Site Closures
Cover System Design

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Dwyer Engineering

Designed, reviewed, provided construction management for over 200 closures

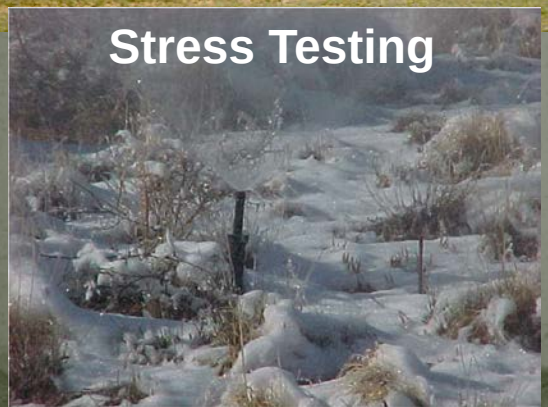
Dwyer Engineering is a small, woman-owned engineering firm based in New Mexico specializing in environmental, civil, and structural engineering.

Dwyer Engineering enjoys an international reputation in alternative earthen cover systems, site closures, mine reclamation, hazardous and radioactive waste remediation; reactive/impermeable barriers.

RESEARCH

Aerial View of SANDIA PROJECT

Sample of Instrumentation



ET Cover Concept

ET Cover - Long-term Design Life

- Cover composed of all natural materials;
- Provide adequate storage capacity to minimize flux;
- Surface admixture (desert pavement) to prevent significant erosion;
- Promote native vegetation;
- ET Cover system should be engineered to do what 'mother nature' has perfected.

Resistive Cover – Expensive & Problematic

EPA design guidance document (EPA 1991) for final covers states: **"In arid regions, a barrier layer composed of clay (natural soil) and a geomembrane is not very effective. Since the soil is compacted 'wet of optimum', the layer will dry and crack".**

Construction Problems

HDPE Liners – Easily Damaged

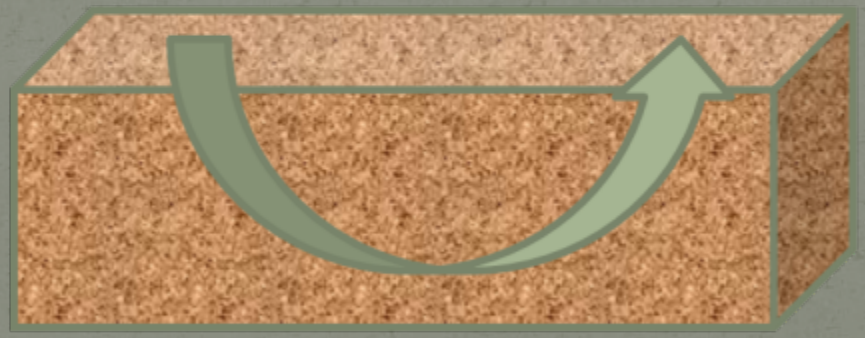
ET Cover Concept

Supply of water = precipitation

Supply

Demand

Demand for water = potential surface evaporation + potential transpiration via plants



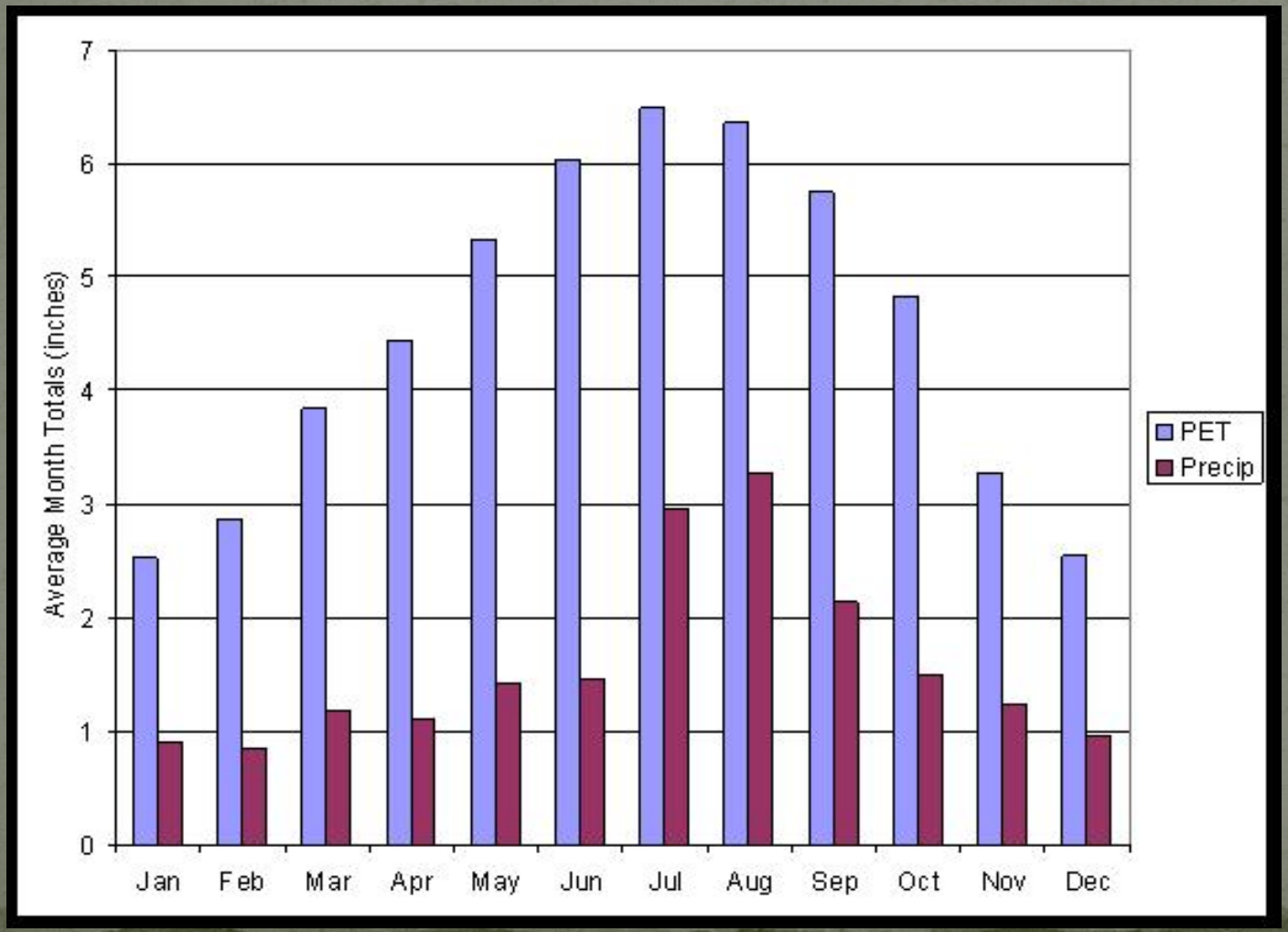
Soil acts like a sponge. Holds on to the water until it evaporates from the surface or is pulled out of the cover profile by plants

Deep Percolation = Supply that exceeds demand. Designed to be zero

ET Covers work where:
Climate DEMAND for Water > Actual SUPPLY of Water

or

PET > Precipitation



Los Alamos, NM

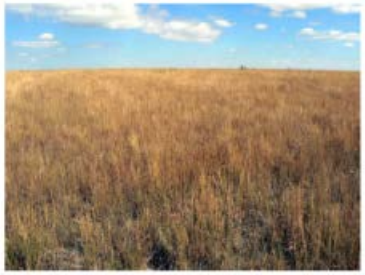
Guidance Documents Authored by Dwyer

EPA United States Environmental Protection Agency

CLOSING SMALL TRIBAL LANDFILLS AND OPEN DUMPS

How to Design Environmentally Safe Covers

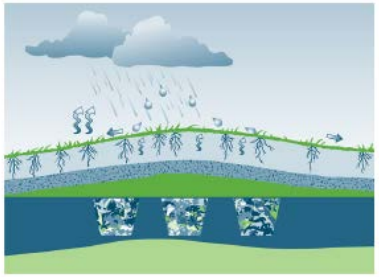
Including additional design guidance for arid regions



EPA-909-R-11-007

Technical and Regulatory Guidance

Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers



December 2003

Prepared by
The Interstate Technology & Regulatory Council
Alternative Landfill Technologies Team

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response Washington DC

EPA Draft Technical Guidar
For RCRA/CERCLA Fi

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United States
Environmental Protection Agency

Office of Solid Waste and
Emergency Response

Washington DC

Title: Cover System Design Gui
and Requirements Docum

Authors: Stephen F. Dwyer, PhD, PE
Ronald E. Hager, PE
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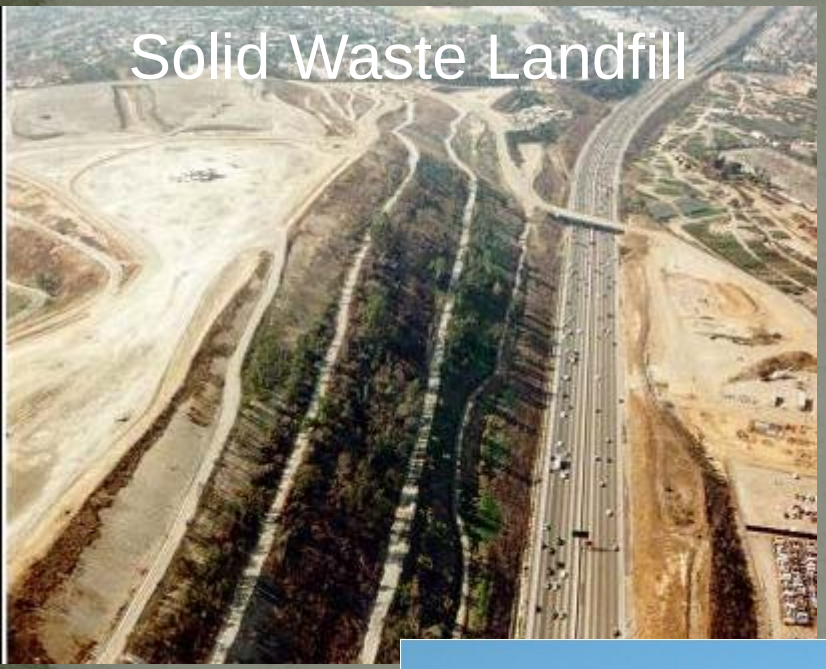
Los Alamos

Examples of

ET Covers Installations

ET Cover Installations



Uranium Mine Site Closure

Uranium contaminated soils and mine waste consolidated and cover with ET Cover.

Rocky Mountain Arsenal, Denver, Co

"Most Contaminated Site in the World" according to 60 Minutes

Landfill covers that will permanently contain the residuals of chemical warfare agents and pesticides at the Rocky Mountain Arsenal Superfund site, in Colorado, were designed to perform many functions, including providing a barrier to water infiltration, soil and wind erosion, and intrusion by wildlife. Designed as alternatives to the types of covers normally used at hazardous waste sites, the covers had to be validated beyond a shadow of a doubt before full-scale construction could begin.

By Laura D. Williams, Stephen F. Dwyer, Ph.D., P.E., M.ASCE, Jorge G. Zornberg, Ph.D., P.E., M.ASCE, Dorthea L. Hoyt, P.E., M.ASCE, and Gregory A. Hargreaves

Covering It All

Featured article in Civil Engineering Magazine: Jan 2011

Mine Evap. Pond

Mine Evaporation Pond

Overcome prior construction & engineering mistakes

Ongoing Monitoring: zero flux since installation

Mine Evap Pond after Closure

Site after cover installation

Site today

Superfund Closure – Farmington, NM

Cover Installation

Cover Today

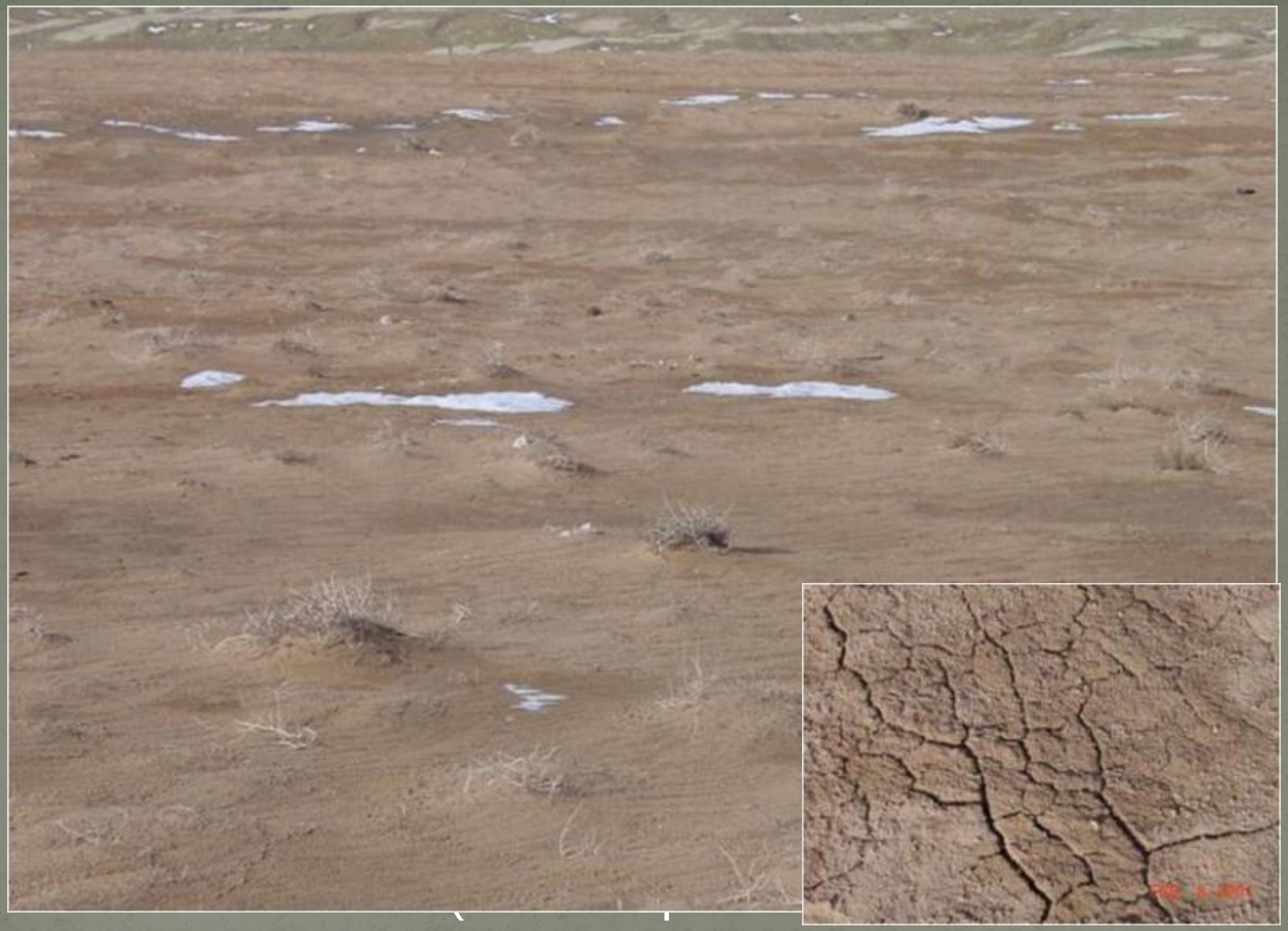
Ongoing Monitoring shows cover is effectively minimizing erosion and flux

Municipal Waste Landfills

Other MSWLs: NE, MN, Iowa, ND, CA, WA, OR, Utah, CO, TX, NM, AZ, NV, Indiana, MI, Wisconsin, Canada

Altamont, CA

Cover Failures are due to Design and / or Construction Flaws



Subtitle D Cover (Later Replaced with ET Cover) on Navajo Nation – Significant Wind Erosion

Congressional Investigation of Rocky Flats Plant, Denver CO – Old Landfill

Sunrise Mountain Landfill, Las Vegas, NV

Slope Instability

Tension Cracks Perpendicular to Surface Water Flow

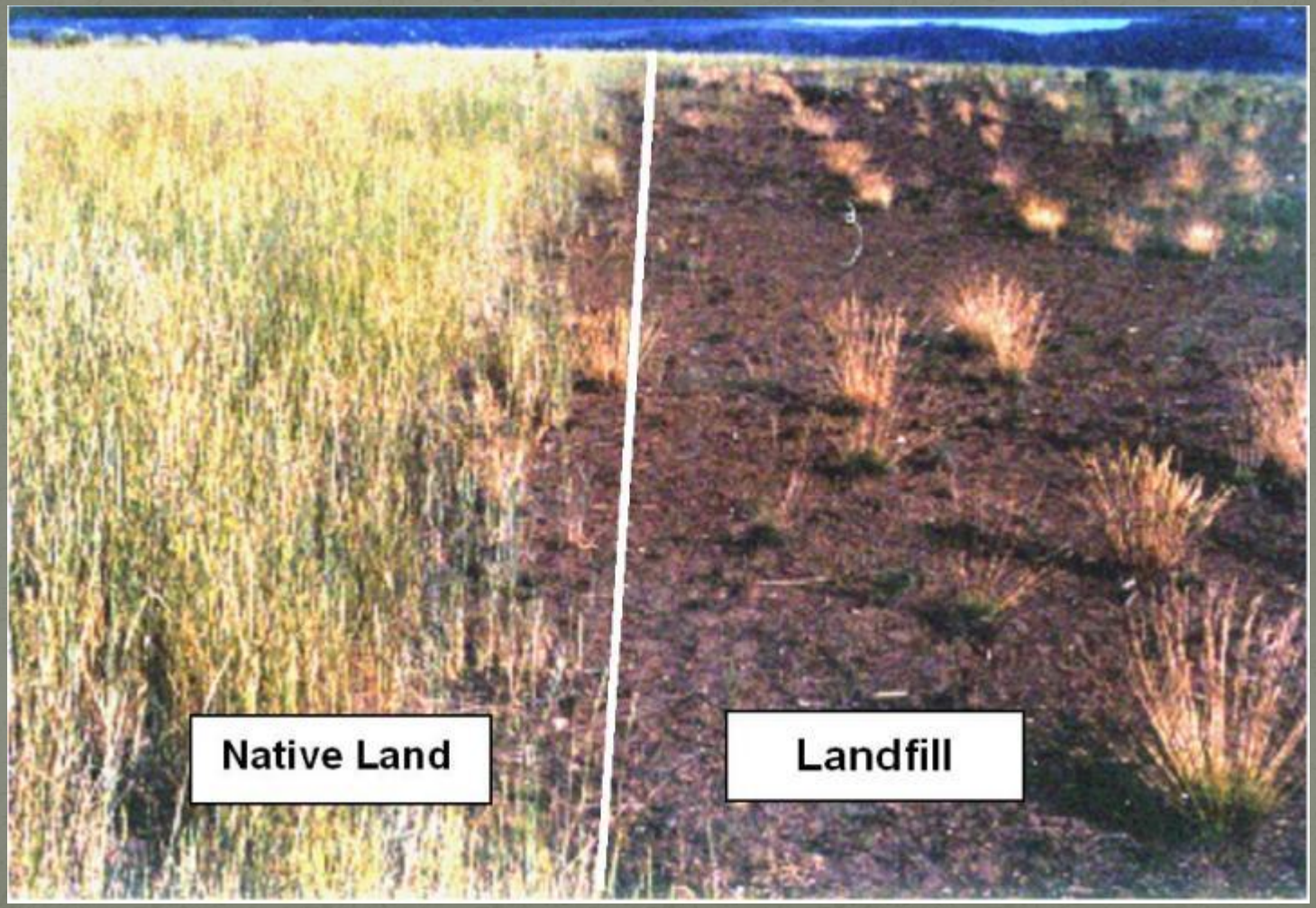
Gas

Inadequate Cover

Poor Surface Water Controls

Erosion Problems

Vegetation Contrast



Soils – ensure adequate soil is used

**Soils with Higher than 10%
Salt Content by Weight**

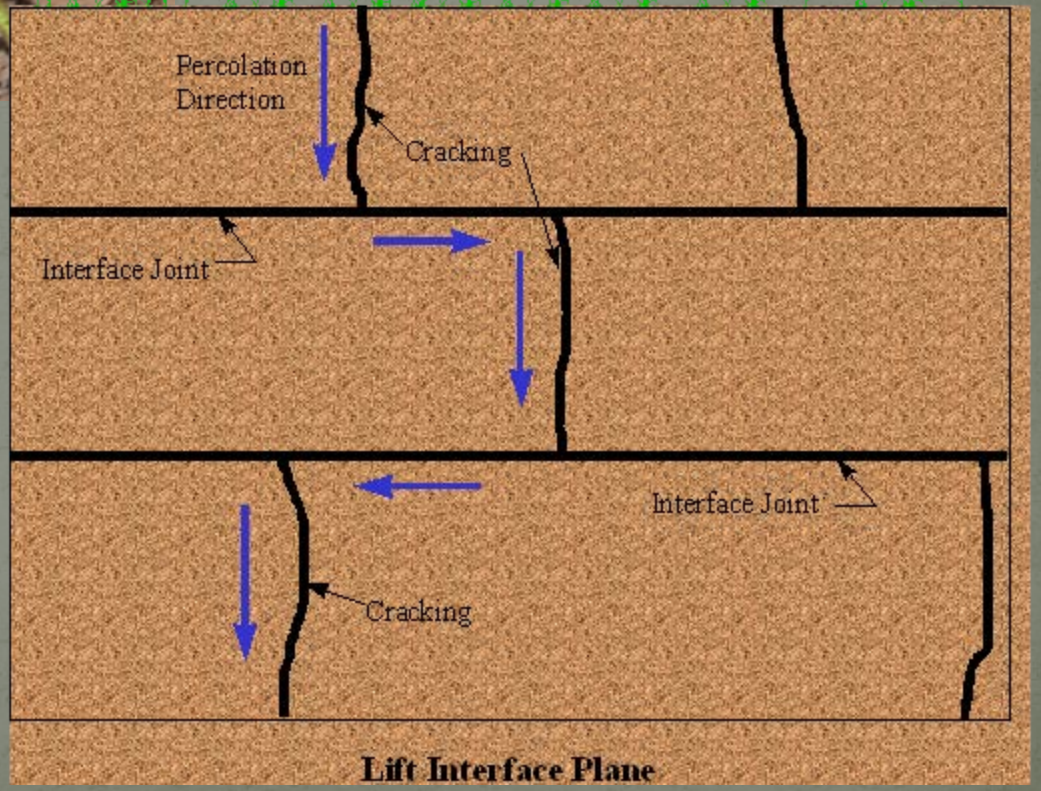
**Soils with Lower than 10%
Salt Content by Weight**

Vegetation in Similar Soil with Different Salt Contents

Proper Construction Material – Meet Design Specifications

Slope Instability with GCL (Interface Friction)

Proper Construction Techniques



Covers Should Isolate the Waste for Its Harmful Life

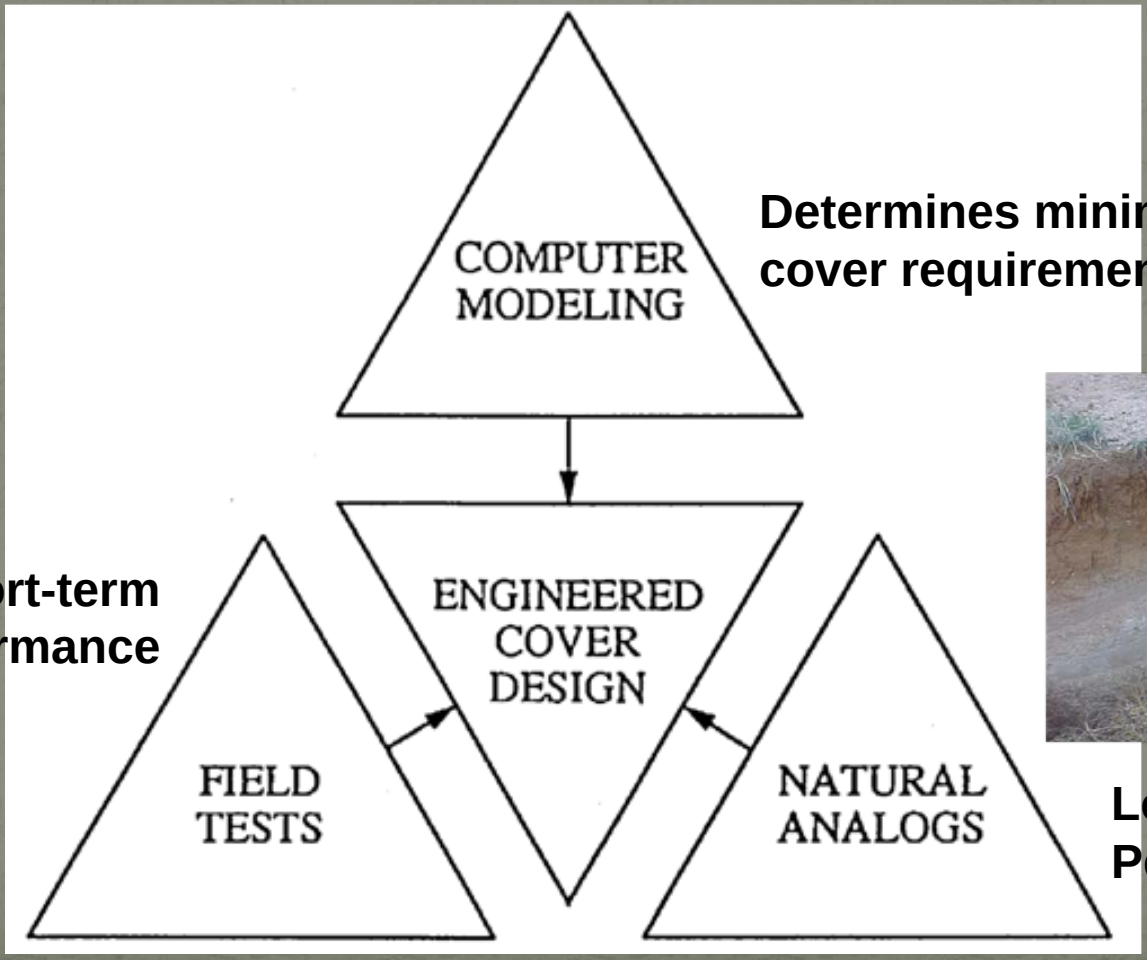
Cover Design

System Approach

A cover system must be designed as a *system* rather than merely as a group of individual components comprising a cover.

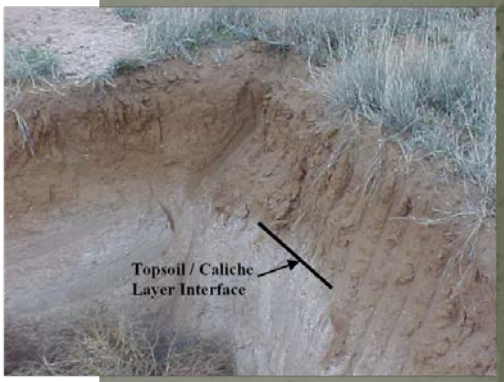
- **Minimize Flux**
- **Minimize Erosion**
- **Control Gas (Radon, Methane,..)**
- **Control Biointrusion (Roots, Burrowing, Insects,..)**
- **Etc.**

Design Components for Landfill Cover System



Determines minimum cover requirements

Short-term Performance

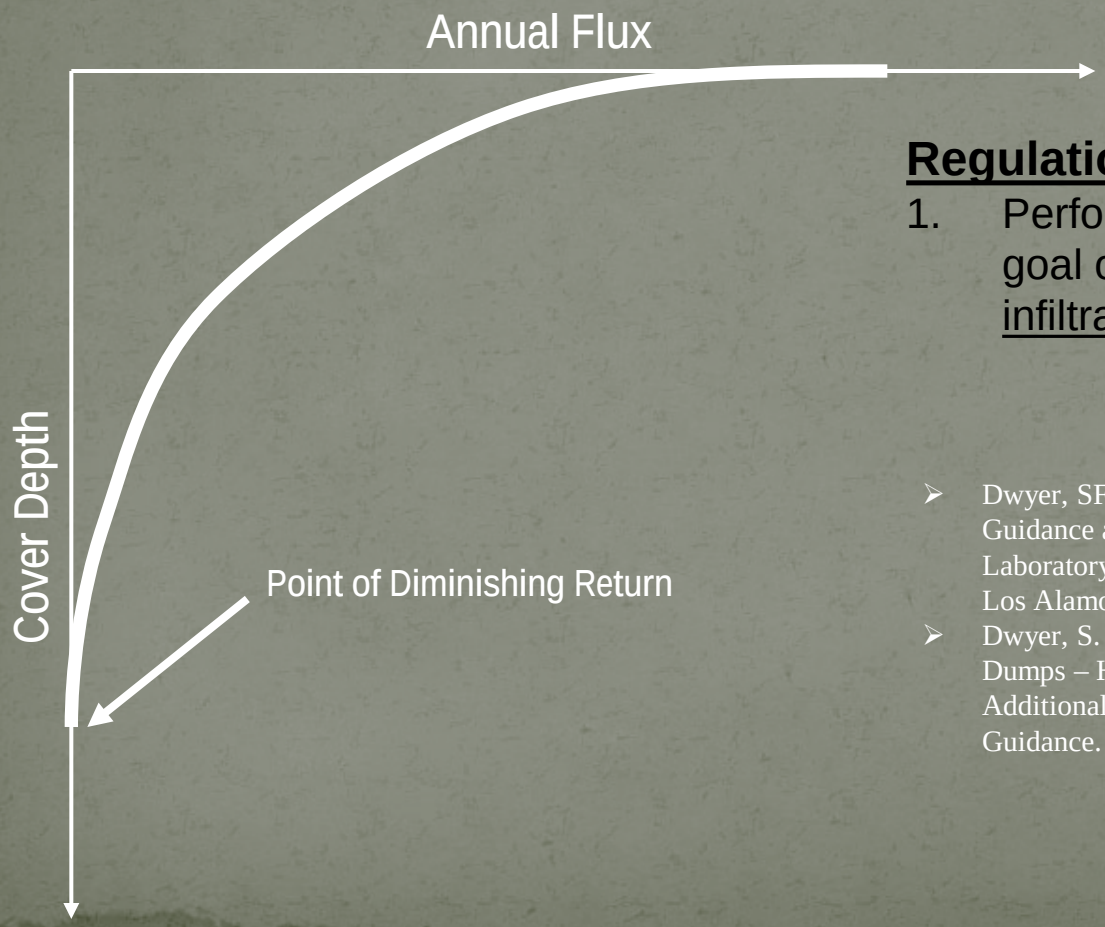


$CaCO_3$/Soil Interface at Shallow Depth

Long-term Performance

Minimum Soil Depth - Refined

Point of Diminishing Returns (PODR) – cover depth where additional soil no longer reduces flux (Dwyer et al 2006, Dwyer 2012).

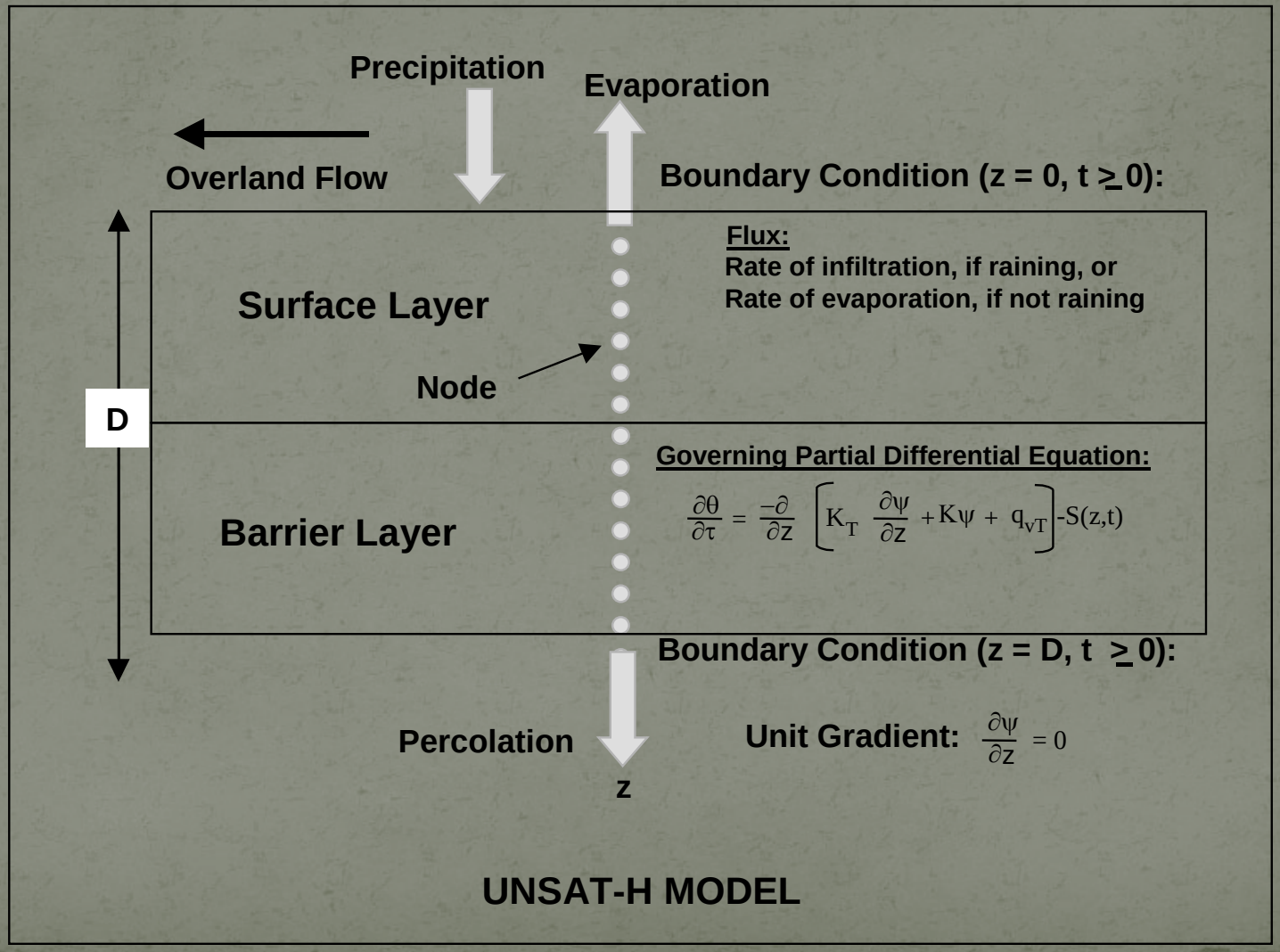


Regulations:

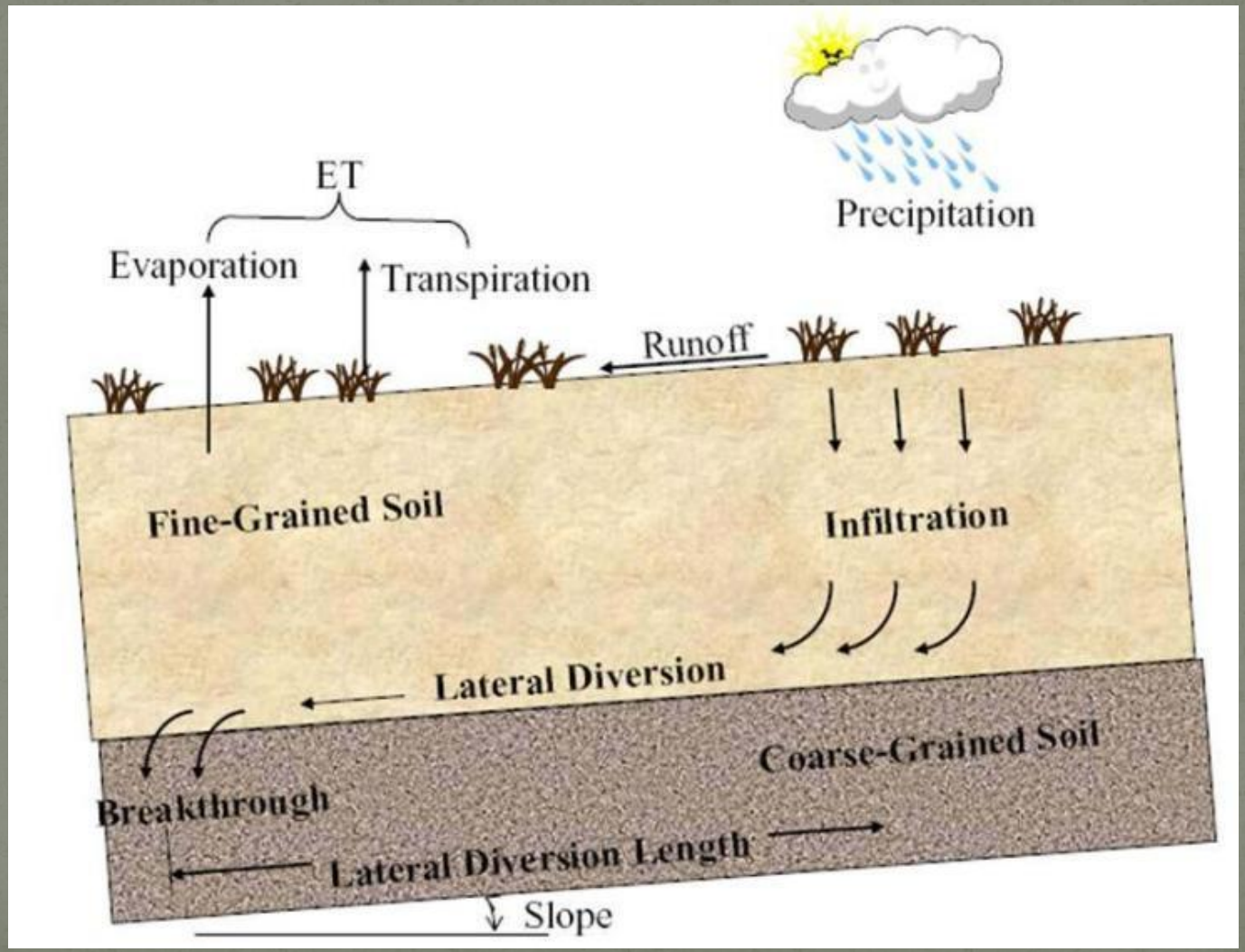
1. Performance Standards – "…the goal of closure…is to minimize the infiltration of water into the waste,."

- Dwyer, SF, R Rager, J Hopkins. 2006. Cover System Design Guidance and Requirements Document. Los Alamos National Laboratory report, LA-UR-06-4715, June 2006, EP2006-0667, Los Alamos, NM.
- Dwyer, S. 2012. Closing Small Tribal Landfills and Open Dumps – How to Design Environmentally Safe Covers Including Additional Design Guidance for Arid Regions. EPA Design Guidance. EPA-909-R-11-007.

MODELING


Precipitation
Evaporation
Overland Flow
Boundary Condition (z = 0, t ≥ 0):
Flux:
Rate of infiltration, if raining, or
Rate of evaporation, if not raining
Surface Layer
Node
D
Barrier Layer
Governing Partial Differential Equation:
$\frac{\partial\theta}{\partial\tau} = \frac{-\partial}{\partial z}\left[K_T \frac{\partial\psi}{\partial z} + K\psi + q_{vT}\right] - S(z,t)$
Boundary Condition (z = D, t ≥ 0):
Percolation
Unit Gradient: $\frac{\partial\psi}{\partial z} = 0$
z
UNSAT-H MODEL

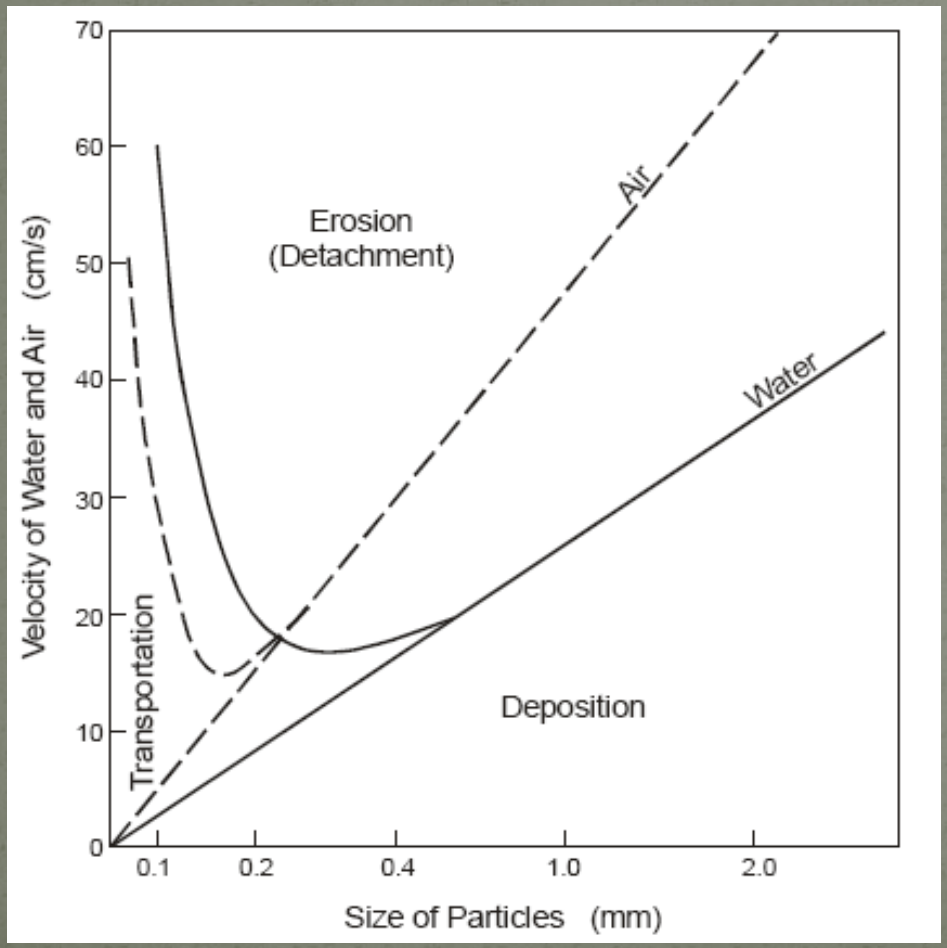
Capillary Barrier – multiple issues



Minimize Erosion & Control Surface Water

Minimize Erosion

Relationship Between Erosion Mechanism (Air or Water), Particle Size and Fluid Velocity



Variables:
1. Slope
2. Slope length
3. Particle size**

Desert Pavement

Rock/Soil Admixture – ‘Desert Pavement’

Concept developed at PNNL, Engineering Design Methodology (Dwyer et al 1998, Dwyer et al 2006, Dwyer 2012).

Don’t forget about Wind Erosion

Slope Stability Issues

QUESTIONS??