Designing Double Lined Containment Systems Using Flexible Geomembranes

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Double Lined Systems

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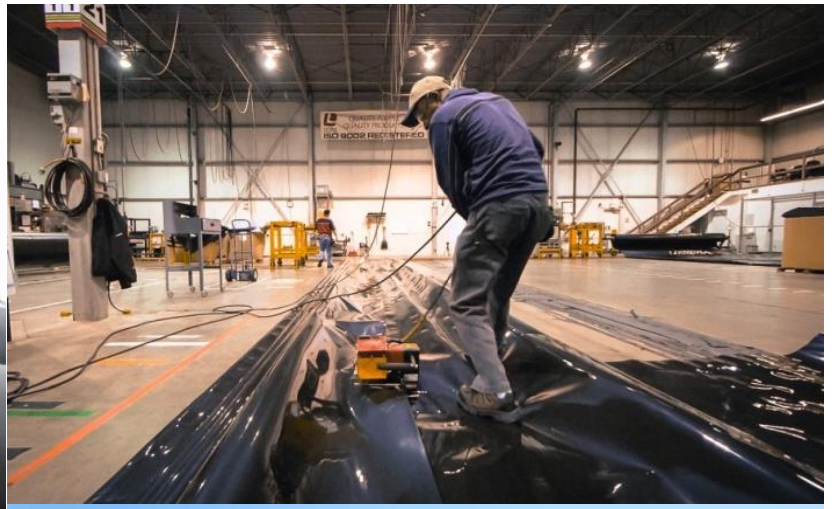
Double Lined Systems

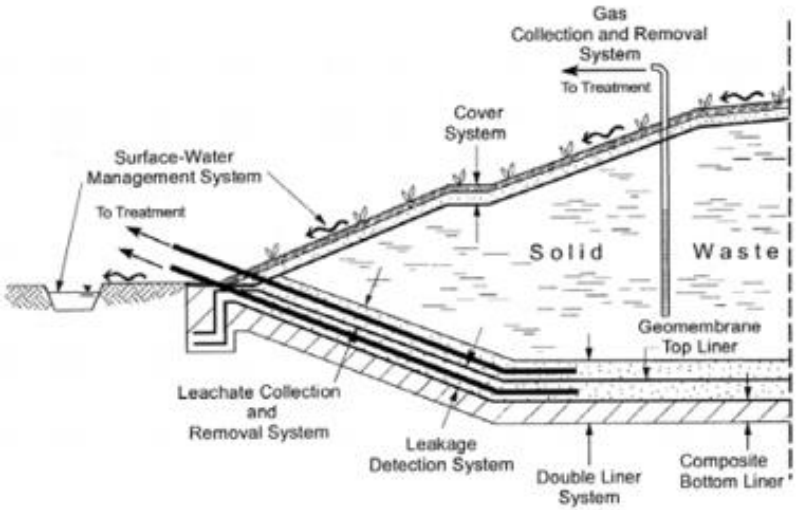
- Market Applications
- Geomembrane Selection
- Performance Testing
- Advantages of Fabricated Geomembranes
- Project Overview of Brine Cavern Project
- Drainage Layer
- Leak Detection of Double Lined Systems
- Questions

Fabricated Geomembrane - Double Lined 40 mil FML

Double Lined Systems



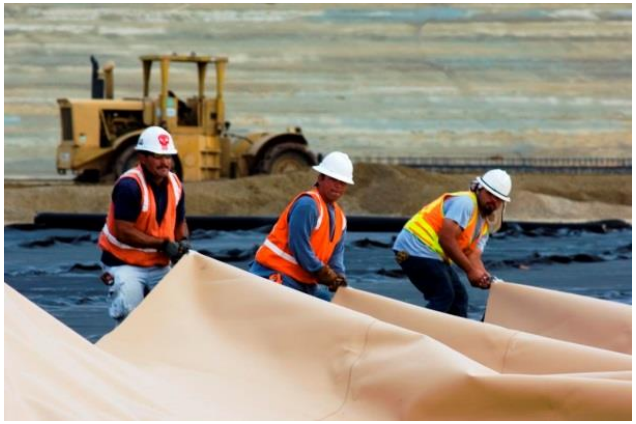
FML Geomembrane System



- Expanding Applications
  - Municipal Waste, Energy Sectors, Mining, Municipal Wastewater, Agriculture Digesters
- Design & Installation
  - Subgrade Preparation
  - Anchor Trench
  - Penetrations, Mechanical Anchorage
  - Design of Drainage Layer
  - Field Welding
  - MQA & CQA
- Selection of Geomembrane & Geocomposite Materials
  - No one material suitable for all applications

Material Selection

- Diverse selection of Flexible Liners
  - LLDPE, PP, PVC, CSPE, RPE, Elvaloys, EPDM, TPO
  - Extruded, Calendaring, Spread Coating
  - Unsupported Homogenous Geomembranes
  - Reinforced Geomembranes
- Fundamentals of Geomembrane Selection
  - Chemical Resistance – Fluid Type
  - Life Expectancy of Liner & Project
  - Liner exposed or backfilled
  - Site Conditions
    - Soil Type, Slope Geometry, Subgrade Compaction, Organic Gases, Seismic
    - Logistics – Location, Time of Year, Site Access
- Material Properties
  - Physical – thickness, density
  - Mechanical – Tensile, Multiaxial, Puncture, Tear
  - Endurance – UV, Oxidative & Chemical degradation,



Multiaxial Elongation Performance

HDPE 60 mil (1.5mm)

Polyolefin FML 50 mil (1.25mm)

- Subgrade compaction
- Differential settlement
- Organic gases
- Seismic activity

Geomembrane Selection

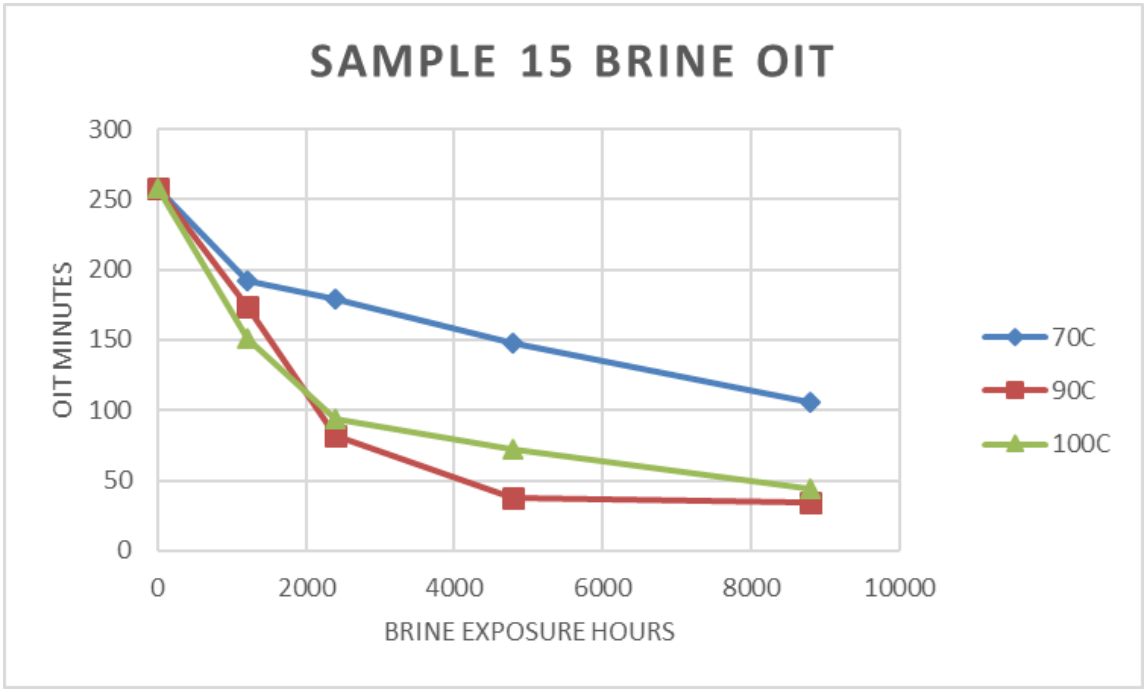
- Performance Testing
  - Chemical Immersion Testing
  - Oven Aging Testing
  - Antioxidant Depletion (OIT, HP OIT)
  - Reduction Tensile Strength
  - Accelerated Testing – High Temperature
    - 120°F, 170°F, 210°F
    - Testing Time – 30, 90, 180 Days (Plus)

- ASTM D5393 – Stress Crack Resistance
- ASTM D1693 – Stress Crack Resistance
- ASTM D3895 – Oxidative Induction Time
- ASTM D7238 - Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation
- ASTM D5322 – Geosynthetic Chemical Immersion Testing
- EPA 9090 – Compatibility Test for Waste & Geomembranes
- ASTM 884 – Solvent Vapor Permeation Testing

212° F Exposure

High Temperature Chemical Immersion Testing

Performance Testing



ASTM D1693 Stress Crack Test

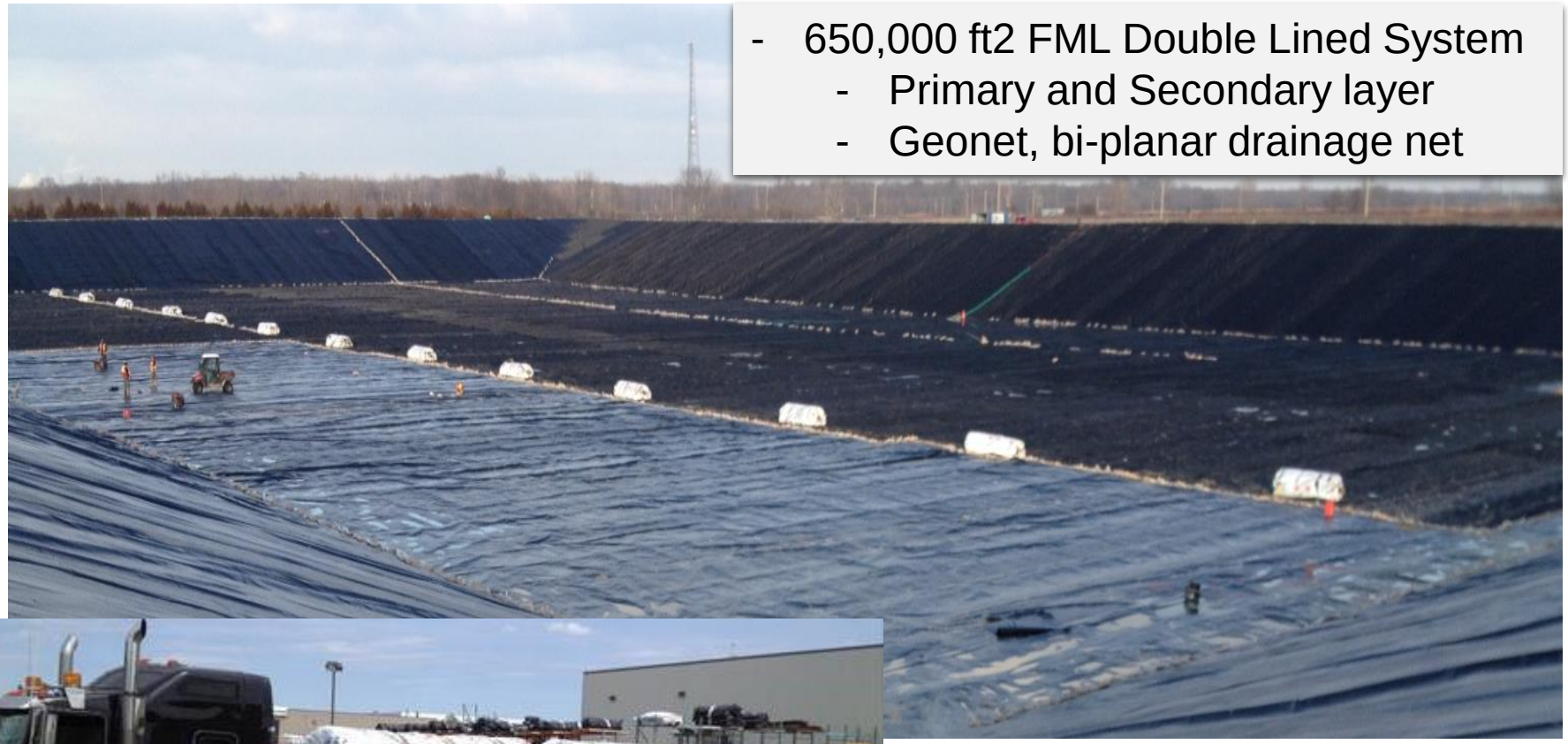
ASTM D3895 Oxidative Induction Time

- 100 g/L Nalco sodium chloride
- 62 g/L $NaHCO_3$ sodium bicarbonate
- 50 g/L Na_2CO_3 sodium carbonate
- pH 9.3 $\pm$ 0.4
- 27% w/w solution

Arrhenius Modeling

FML Double Lined Containment System

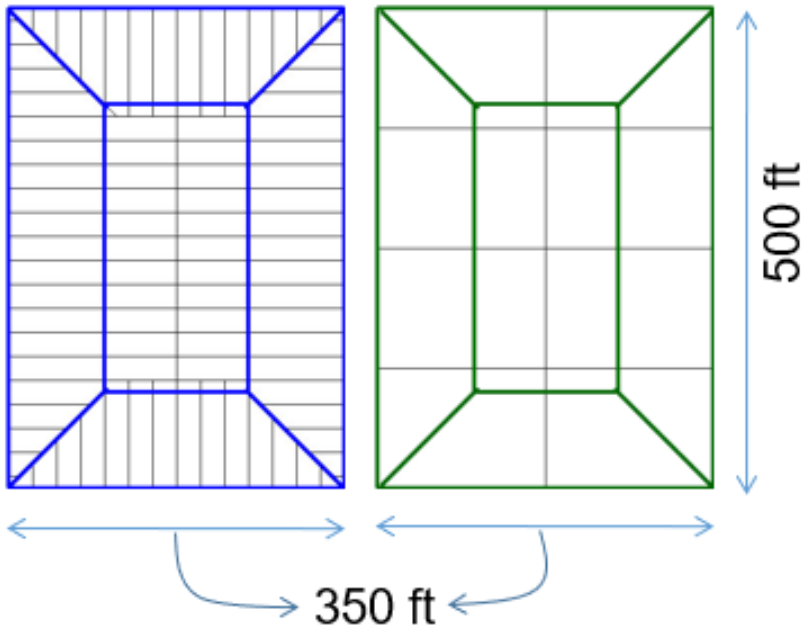
- 650,000 ft2 FML Double Lined System
  - Primary and Secondary layer
  - Geonet, bi-planar drainage net



Field Fabrication versus Factory

For a pond 350’ x 500’ (105 m x 150 m)
10’ deep (3m) deep; 4:1 slopes

Parameters	Prefabricated panels	Field Assembled
Total Length of Seam	915 m (3000’)	2435 m (8000’)
Deployment Efficiency	Very Efficient	Depends on lot of factors
Seam Quality	Excellent	Good
Dependence of Weather Elements	Partial Dependency	Total Dependence



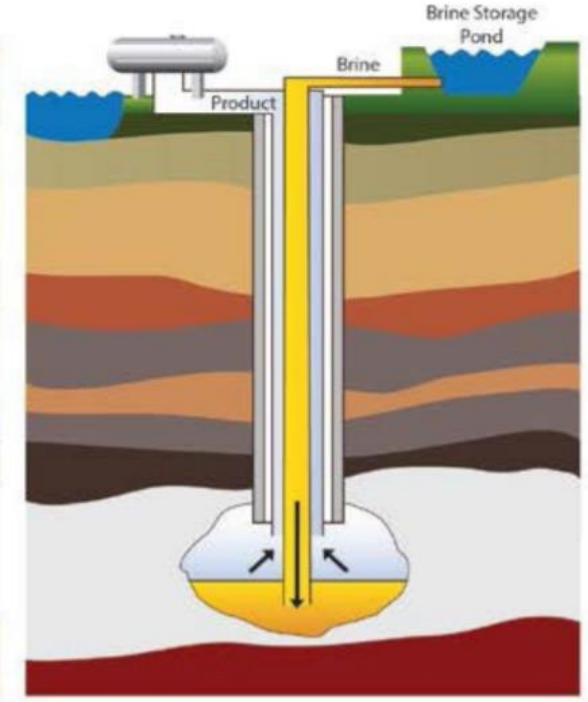
- Less Destructive Field Testing
- Reduced CQA

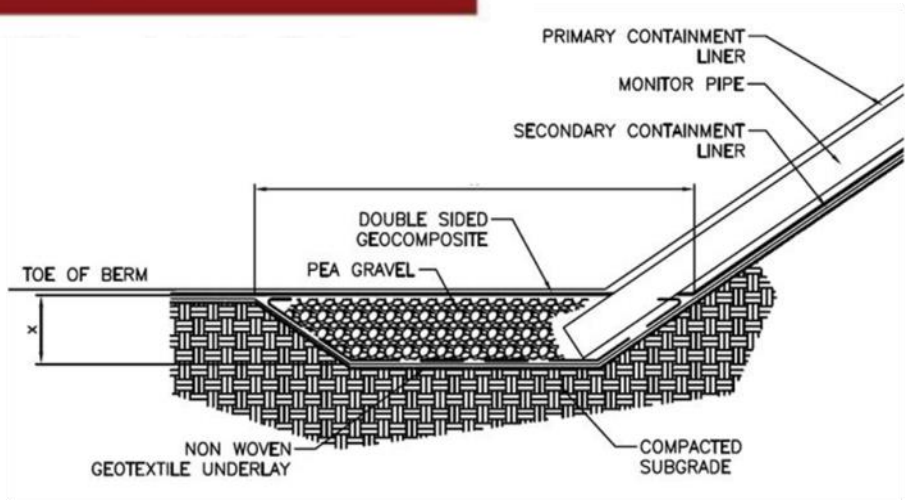
Fabricated Geomembranes

- Wide Selection of Fabricated Geomembrane Materials
- Mechanical & Endurance Properties
  - Tensile Elongation, Multiaxial, Yield Stress, Puncture, Tear, Flexibility, Fatigue, UV, Chemical Resistance
- Reduced field welding, construction time & cost
- Factory & Field seaming compliance to industry standards
- Manufacturing, Fabrication, Installation to industry standards
  - FGI 1120, GM 19, GM 17, GM 18, GM 25, GM 28
  - IAGI FGI Installation Guidelines
  - ASTM Test Methods

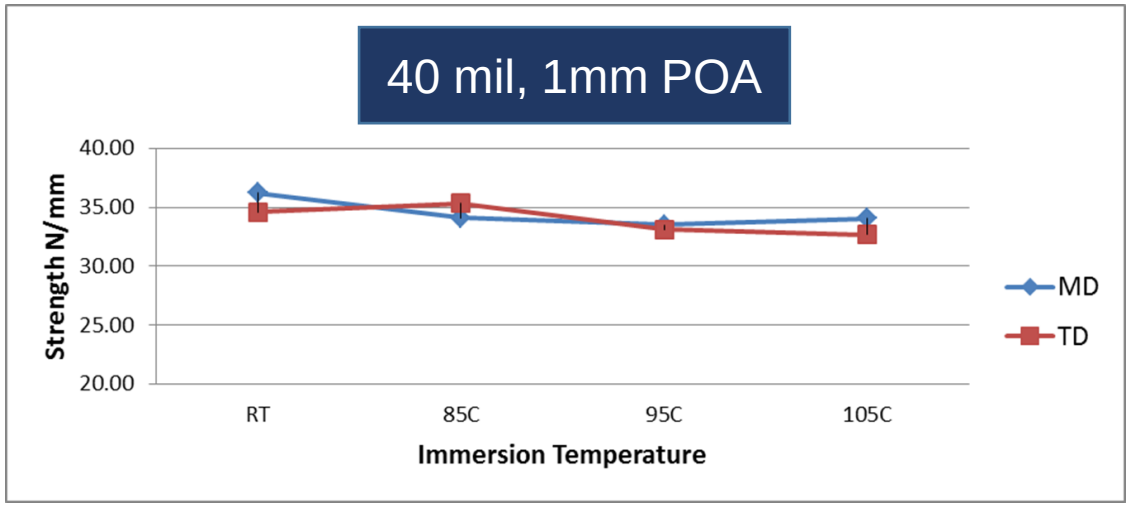
Case Study- Natural Gas Storage/Brine Containment

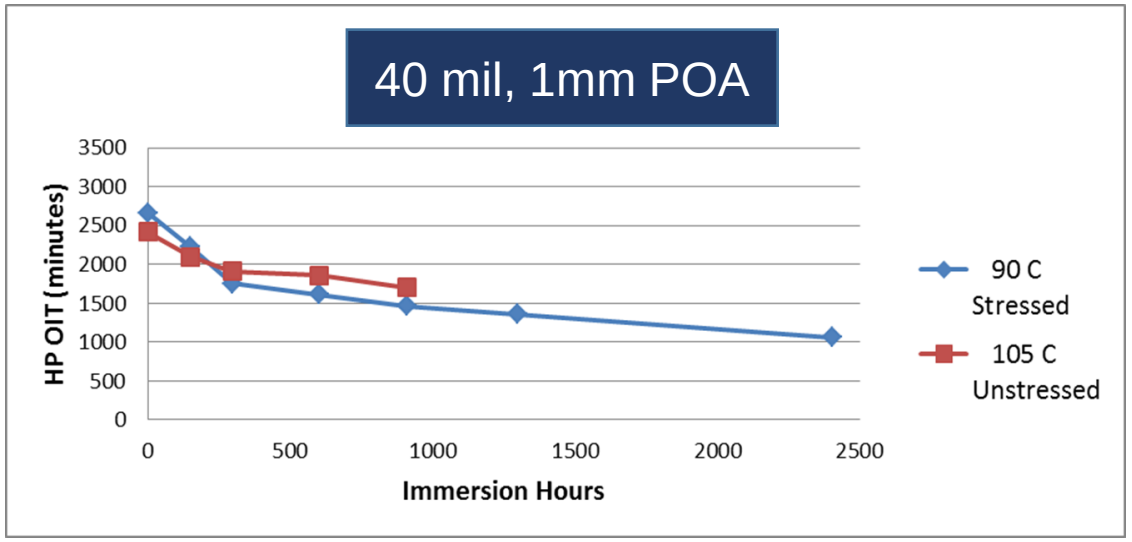
- Double Lined Containment
  - Primary/Secondary GMB, Polyolefin Alloy: 650,000 ft^2 (60,000 m^2) per layer
  - Drainage Layer, Geonet: 650,000 ft^2 (60,000 m^2)
  - NW Geotextile 650,000 ft^2 (60,000 m^2)
- Challenges
  - Long term resistance to saturated salt solution
  - UV resistance in a long term exposed application
  - Performance of a LDS using a flexible GMB
    - GMB deflection into Geonet
  - Meeting Project timelines
    - Saturated Site Conditions and Field fabrication



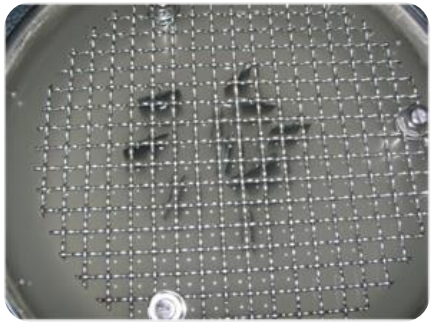


Chemical Resistance: Immersion testing



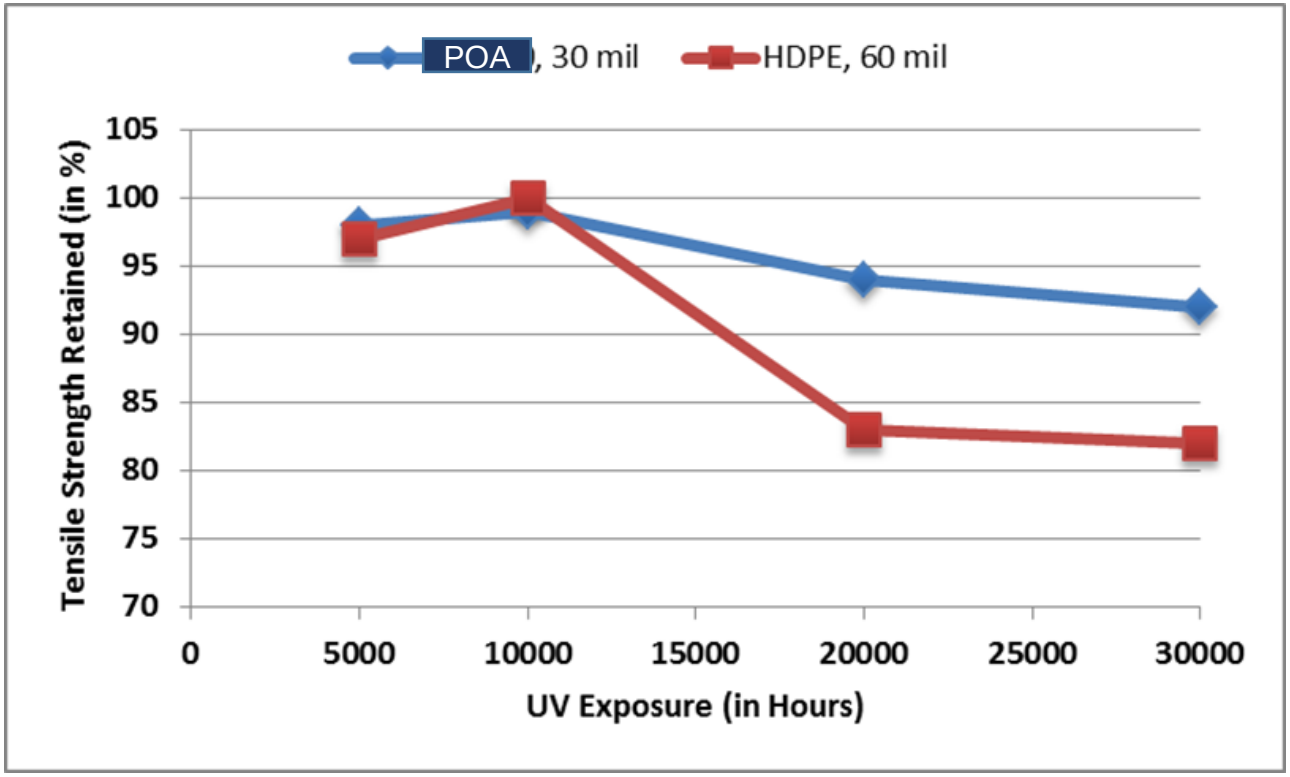


Stressed Condition



Unstressed Condition

UV Resistance



Long Term Weather Stability and Warranty Implications For Thin Film Geomembranes, Andrew Mills, C.E.T., Dave Martin, P.Eng., Rohit Sati, M.Sc

Shop Fabrication: Panel Layout

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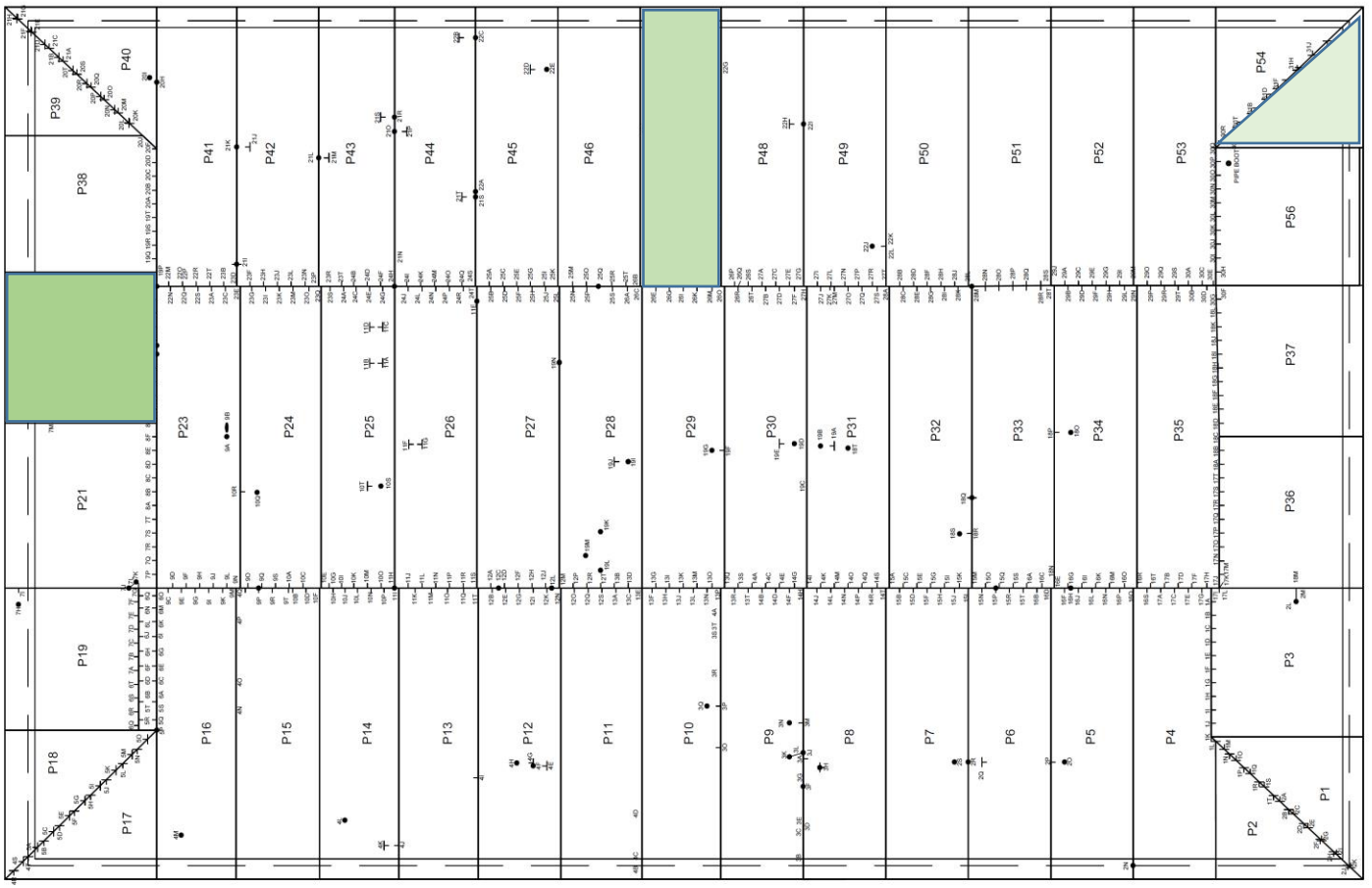


LEGEND:

- PATCH
- PIPEBOOTS
- T-JOINT

PANEL LAYOUT FOR SECONDARY LINER

LAYFIELD ENVIRONMENTAL SYSTEMS LTD.

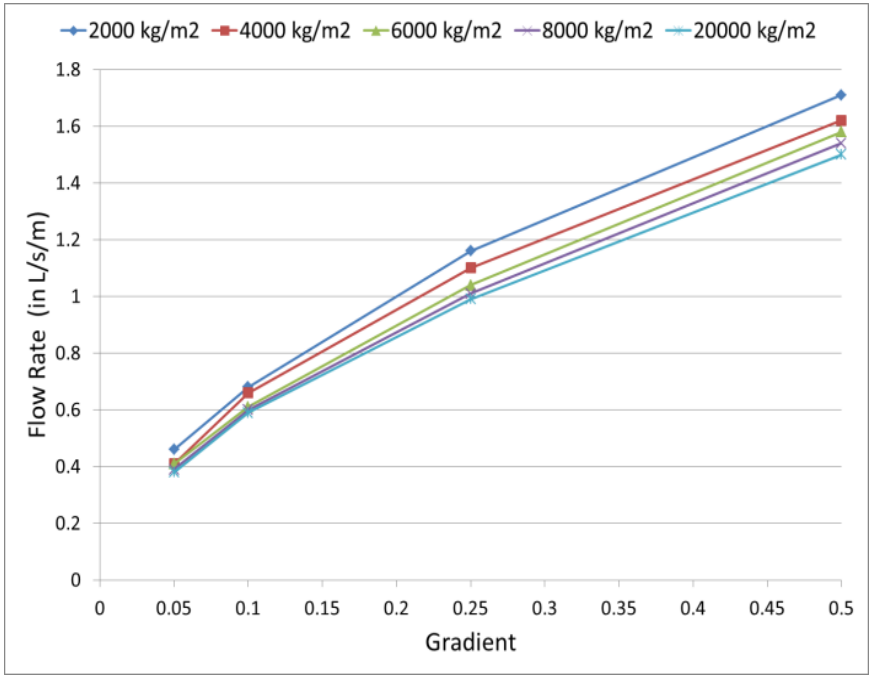
PEMBINA EMPRESS
SNC WEST BRINE POND
AS BUILT PANEL LAYOUT
SECONDARY LINER

PROJECT ESL NO.	13C-146
MANUFACTURE NO.	
DWG : 2 OF 2	SCALE: N.T.S.
DWN: LG	CHKD: RP / APP'D: RP
DATE: 031013	REVISION: 0

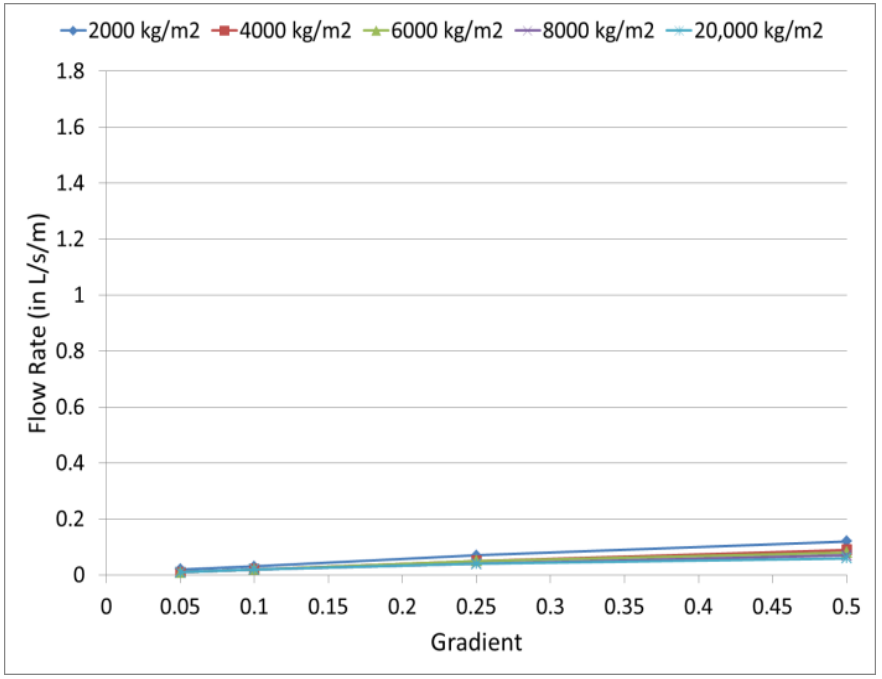
ANSI B Size Page (Horizontal)

Drainage Performance: w/wo Geotextile

- Objective: To compare drainage performance of a flexible PAO GMB in contact with Geonet and Geocomposite using ASTM D4716
- Test Conditions:
  - Normal loads: 2000, 4000, 6000, 8000, 20,000 kg/m^2
    : 410, 815, 1230, 1640, 4100 PSF
  - Gradient: 0.05, 0.1, 0.25, 0.50



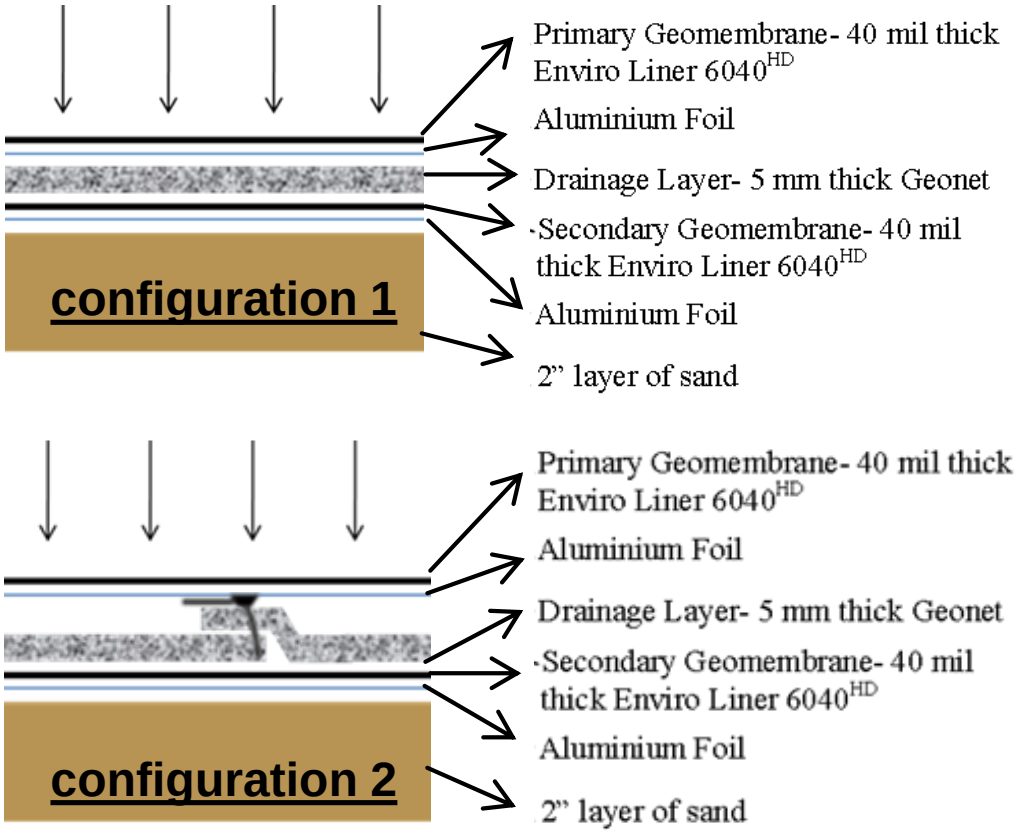
Flow Rates at different loads for **GM/GN/GM** interface

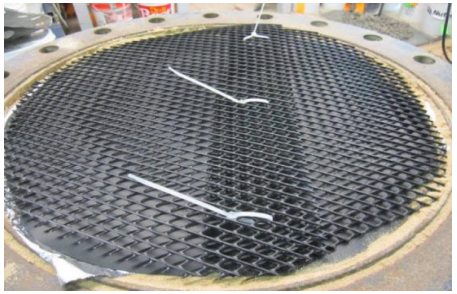


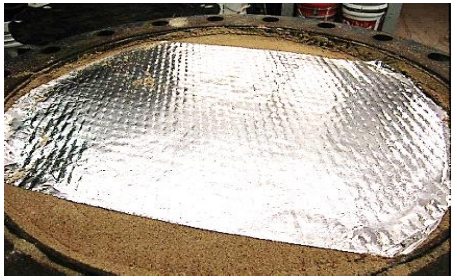
Flow Rates at different loads for **GM/GC/GM** interface

Compressive Study

- Objective: To measure out of plane deflection of POA GMB using ASTM D5514; 25 psi (3600 psf) @ 48 hours seating time







GMB Deflection

Primary Geomembrane		Secondary Geomembrane	
Width of Deformation	Depth of Deformation	Width of Deformation	Depth of Deformation
0.142	ND	0.239	ND
0.149	ND	0.285	ND
0.141	ND	0.25	ND
0.136	ND	0.225	ND
0.159	ND	0.274	ND
0.119	ND	0.279	ND
0.156	ND	0.305	ND
0.121	ND	0.291	ND
0.125	ND	0.277	ND
0.118	ND	0.252	ND

Geomembrane deformation for <u>configuration 1</u> at 25 psi (in inches)

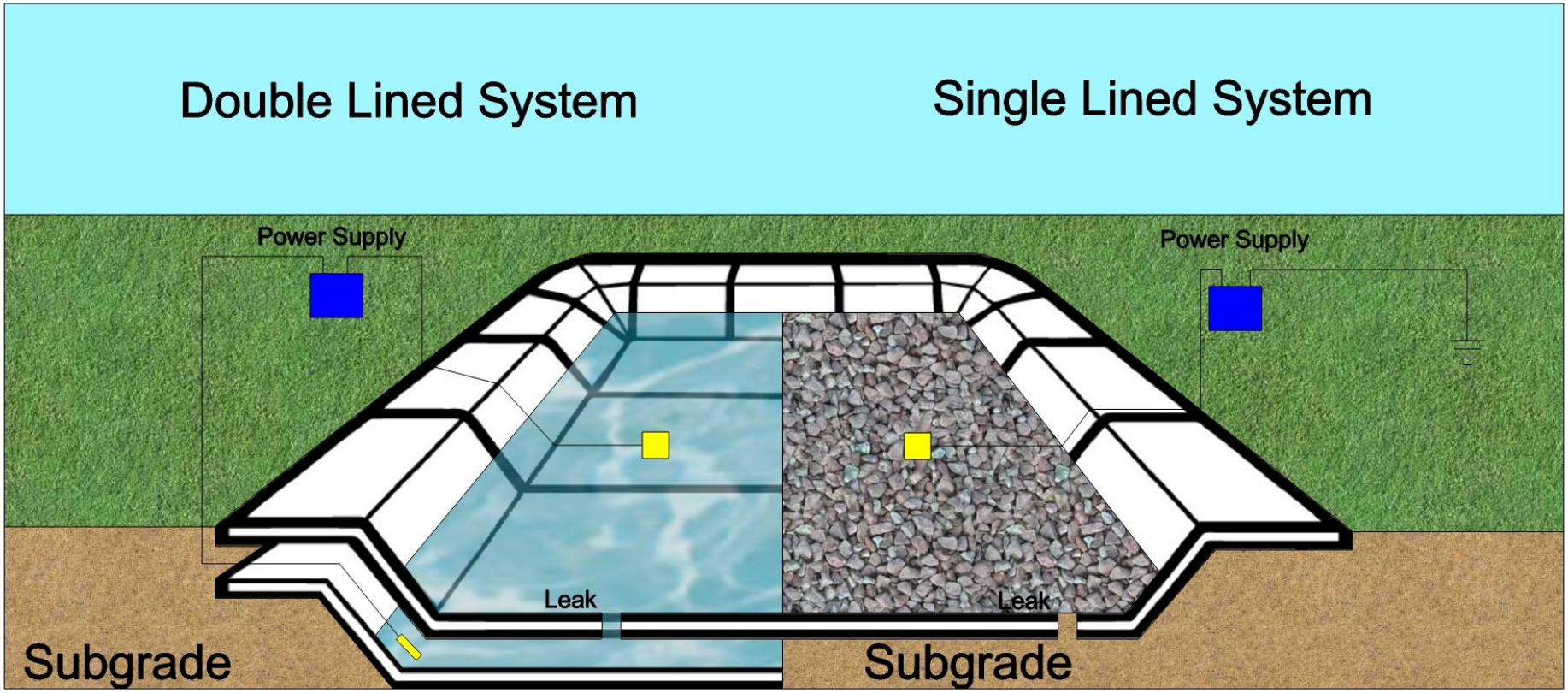
Primary Geomembrane		Secondary Geomembrane	
Width of Deformation	Depth of Deformation	Width of Deformation	Depth of Deformation
0.36	0.029	0.353	0.02
0.346	0.035	0.33	0.021
0.297	0.04	0.273	0.023
0.415	0.031	0.321	0.018
0.352	0.033	0.367	0.019
0.342	0.042	0.363	0.02
0.348	0.029	0.344	0.021
0.338	0.033	0.325	0.022
0.391	0.03	0.352	0.023
0.352	0.036	0.306	0.022

Geomembrane deformation for <u>configuration 2</u> at 25 psi (in inches)

Other Design Considerations-Double lined system

- Welding parameters for flexible POA
  - Trial Weld to establish weld parameters
- Anchor Trench
  - No special requirements
- Seams (GRI GM19)
  - Fabricated
  - Field
- Field QA/QC
  - Standard Quality Assurance Testing
- Action leakage rate
- Electrical leak location testing

Basics of the Technology



Types of Surveys that work on Double Lined Systems

Water Puddle (Bare Liner) – ASTM D7002

Spark Test – ASTM D7240

Arc Test – ASTM D7953

Soil Covered – ASTM D7007

Shallow Water – ASTM D7007

Deep Water – ASTM D7007

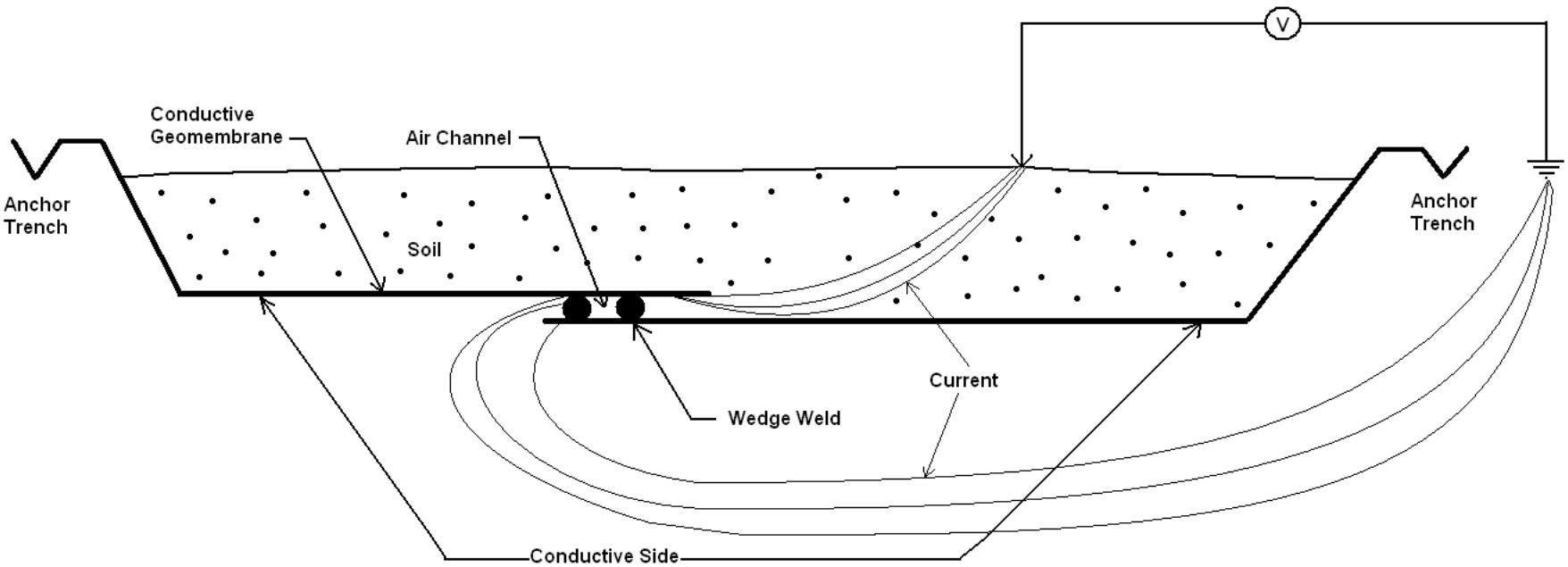
ELIM System

Electrical Leak Surveys – Double Lined Systems

Conductive Material Between the Liners

What can be used?	How it works
Water	Very conductive
Soil	Must have moisture
GCL (Geosynthetic Clay Liner)	Must have moisture
Conductive Underside of Primary Liner	Must be welded correctly
Conductive Geotextile	Moisture not required, no special welding needed

Conductive Liner or Conductive Material Between the Liners



What Kind of Leaks are Located?

Double Lined Systems

Questions & Discussions

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Next FGI Webinar

GCLs and Fabricated Geomembranes: Design and Construction

Tuesday, June 29, 2021 at 11 a.m. CDT
Free to Industry Professionals
1.0 PDH

Presenter:
Professor Chris Athanassopoulos, P.E.
Harper College

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