Geosynthetics in Waste Containment Systems

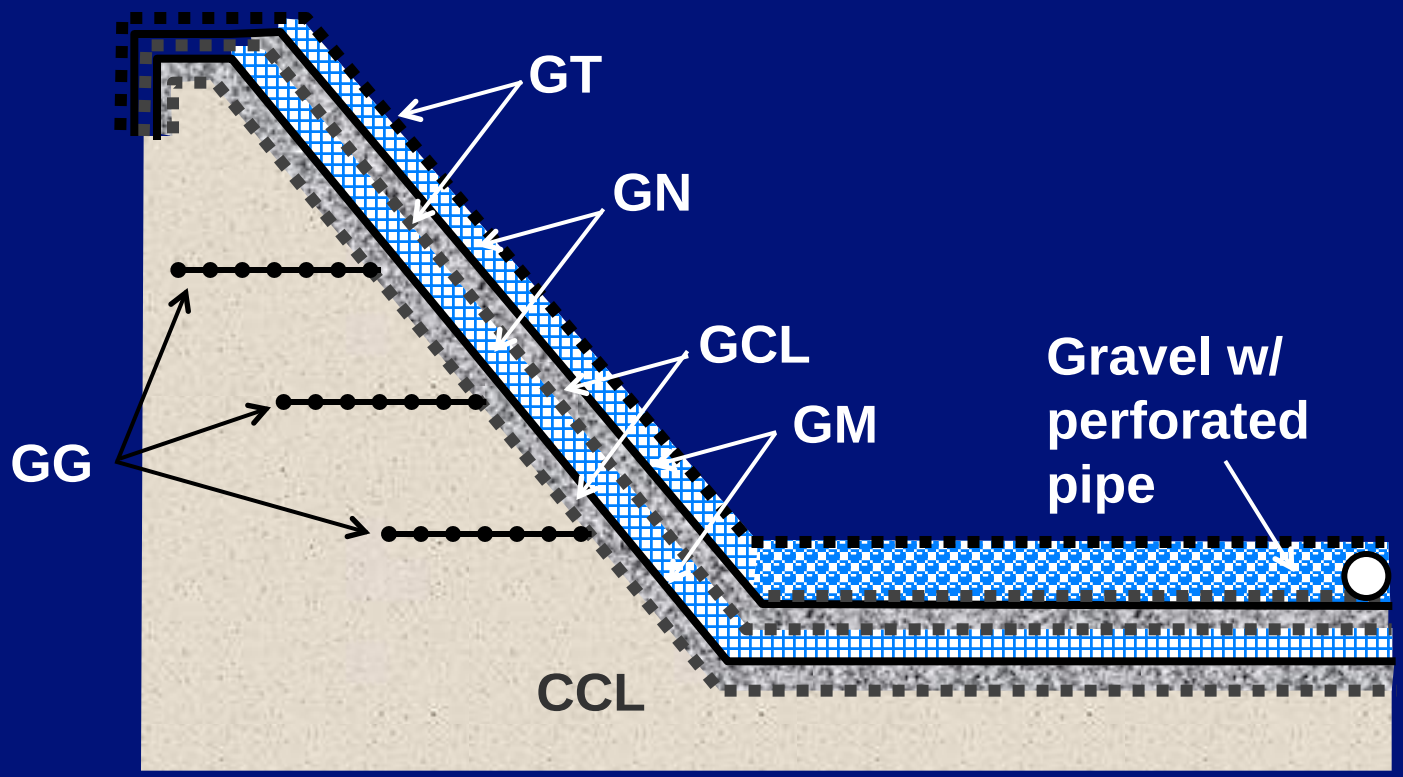
by
Geosynthetic Institute
475 Kedron Ave.
Folsom, PA 19033, USA
Phone (610) 522-8440
Fax (610) 522-8441
E-mail: robert.koerner@coe.drexel.edu

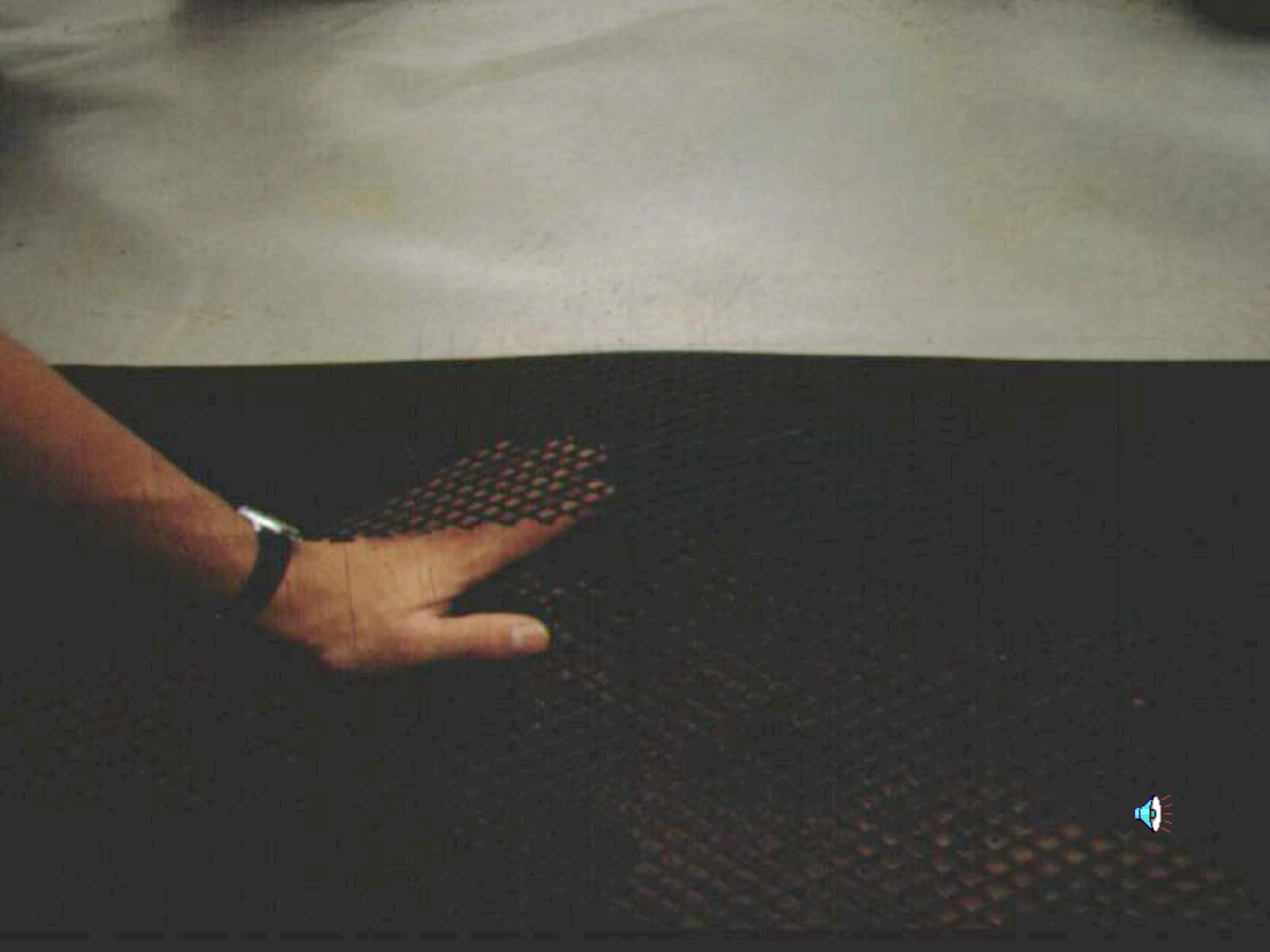
Geosynthetics in Waste Containment Systems*

*also surface impoundments, waste piles and heap leach pads

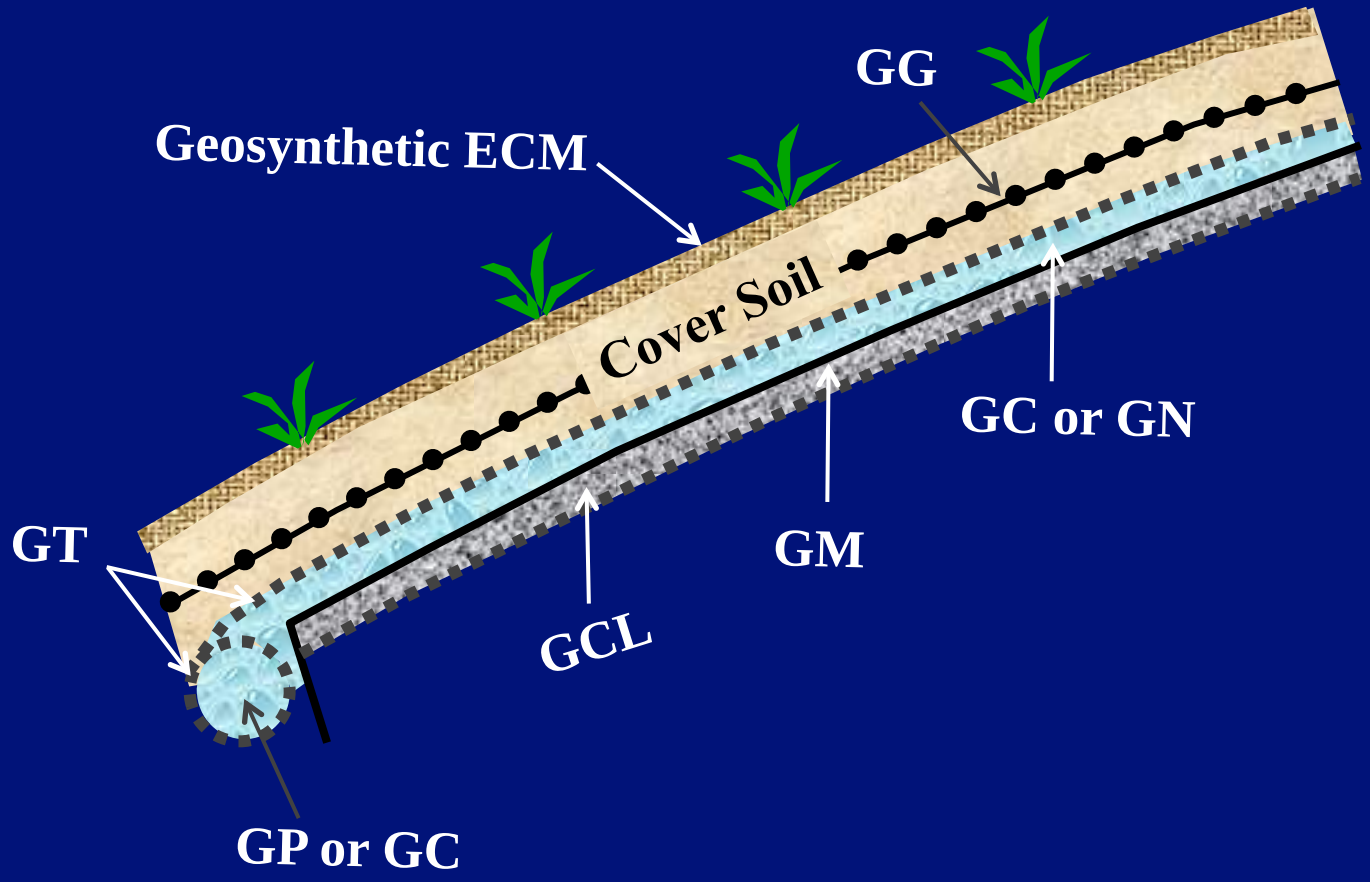
1.0 Introduction and Overview
2.0 Geosynthetic Materials
3.0 Design and Testing
4.0 System Considerations
5.0 Concerns and Summary

Liner System



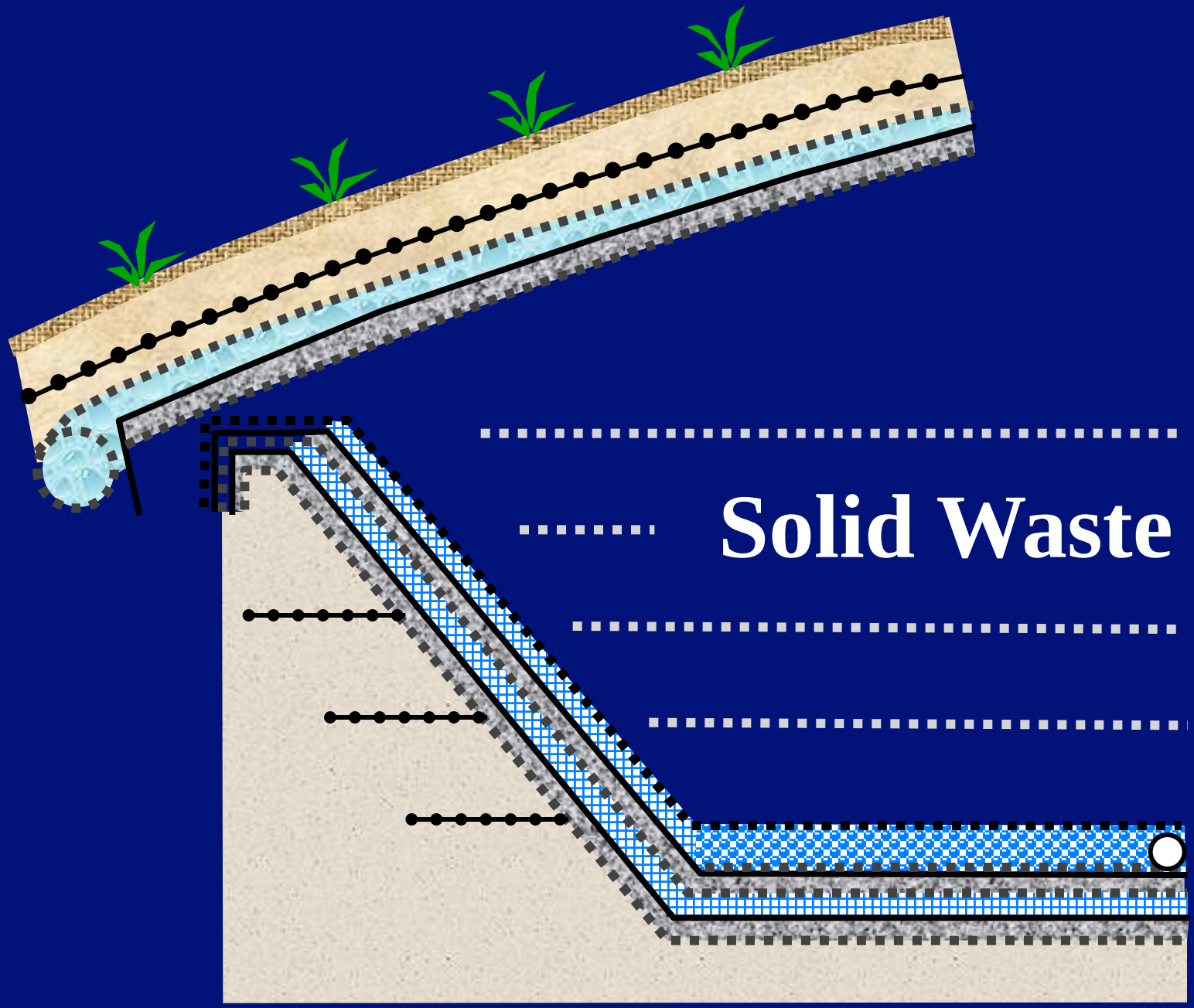


Final Cover System




8 28 '96


8/24/96


Solid Waste

Possible Geosynthetic Layers in a Waste Containment System

in Final Cover - 7

in Waste Itself - 2

in Base Liner - 9

18 Layers!

1.0 Introduction and Overview

1.1 Nature of solid waste problem

1.2 Genesis of liner systems

1.3 Current legislation

1.4 Natural soil vs. Geosynthetics

1.5 Equivalency issues

1.1 Nature of Waste Problem

- Moisture within and flowing on the waste generates leachate
- Leachate takes the characteristics of the waste
- Thus leachate is very variable and is site-specific - there is no "typical" leachate
- Flows gravitationally downward into the leachate collection system
- Enters groundwater unless a suitable barrier layer or system is provided

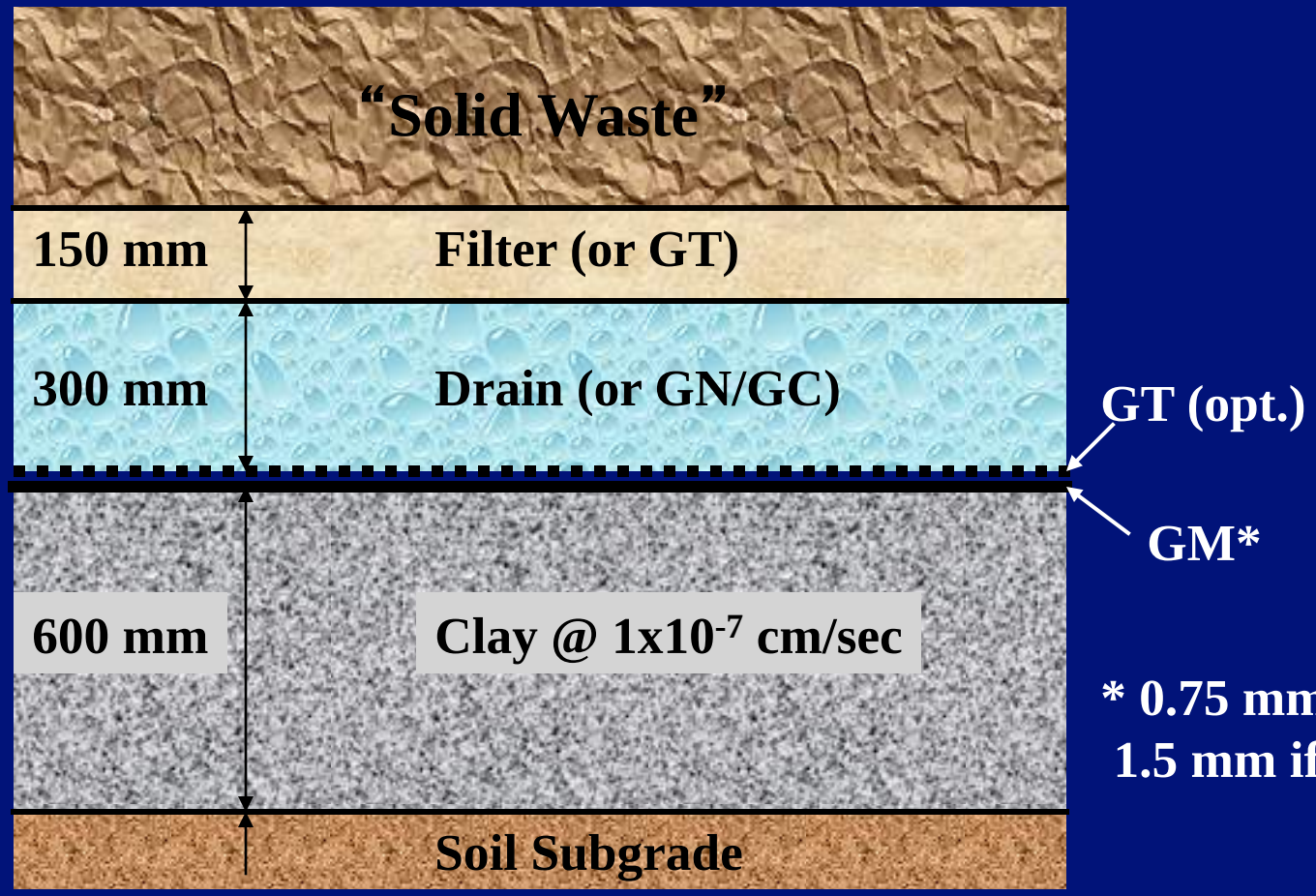
1.2 Genesis of Liner Systems

- **single CCL**
- **single GM**
- **double GM**
- **single GM/composite GM/CCL**
- **composite GM-GCL/composite GM-CCL**
- **composite GM-GCL/comp. GM-GCL-CCL**

1.3 Current U.S. EPA Legislation

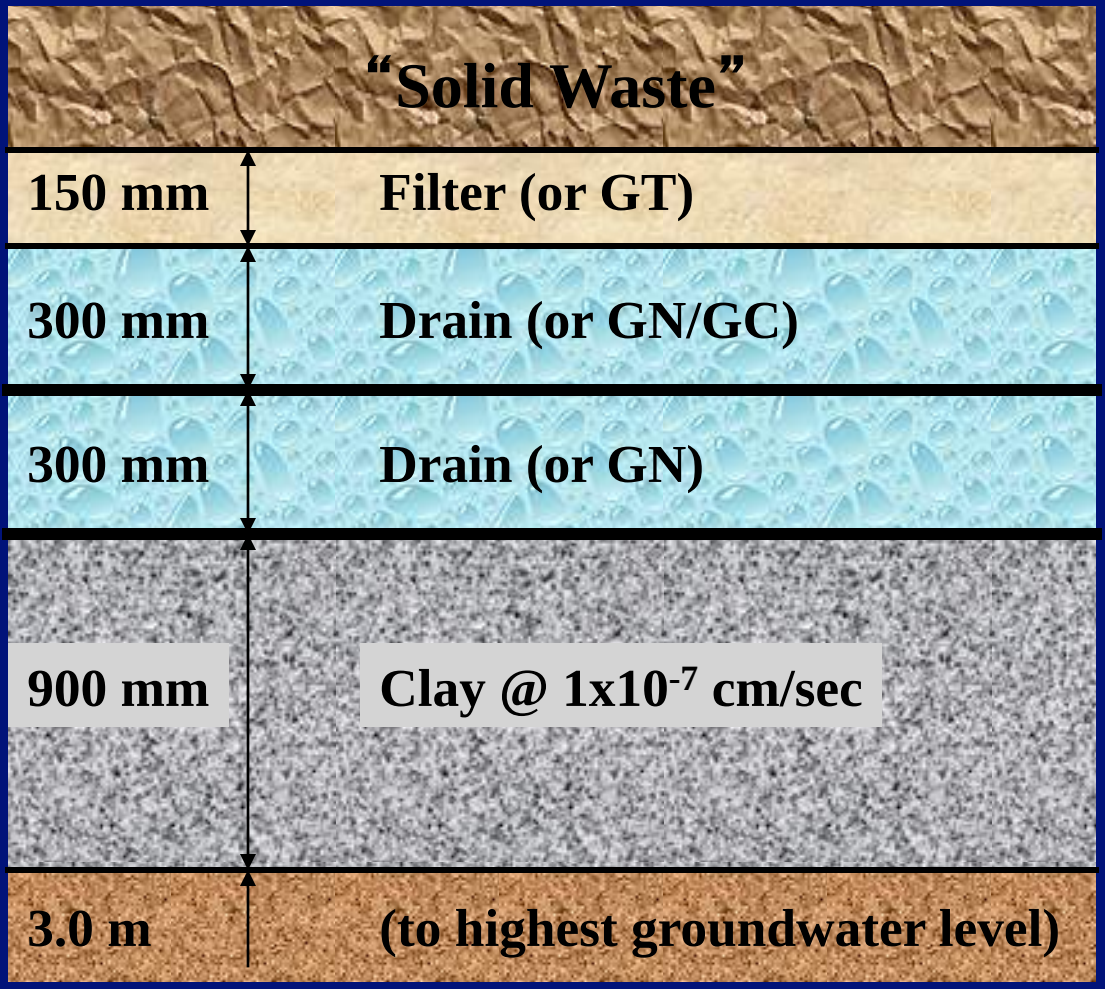
- **EPA Subtitle "D" of RCRA (Nonhazardous)**
- **EPA Subtitle "C" of RCRA (Hazardous)**
- **Superfund via Corps of Engineers**
- **DOE/NRC for Radioactive Wastes**
- **Worldwide approx. 40 countries have legislation/regulations (survey in GRI Report #23)**

Subtitle "D"
(MTG) Liner System



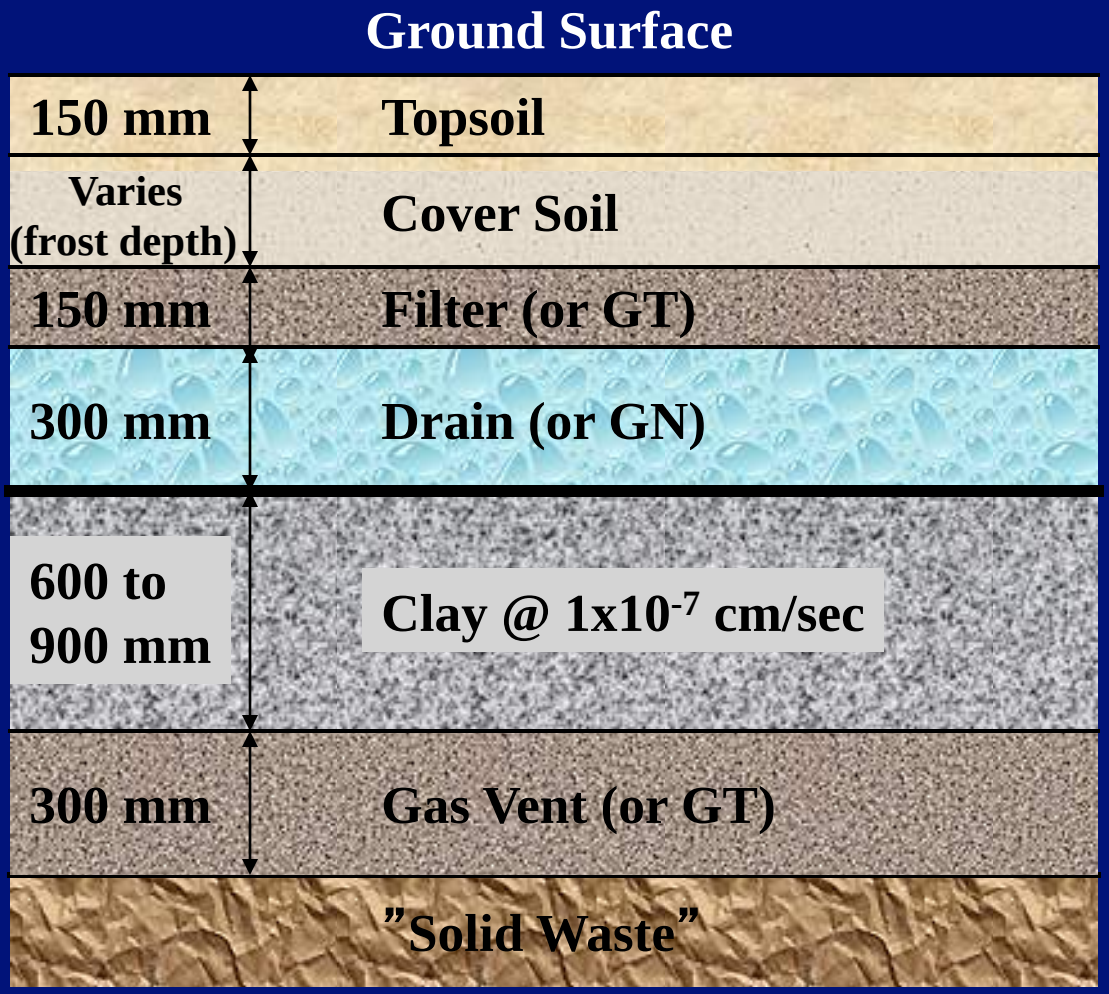
* 0.75 mm min.,
1.5 mm if HDPE

Subtitle "C"
(MTG) Liner System



* 0.75 mm min.,
1.5 mm if HDPE

Closure System (EPA and Corps of Engineers)



1.4 Natural Soils vs. GSs
(i.e., contrasting materials)

Function	Natural Soil	Geosynthetic
Barrier-Single	CCL CCL	GM GCL
Barrier-Composite	GM/CCL	GM/GCL GM/GCL/CCL
Drainage Layer	SA GV or SA GV or SA	GT GN GT/GN/GT
Filter Layer	SA	GT

Where CCL = compacted clay liner; SA = sand; GV = gravel;
GM = geomembrane; GCL = geosynthetic clay liner;
GT = geotextile; GN = geonet.

1.5 Equivalency Issues

- **Most (all?) regulations allow for replacement if alternate is "technically equivalent”**
- **Regulations rarely (never?) illustrate how technical equivalency is to be justified**

Technical Equivalency Considerations

General Concerns	Barrier	Drain	Filter
chemical resistance	√	√	√
permeability (or diffusion)	√	n/a	√
transmissivity	n/a	√	n/a
thickness concerns	√	√	√
long-term behavior	√	√	√

2.0 Geosynthetics in Liners and Covers

2.1 Categories and Types

2.2 Primary Functions

2.3 Design-by-Function

2.4 Testing Issues

2.5 Design Models

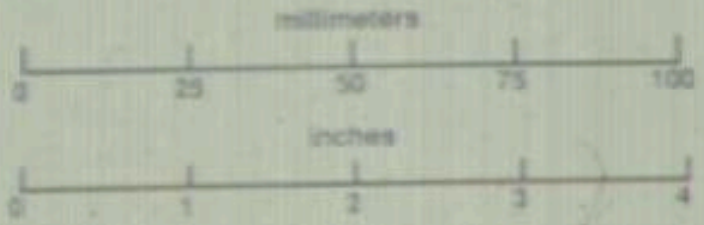
2.6 Factor-of-Safety Comments

2.1 Categories of Geosynthetics (GS)

- geomembranes (GM)
- geosynthetic clay liners (GCL)
- geonets (GN)
- geotextiles (GT)
- geogrids (GG)
- geopipe (GP)
- geocomposites (GC)

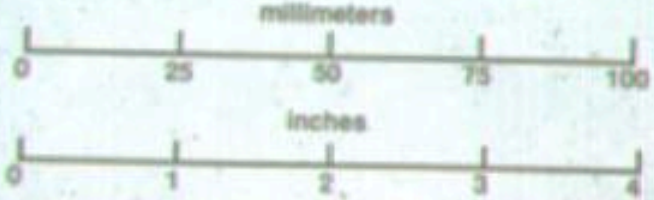

Geomembranes
millimeters
0
25
50
75
100
inches
0
1
2
3
4

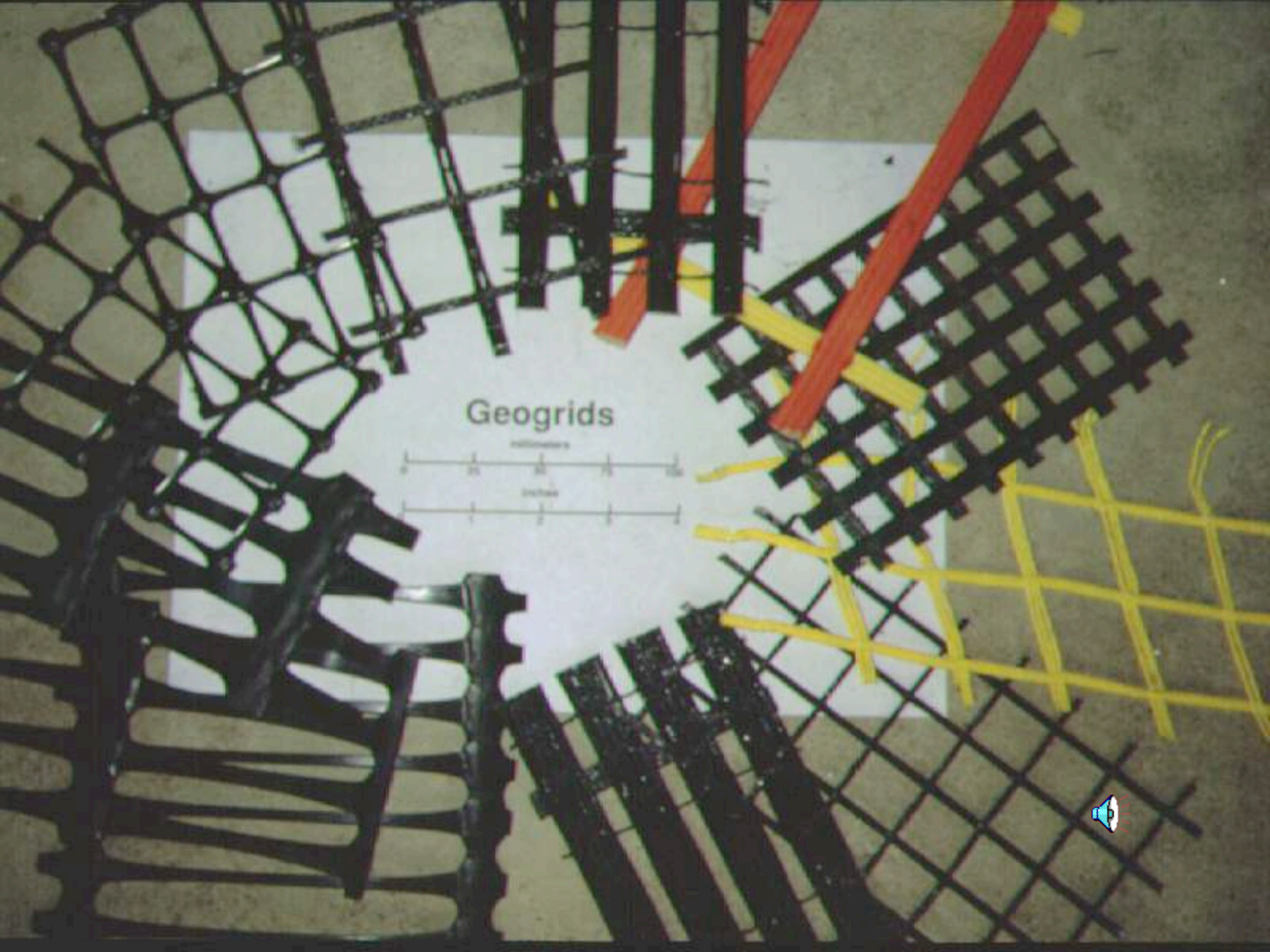
Geosynthetic Clay Liners



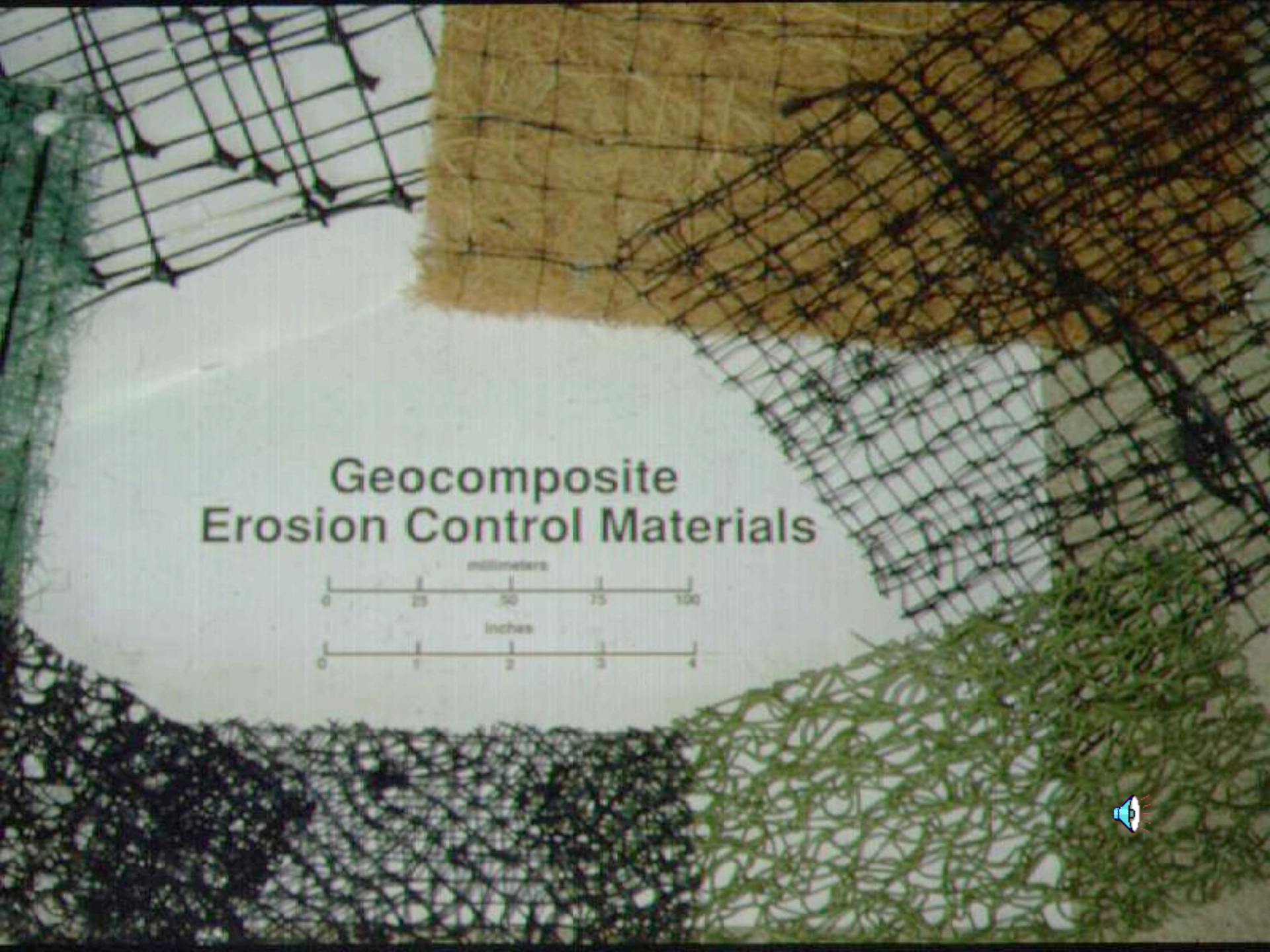
Geonets

Geotextiles

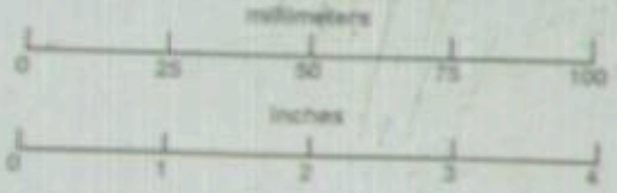



Geogrids

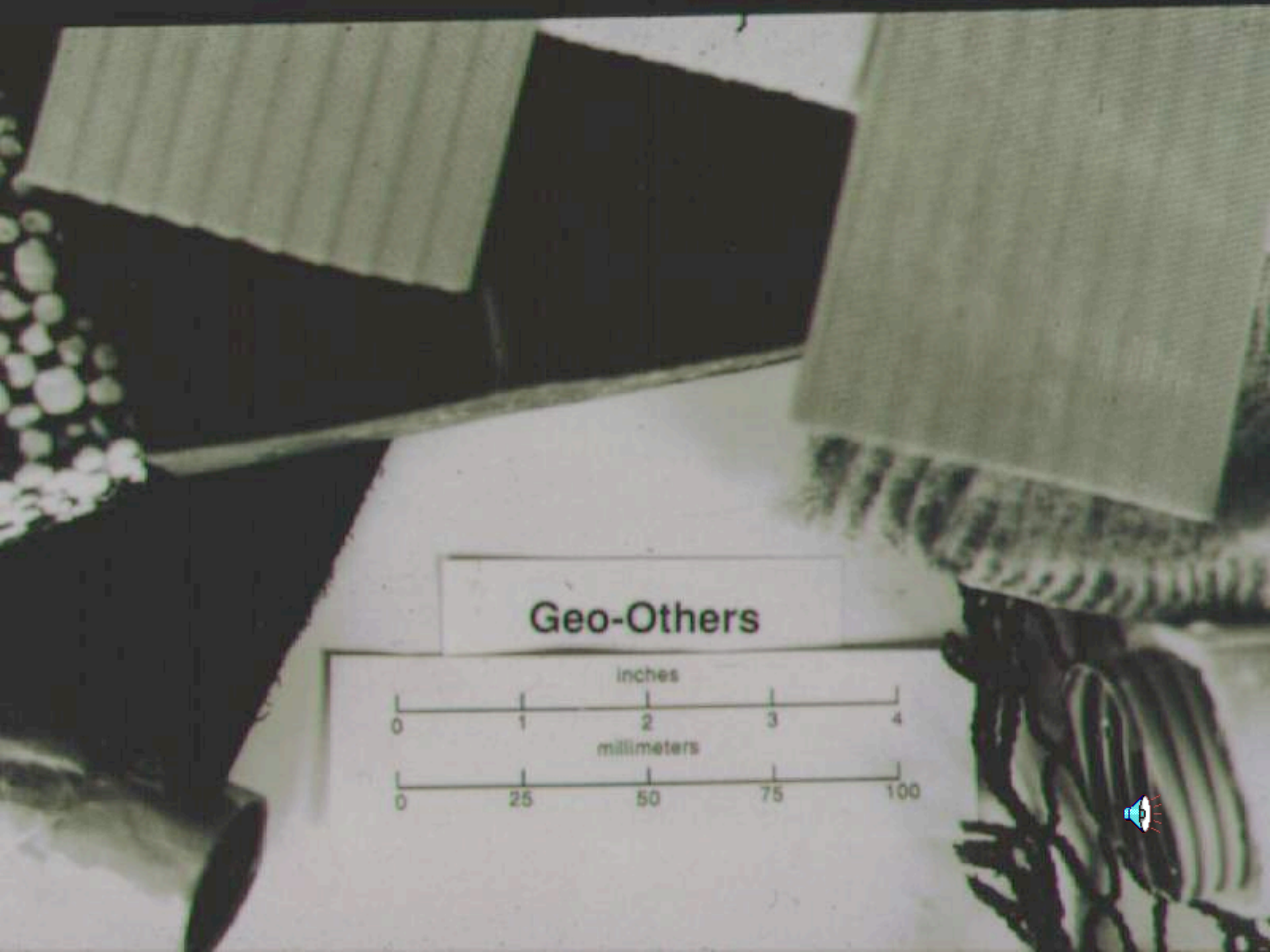

Geopipes


Geocomposite
Erosion Control Materials
millimeters
0
25
50
75
100
Inches
0
1
2
3
4

Strip (Wick) Drains




Edge Drains
millimeters
0
25
50
75
100
inches
0
1
2
3
4


Geo-Others
inches
0
1
2
3
4
millimeters
0
25
50
75
100

2.2 Primary Functions

Type of GS	S	R	F	D	B
GM	-	-	-	-	Y
GCL	-	-	-	-	Y
GN	-	-	-	Y	-
GT	Y	Y	Y	Y	-
GG	-	Y	-	-	-
GP	-	-	-	Y	-
GC	Y	Y	Y	Y	Y

S = separation; R = reinforcement; F = filtration; D = drainage; B = barrier.

2.3 "Design-by-Function" Concept

$$FS = \frac{\text{Allowable (Test) Property}}{\text{Required (Design) Property}}$$

where

- Test Methods are from ASTM, ISO or GRI
- Design Models from the Literature
- Factor-of-Safety is Site Specific

2.4 Testing Issues

- ASTM Committee D-35 (≃ 60 test methods, practices and guides)
- Subcommittees (67 TG's)
  - Mechanical
  - Hydraulics
  - Endurance
  - Geomembranes
  - Geosynthetic Clay Liners
- ISO is very active (≃ 20 tests)
- Topics are the same, but ISO & ASTM differ somewhat in details and procedures
- GRI Standards are also available

GRI Standards*

- Geotextiles (8 Stds)
- Geogrids (6 Stds)
- Geonets (1 Std)
- Geomembranes (15 Stds)
- Geosynthetic Clay Liners (2 Stds)
- Geocomposites (8 Stds)
- Geosynthetics (7 Stds)

---

* For use by everyone until ASTM or ISO develops a test method on the similar subject; then the GRI method is discontinued

Reduction Factors

- **Concept - modify an index test value to a site-specific performance value**

  where

$$\text{Property}_{(\text{allow})} = \text{Property}_{(\text{test})} \left[\frac{1}{RF_1 \times RF_2 \times \cdots} \right]$$

  RF_i = those details not included in test

- **Currently used for reinforcement and flow related problems**
- **Not currently used on barrier problems**

2.5 Design Models

- Utilize geotechnical, hydraulic, environmental engineering concepts
- Typically free body, then limit equilibrium
- Viscoelasticity sometimes considered via strain compatibility
- FEM just beginning
- Judgment (i.e., empiricism) still required, but models are improving rapidly

2.6 Factor-of-Safety Comments

Time → / ↓ Severity	Temporary	Permanent
Noncritical	moderate	high
Critical	high	very high

Recommended FS-values for cover systems*

Type of Waste → ↓Ranking	Hazardous waste	Non-hazardous waste	Abandoned dumps	Waste piles and leach pads
Low	1.4	1.3	1.4	1.2
Moderate	1.5	1.4	1.5	1.3
High	1.6	1.5	1.6	1.4

*other problems have less defined FS-values

For example; ref: Koerner, R. M. and Soong, T.-Y. (1998), "Analysis and Design of Veneer Cover Soils," 6th ICG Proc., IFAI, p. 1-26

Next File