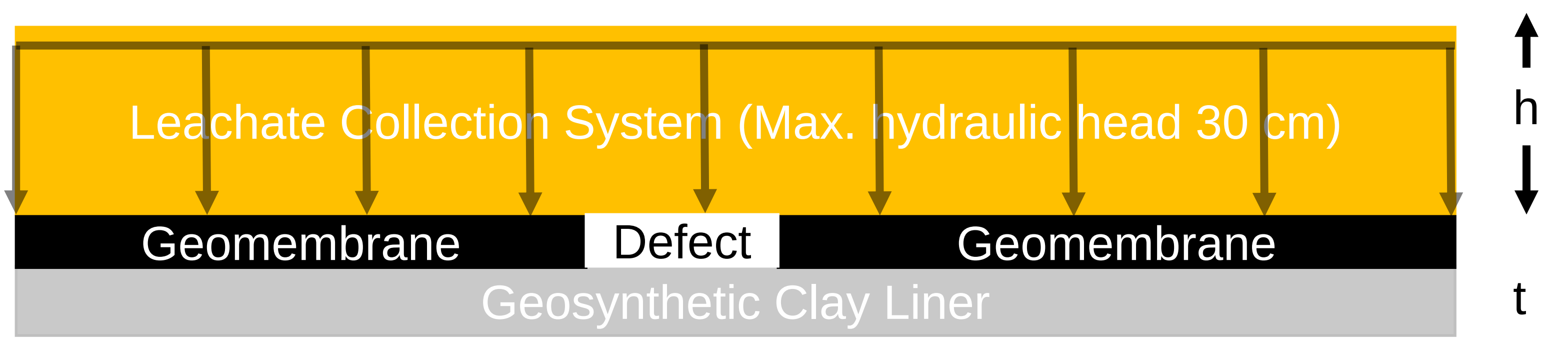
Bottom Liner System

- Geomembrane
  - 30 mil (0.76 mm) minimum thickness

Fabricated Geomembrane Deployment

Bottom Liner System

- Alternative Composite Liner
- GM/Lower Component
  - Was added in response to comments
    - Clay availability in different areas of country
  - Demonstrated with Darcy's Law:
    - $\frac{Q}{A} = q = k\left(\frac{h}{t} + 1\right)$
    - k – hydraulic conductivity of alternative liner
    - h – hydraulic head above the liner
    - t – thickness of alternative to clay liner



Bottom Liner System

- Hydraulic Conductivity of GCL
  - Perm – Minimum Average Roll Value (MARV)
    - Average (–) 2 standard deviations
    - 97.7% - degree of confidence values will be achieved
    - Typically reported as 5 x 10^{-9} cm/s for standard GCL's
  - Per Darcy's Law - Requires ~3E-09cm/s for equivalency to 24 inch CCL
  - What is the Solution?
    - GCL manufacturers have developed new polymer modified GCL's for reduced hydraulic conductivity values

Bottom Liner System

- Other Bottom Liner Requirements:
  - Interface shear resistance on all interfaces
  - Placed on a foundation capable of providing support to the liner.
  - Cover all surrounding ground in contact with waste
  - Need appropriate **chemical properties** and strength to resist affects of leachate

Bottom Liner System

- Case Study:
  - *GCL Chemical Compatibility Testing with CCR Landfill Leachate*
  - Authors: Jason Ross, P.E. and Mike Rowland, P.E.
  - World of Coal Ash Conference, May 2017
  - Available: www.flyash.info

GCL Hydraulic Conductivity

- CCR Landfill
- Designed and Permitted over a decade prior to construction.
- Geosynthetic Bottom Liner System:
  - GCL (standard bentonite), Geomembrane, Geotextile
- CCR's placed into Landfill:
  - FGD, Fly Ash
  - *Trona used periodically in pollution control process

GCL Hydraulic Conductivity

GCL’s with CCR Landfill Leachate

(Benson, Edil, Shackleford and others)

- Bentonite swelling – lowers hydraulic conductivity

- High ionic strength of landfill leachate
  - reduces swell capabilities
  - FGD and trona ash = highest ionic strengths

- Results in higher hydraulic conductivity for GCL

GCL Hydraulic Conductivity

- Response from manufacturer's:
  - Add polymer blends to the bentonite
    - Polymer 'coats' the bentonite and helps it resist cation/anion exchange
  - Development of these products continues
  - Interface shear strength considerations
  - Project specific testing
  - ASTM D 6766 *Standard Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Aqueous Solutions*
  - Scenarios I and II (saturation)
  - Methods A, B or C (falling head/constant head)

GCL Hydraulic Conductivity

- Representative sample

- Existing leachate collection system
  - same site
  - same waste
  - same bottom liner system

  - Tested for:
    - Ca, Mg, Na, K, SO_4, ph….

GCL Hydraulic Conductivity

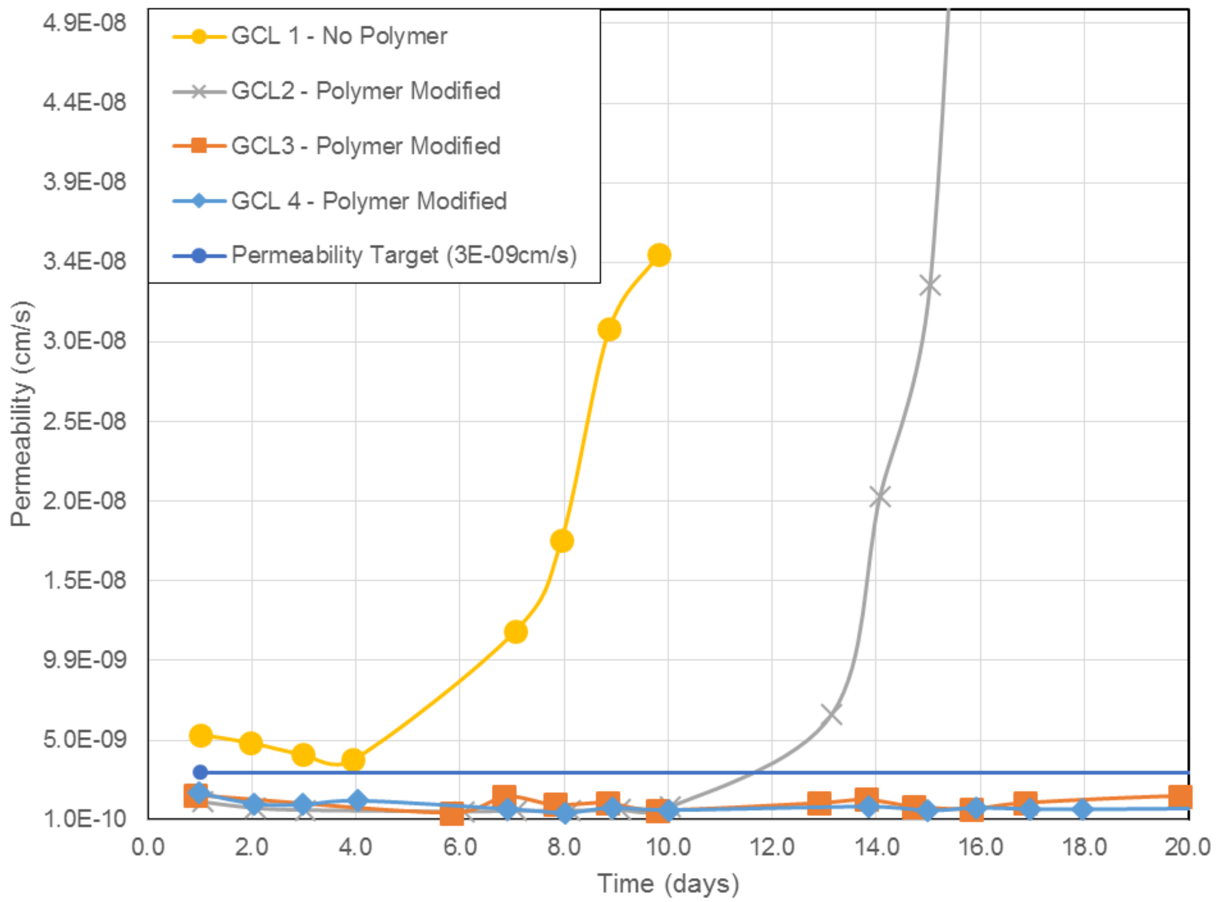
- Products selected based on manufacturer's recommendations
- Index testing of GCL products for conformance to project requirements.
- Tested using low confining pressures (<5 psi)
- 4 GCL Products (3 polymer modified)

GCL Hydraulic Conductivity

- Termination Criteria:
  - Passing results for 6 months
  (Permitting recommendation for this specific case)
  - pH and electrical conductivity
  - 6766: hydraulic conductivity
  consistent, 2 pore volumes

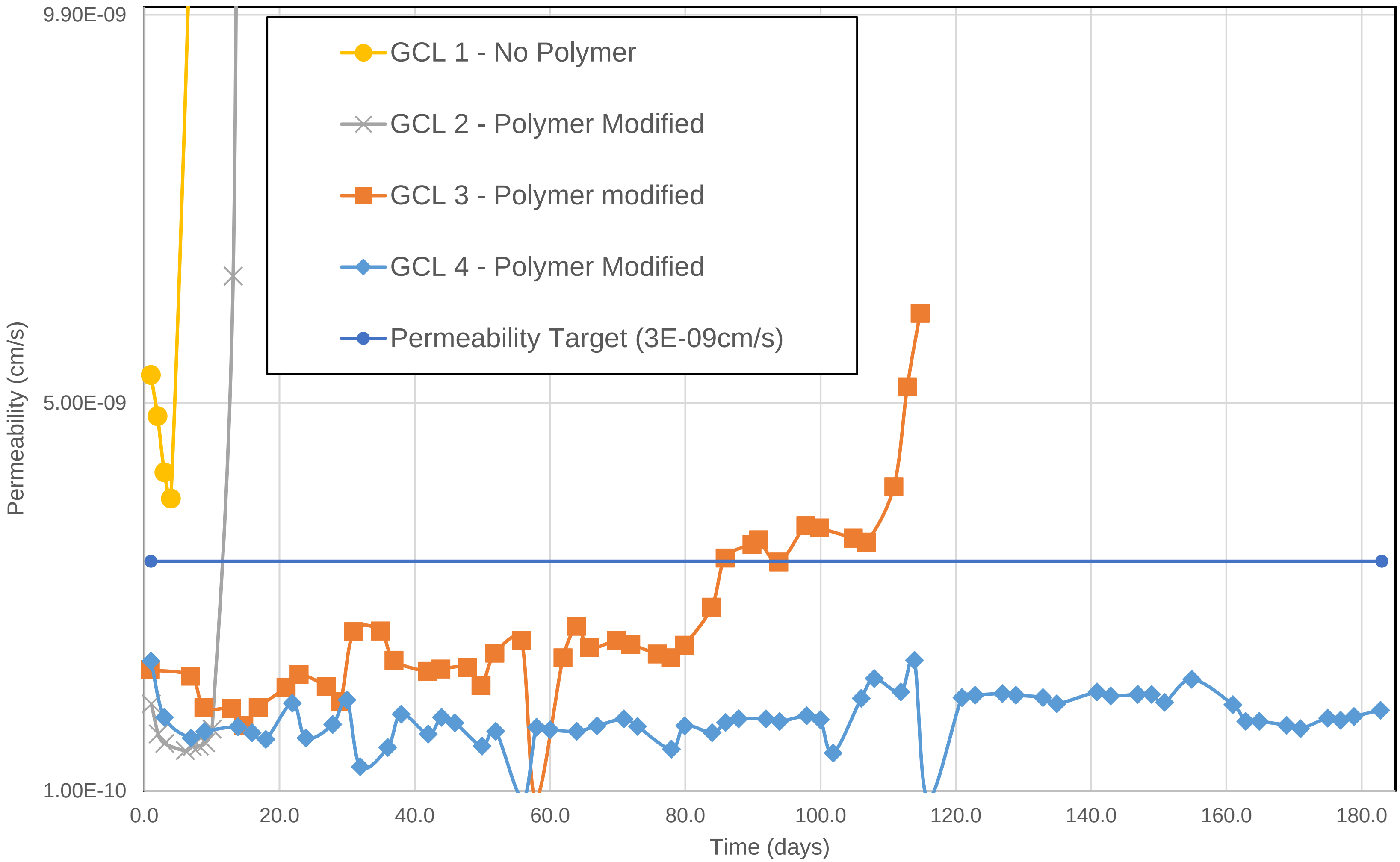
GCL Hydraulic Conductivity

- Results up to 20 days of testing



GCL Hydraulic Conductivity

- Full results to 6 months of testing



GCL Hydraulic Conductivity

CONCLUSIONS

- Chemical compatibility was achieved and documented.

- Chemical compatibility testing of GCL's is recommended, regardless of the type of CCR materials (fly ash only, FGD, trona, gypsum..).

- A sudden increase in hydraulic conductivity of a polymer-modified GCL was observed after 3 months of passing test results.

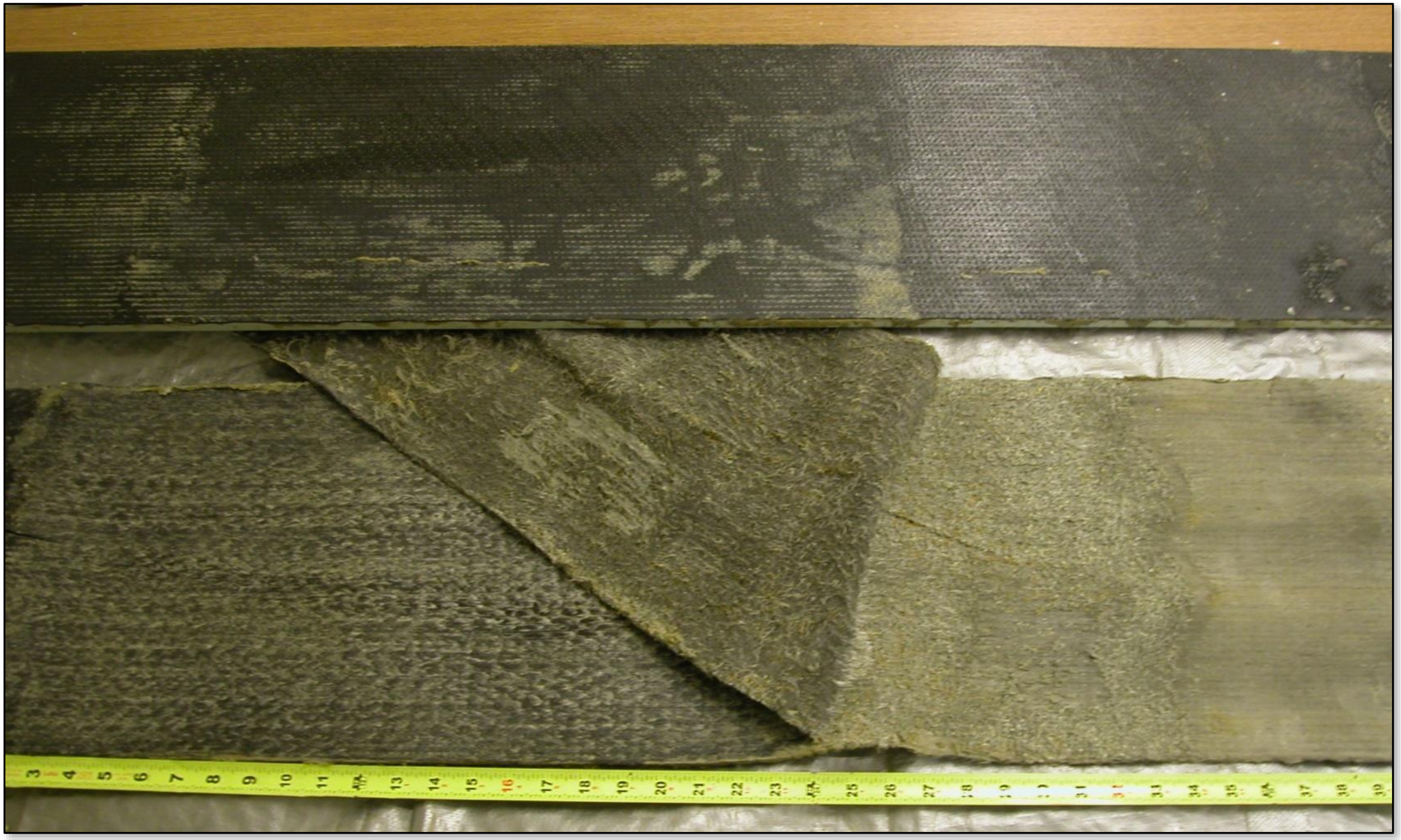
GCL Hydraulic Conductivity

CONCLUSIONS

- Periodic re-verification of compatibility may be warranted – changing pollution controls.
- Permit documents should allow future consideration of new products and procedures.
- Testing requires early planning to ensure that multiple GCLs are pre-qualified when obtaining construction bids.
- Industry Needs – Construction conformance testing for polymer products

Bottom Liner System

- Design Considerations
- Interface shear strength



Bottom Liner System

- Design Considerations
- Interface shear strength

  - ASTM D5321 – Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces
  - ‘Faster’ shearing rates allowed (1 mm/min), quicker loading

  - ASTM D6243 – Internal and Interface Shear of Geosynthetic Clay Liners
  - Slower shear rates (0.1 mm/min), slower loading requirements.

Constructability

Cover Systems

Cover Systems

- Cover System (257.102)
- Requirements:
  - Perm ≤ bottom liner system
    - (1E-05 cm/s maximum)
  - 18-inch earthen layer to minimize infiltration
  - 6-inch earthen layer capable of supporting vegetation to minimize erosion.
  - Accommodate settling and subsidence
  - Alternative Cover System – allowed provided that a PE can demonstrate all the requirements are met.

Cover System

- Examples: Cover System

Vegetative Layer (6-inch thickness)

Infiltration Layer (18-inch thickness) Perm ≤1E-05cm/s

Waste/Cover Soil

<u>Scenario 1:</u>
No Bottom Liner or
Soil liner = 1E-05cm/s

Vegetative Layer (6-inch thickness)

Infiltration Layer (18-inch thickness)

Compacted Clay Liner (Perm ≤1E-07cm/s)

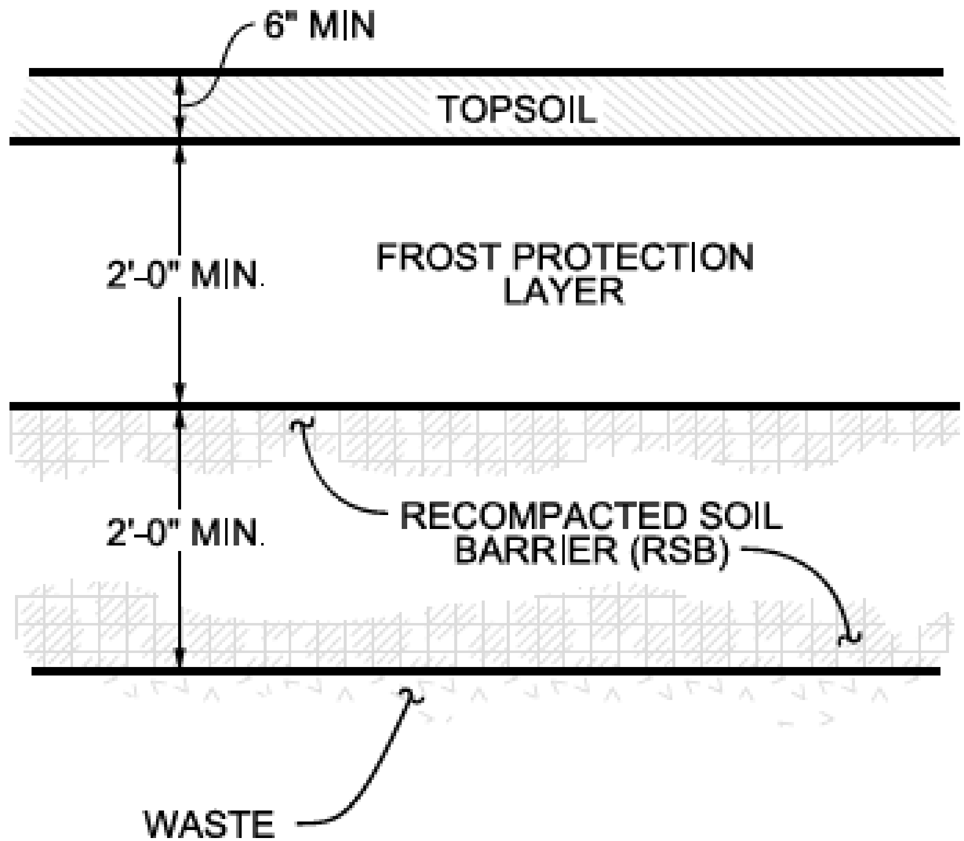
Waste/Cover Soil

<u>Frost Protection</u>

<u>Scenario 2:</u>
Compacted Clay Liner
in Bottom Liner

Cover System

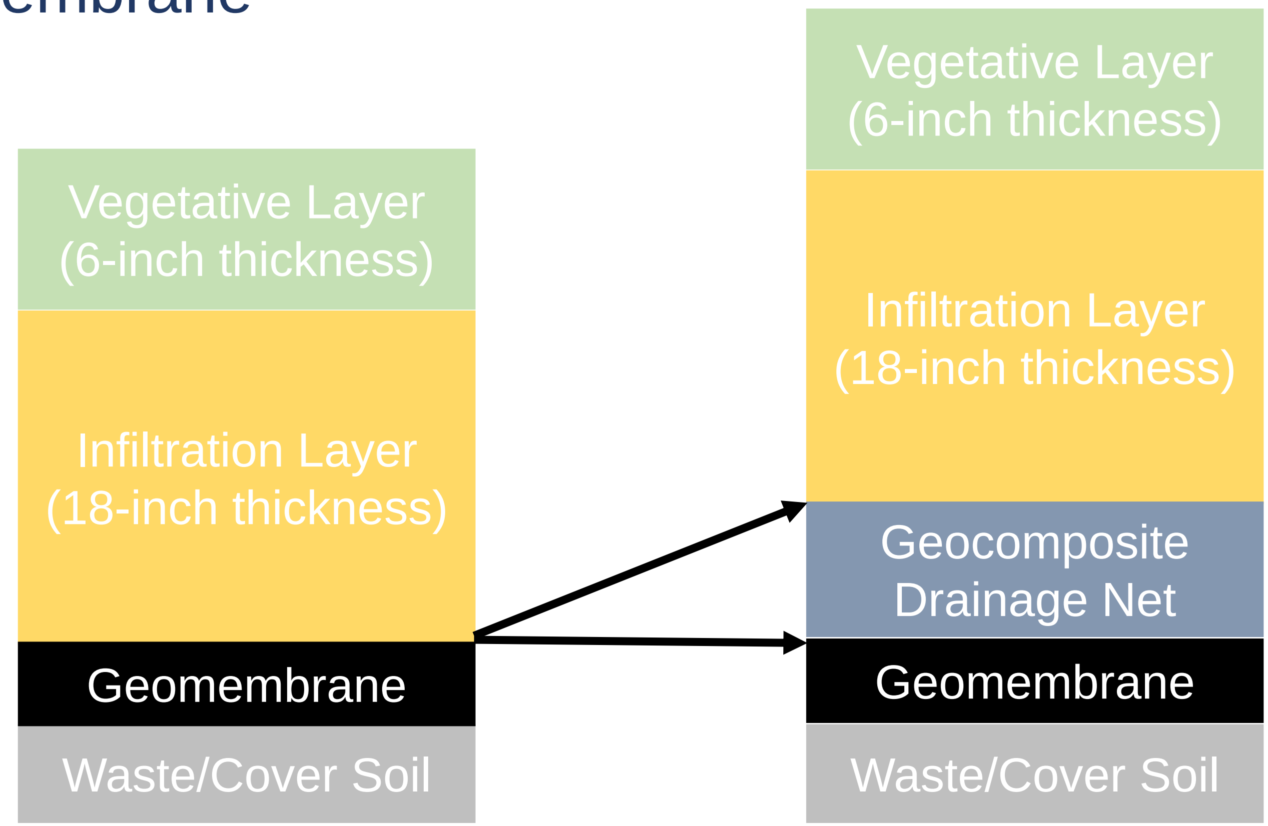
- Examples: Cover Svstem



Cover System with Frost Protection Layer

Cover System

- Cover Design – Must have effective drainage above the geomembrane



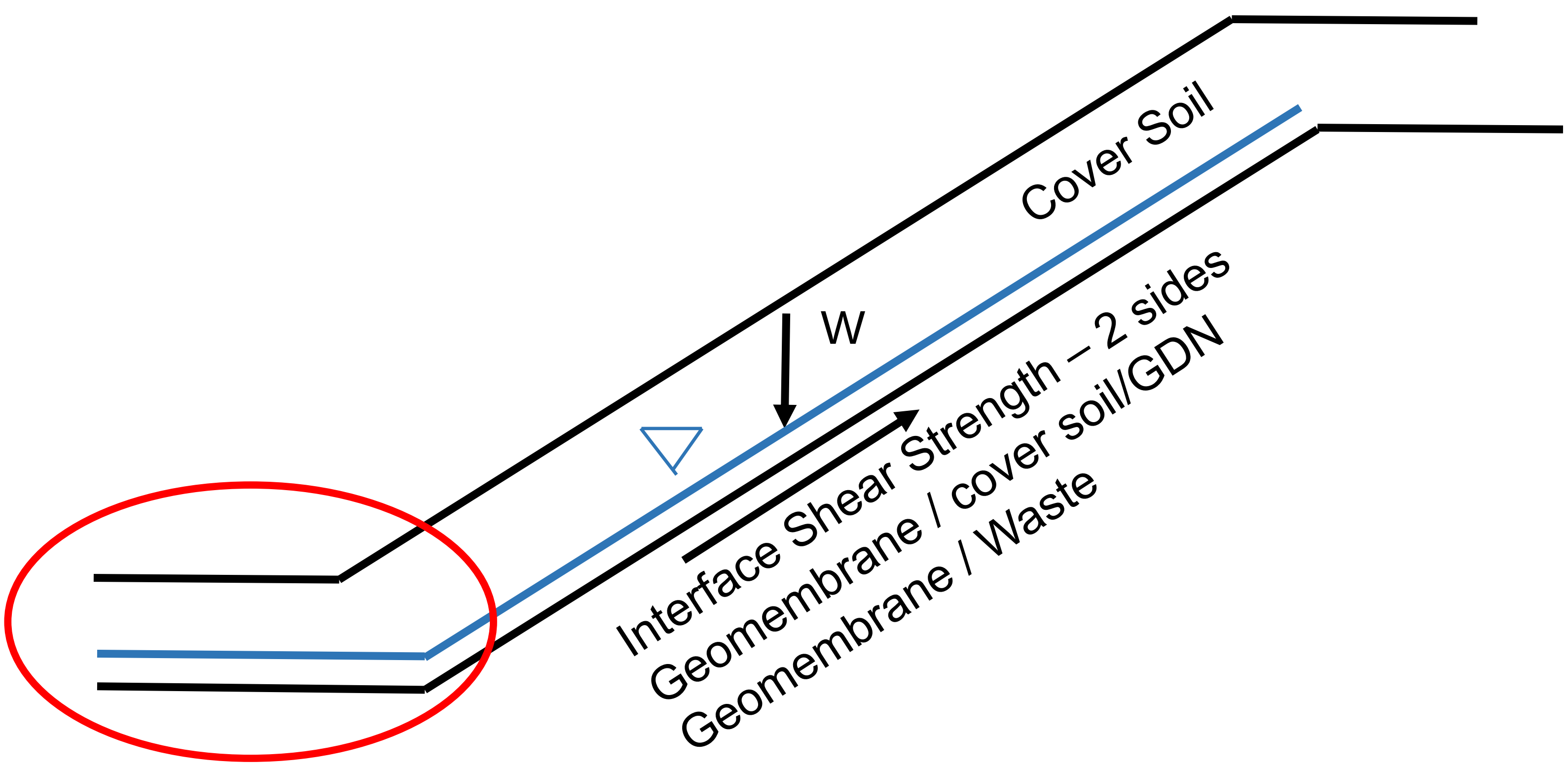
<u>Scenario 3:</u>
Geomembrane in
Bottom Liner System

Cover System

- Main take-aways:
  - ➢ Bottom Liner determines cover requirements
  - ➢ Interface shear strength – project specific testing
    - How low can we assign a normal stress?
  - ➢ Drainage of water from liner interface is critical

Cover System

- Design Considerations:
  - Veneer Stability
    - Provide required transmissivity value
    - Project specific testing



Constructability

Construction Considerations

Constructability

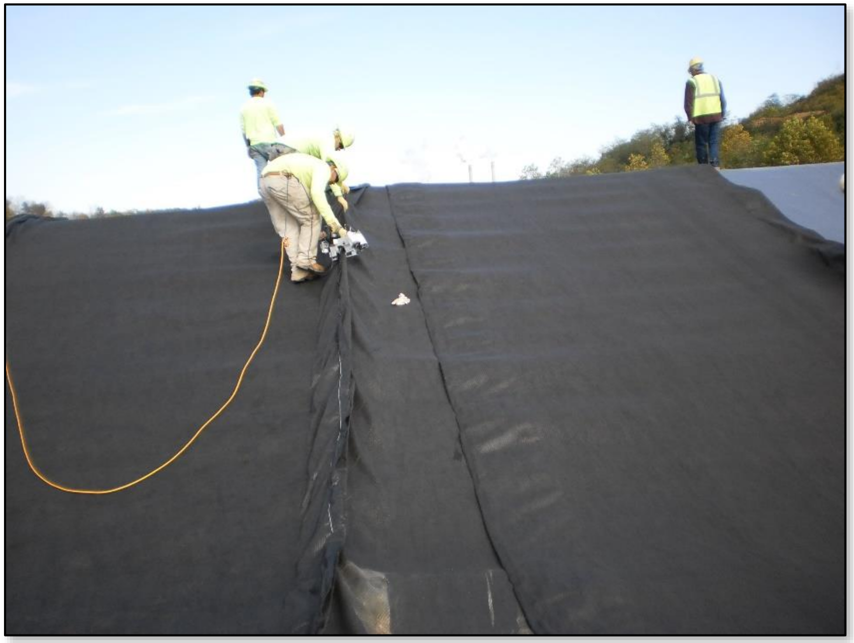
- Additional Construction Considerations
- Geocomposite Drainage Outlets –
  - Robert M. Koerner and George R. Koerner – GSP 306 – *Lessons Learned Regarding Exit Strategies from Geosynthetic Drainage Composites.* GeoCongress, March, 2019.
  - Ineffective drainage/clogged drainage can lead to sliding cover soils
  - Clogging of outlets due to maintenance (grass clippings etc…)

Geocomposite Drainage Net Deployment

Constructability

- Additional Considerations
- Geocomposite Drainage Outlets –
  - Overlap lengths of Geocomposite drainage nets along slopes

Zip tie connection of drainage net core



Sewing and Overlap of Geotextiles

Constructability

- Design and Construction Considerations:
  - Tie-ins to Structures
  - Boots and Attachments

  - Reference: Guidance on the Design and Construction of Leak-Resistant Geomembrane Boots and Attachment to Structures
    - IFAI Conference Geo, 2009 Conference, Salt Lake City, Febuary 2009
  - Authors:
    - Richard Thiel, Thiel Engineering,
    - Greg DeJarnett, Envirocon
    - Available: www.rthiel.com

Constructability

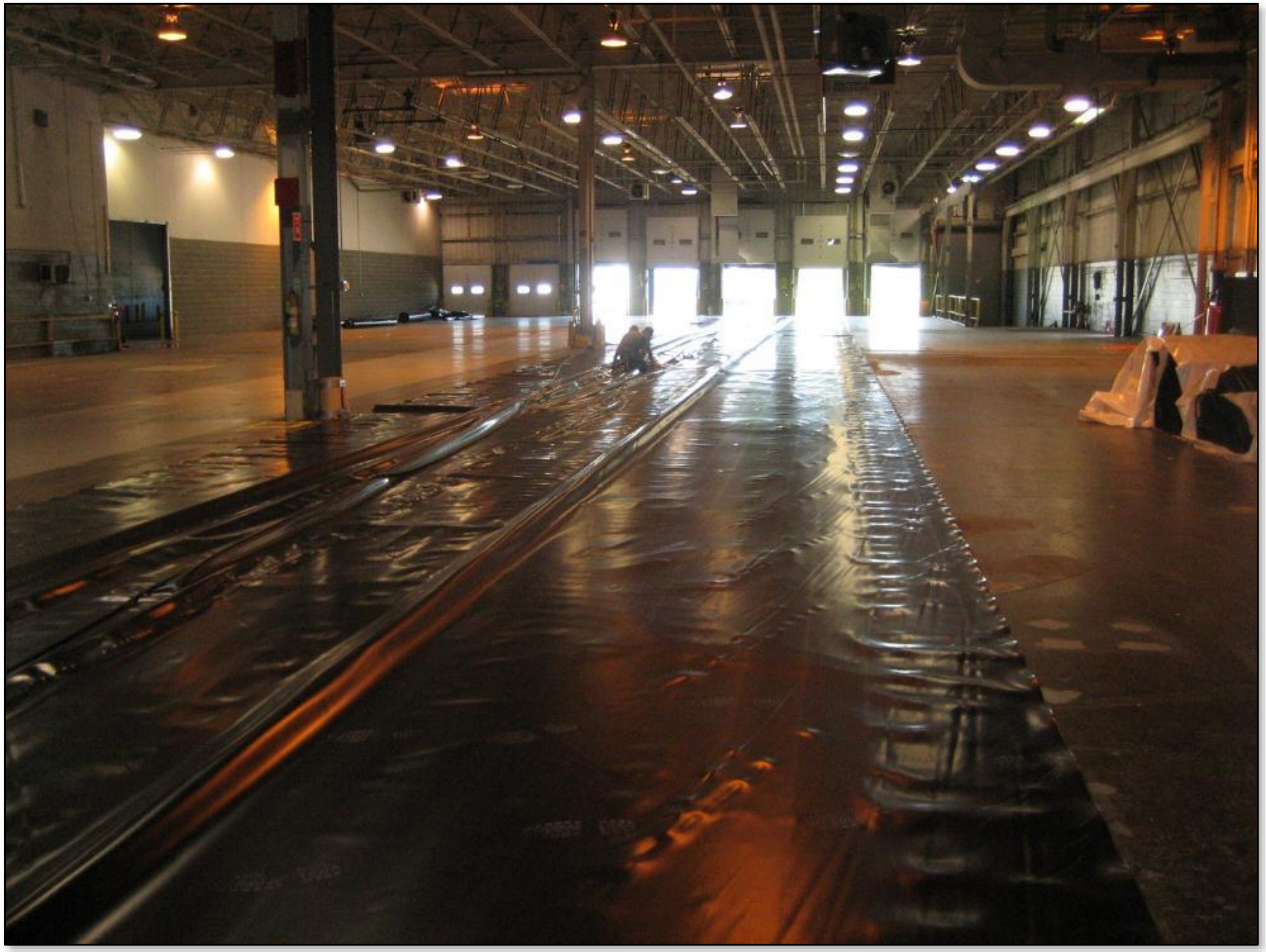
- Design and Construction Considerations:
  - Thiel and DeJarnett covers:
    - Pre-fabricated vs. field fabricated boots
    - Boot gaskets
    - Spark Test
    - Clamping Options
    - Concrete Collars with embedded Geomembrane
    - Batten Strip details
    - Examples of bad and good installations, with photos
  - Extremely practical reference for design and construction of geosynthetics – the tricky details that are difficult to get right.
  - Penetrations and attachments require the greatest oversight on a construction project.

Constructability

- Geomembrane Deployment
- Fabricated vs. Non-Fabricated Geomembranes
- Non-Fabricated Geomembranes – arrive to site in rolls
- Fabricated Geomembranes:
  - Arrive to site in panels and/or factory fabrication of the manufactured rolls
  - Faster deployment and less testing once on-site

Constructability

- Geomembrane Deployment – Off-Site Fabrication



Constructability

Fabricated Geomembrane Deployment – 1 Panel!

Constructability

Deployment halted due to weather.

- Removal and recompaction of subgrade.
- Additional density testing
- Re-survey
- Then it rains again
- Fabricated Geomembranes can pay off.

Constructability

- Electrical Leak Detection
- Exposed Geomembrane Surveys
  - Water Puddle Method (D7002)
  - Water Lance Method (D7703)
  - Conductive-Backed Geomembrane Spark Testing (D7240)
  - Arc Testing Method (D7953)
- Covered Geomembrane Surveys
  - **Dipole Method – Soil Covered Geomembrane (D7007)**
  - Dipole Method – Water Covered Geomembrane (D7007)

Constructability

- Electrical Leak Detection

Dipole Method

Constructability

- Electrical Leak Detection

Excavator bucket striking the liner.

Constructability

- Electrical Leak Detection

Able to find
small defects

Ductile Iron
Pipe Outlet

Constructability

Liner Defect found from Electrical Leak Detection

Conclusions

- Use of geosynthetics in CCR Applications is still growing and evolving.

- Learn from past failures and modify our designs.
- Stay current with best practices in construction.

- These facilities will be around for generations.

Questions???

Jason D. Ross, P.E.
Project Engineer
S&ME, Inc.
jdross@smeinc.com

BUILT FOR VERSATILITY

Contact Information

Jason D. Ross, P.E.
Project Engineer
S&ME, Inc.
jdross@smeinc.com

Jen Miller, M.S.
Coordinator
Fabricated Geomembrane Institute
University of Illinois at Urbana-Champaign
fabricatedgeomembrane@gmail.com

John M. Allen, P.E.
IGS-NA President - Elect
Technical Services Manager
CETCO Environmental Products
john.allen@mineralstech.com

Timothy D. Stark Ph.D., P.E.
Professor of Civil & Environmental Engineering
University of Illinois at Urbana-Champaign
Technical Director
Fabricated Geomembrane Institute
tstark@Illinois.edu

FGI's Next Webinar

Insane in the Geomembrane: The Story Behind Coal Combustion Residual (CCR) Surface Impoundment Liners

Tuesday, August 6, 2019 at Noon CDT

Free to Industry Professionals

1.0 PDH

Presenters:

Harold (JR) D. Register, P.E. (Consumers Energy)

Andrew B. Bittner, P.E. (Gradient)

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