InstaTurf™
Soft Armor Rock Solid Protection

The Evolution of Turf Reinforcement Mat Technology

Tim Lancaster, Vice President of Sales-Erosion Control Products
GrassWorx LLC

Definition of Turf Reinforcement Mat (TRM)

- **According to the Erosion Control Technology Council (ECTC):**

A turf reinforcement mat (TRM) is a permanent rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. TRMs typically are used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated.

ECBs vs TRMs

- **Temporary Erosion Control Blanket (ECB) – Used to control erosion and establish vegetation in areas where natural vegetation alone will sustain the expected long-term flow conditions**

- **Permanent Turf Reinforcement Mat (TRM) – Used to control erosion, establish, and permanently reinforce vegetation in areas where natural vegetation will NOT sustain expected long-term flow conditions**

Modern TRM Performance Capabilities

Channel Lining Permissible Shear Stress			
	Permissible Shear Stress (lbs/sf)		
Material	Low	Mid (Typical)	High
Unreinforced Vegetation (USDA NEH 2007)	2	4.2	7.5
TRM Reinforced Vegetation (Manufacturer Spec Values)	10	12	16
24 inch Rock (FHWA HEC 15, 2005)	9.6		
30 inch Rock (FHWA HEC 15, 2005)		12	
36 inch Rock (FHWA HEC 15, 2005)			14.4

TRM Benefits vs Hard Armor

- **Enable the use of more vegetation on construction sites**
- Typically 50% lower installed cost than rock
- Much easier to transport and install with no heavy trucks or equipment required
- Can be mowed over for reduced long-term maintenance
- Less Hazardous along Roadways and Pedestrian Areas
- Increased stormwater filtration/infiltration
- Environmentally Friendly/Ecologically Functional

Conventional TRM Disadvantages vs Hard Armor

Conventional TRMs have relatively low erosion resistance prior to vegetation establishment (Permissible shear stresses 2 – 3 lbs/sf unvegetated)

Full vegetation establishment with mature root systems can take one year or longer to develop

Rock and concrete are immediately fully effective

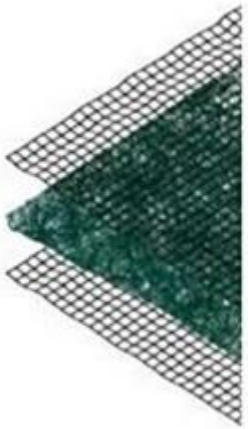
History of TRM Development

- First TRM Developed in early 1970's
- Extruded Nylon Matrix
  - Open structure for accepting soil/seed infill and reinforcing veg roots
  - Sod over-laid or Soil/seed in-filled to facilitate reinforcement of root systems of developing vegetation
  - Initial theory: TRM must reinforce vegetation roots in order to decrease plant extraction and increase erosion resistance and stability
  - Often required a degradable erosion control blanket on top for supplemental protection until vegetation establishment

Root Reinforcement TRM Applications

Surface-Applied TRMs

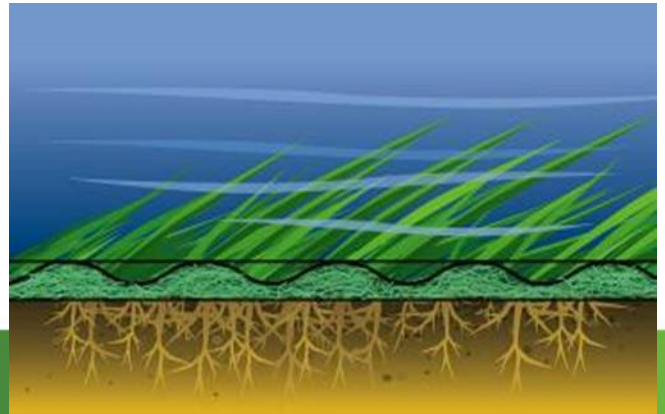
- Surface-Applied TRMs introduced by ECB manufacturers (mid ’80s)
- Polyester and polypropylene fibers stitched between poly nettings
  - Applied directly over seeded soil, without soil in-fill
  - Increased ground cover for improved pre-vegetated erosion control
  - Assumed veg “root” reinforcement was not necessary for increasing long-term veg erosion resistance
  - Initiated the term “stem” reinforcement



Surface-Applied TRM Applications

Design Methodology Supporting the Surface-Applied Theory

- USDA Ag Handbook #667 (Temple et al 1987) – "Stability Design of Grass-Lined Open Channels"
  - Most established grass channel linings fail due to erosion of the base soils the individual plants are anchored into.
  - Hold the soil in place, hold the plants in place, and increase erosion resistance of the vegetative system
  - Introduced the concept of maximum and effective flow-induced shear stress vs maximum flow velocity for designing grass linings

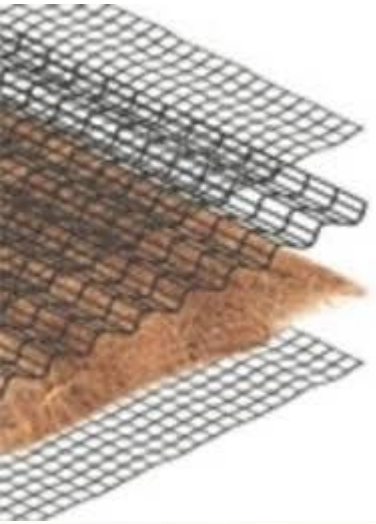


TRM Channel Lining Design Methodology

- FHWA HEC #15 (Chen and Cotton, 1988)
  - Further drove the use of maximum flow-induced shear stress for designing flexible channel linings
  - T = Y x D x S
    - T – Maximum Flow Induced Shear Stress (lbs/sf)
    - Y – Unit weight of water (62.4 lbs/cf)
    - D – Max flow depth (ft)
    - S – Channel bed slope (ft/ft)

Composite TRMs (C-TRMs) for Enhanced Immediate Erosion Control vs 100% Syntethic TRMs

- First Surface-Applied Composite TRM (1993) Permanent three-dimensional netting structure incorporated with coconut fiber
  - Coconut fiber for improved immediate erosion control and mulching
  - Synthetic netting structure for vegetation stem and root reinforcement

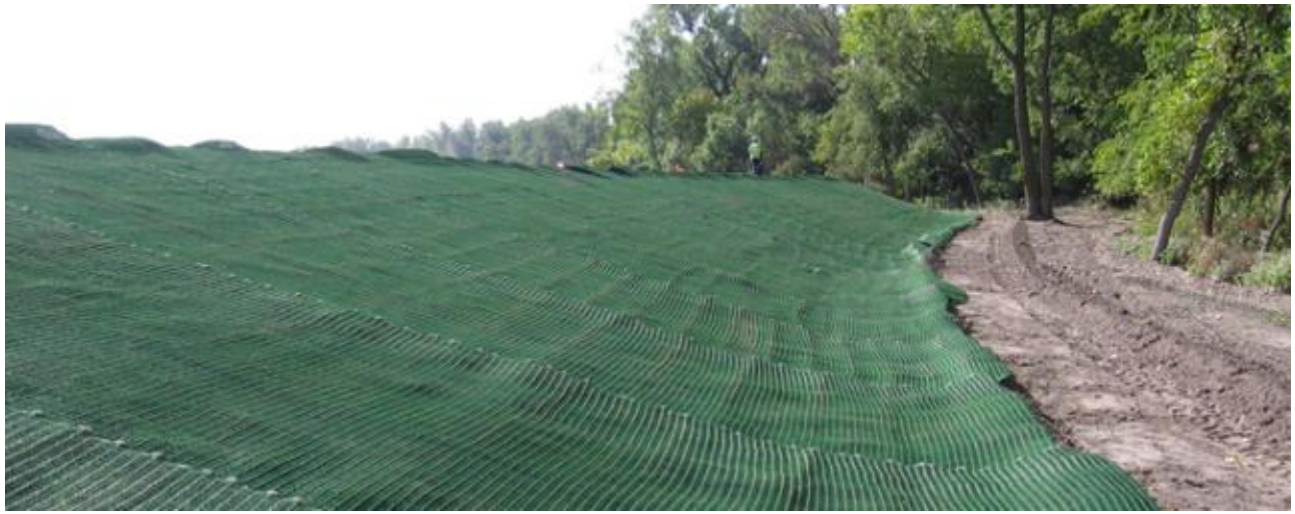


Composite TRM Applications

Woven High Performance TRMs (HPTRMs)

- Launched in the mid ‘90s
- Woven, high strength polypropylene matrix for increased vegetation reinforcement and damage resistance
  - High tensile strength DOES NOT equate to increased erosion protection
  - Typically Overlayed with Sod or soil/seed in-filled for best vegetation growth
  - Supplemental erosion protection with erosion control blanket

HPTRMs Applications



Recent TRM Innovation- Targeting the Need for a TRM with the Immediate Erosion Control Capabilities of Rock Riprap

- Many engineers prefer the lower cost, long-term maintenance and environmental benefits of using “Soft Armor” TRMs for severe erosion protection applications
- Many hesitant to use TRMs in place of rock, concrete and other “Hard Armor” materials due to the disparity between the Unvegetated Permissible Shear Stress (2 - 3 lbs/sf) and Vegetated Permissible Shear Stress (approx. 12 lbs/sf) of these products
- **TOO MUCH RISK OF TRM SYSTEM FAILURE BEFORE VEGETATION ESTABLISHMENT**

Recognized Need to Fill the Wide Gap between Pre-vegetated and Vegetated TRM Performance

Industry Standards Recognize Gap between TRM Unvegetated and Vegetated Performance

Table 2. ECTC Standard Specification For Turf Reinforcement Mats (TRMs)

For applications where vegetation alone will not sustain expected flow conditions and/or provide sufficient long-term erosion protection.

							Index Value at Time of Manufacture				
Type	Product Description	Material Composition	Slope Application Maximum Gradient	Performance Test Unvegetated Shear Stress [b,c,d] Typical ASTM D6460	Performance Test Vegetated Shear Stress [c,d,e,f] Typical ASTM D6460	Seedling Emergence [d] Typical ASTM D7322	Tensile Strength MD [d,f] Typical ASTM D6818	Tensile Strength TD [d,f] Typical ASTM D6818	Material Mass / Unit Area [d] Typical ASTM D6566	Thickness [d] Typical ASTM D6525	UV Stability [d,f] Typical ASTM D4355
5.A	Turf Reinforcement Mat	*A product composed of UV-stabilized non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix which may be supplemented with degradable components.*	1:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 6.0 lb/ft² (≥ 287 Pa)	≥ 250%	≥ 150 lbs/ft (≥ 2.2 kN/m)	≥ 150 lbs/ft (≥ 2.2 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 500 hrs
5.B	Turf Reinforcement Mat		1:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 8.0 lb/ft² (≥ 383 Pa)	≥ 250%	≥ 175 lbs/ft (≥ 2.6 kN/m)	≥ 175 lbs/ft (≥ 2.6 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 500 hrs
5.C	Turf Reinforcement Mat		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 10.0 lb/ft² (≥ 479 Pa)	≥ 250%	≥ 200 lbs/ft (≥ 2.9 kN/m)	≥ 200 lbs/ft (≥ 2.9 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 1,000 hrs
5.D	Turf Reinforcement Mat		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 12.0 lb/ft² (≥ 575 Pa)	≥ 250%	≥ 325 lbs/ft (≥ 4.8 kN/m)	≥ 225 lbs/ft (≥ 3.3 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 1,000 hrs
5.E [a]	Turf Reinforcement Mat		0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 12.0 lb/ft² (≥ 575 Pa)	≥ 250%	≥ 1,500 lbs/ft (≥ 21.9 kN/m)	≥ 1,500 lbs/ft (≥ 21.9 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 90% @ 1,000 hrs
5.F [a]	High Performance Turf Reinforcement Mat	*A product composed of UV-stabilized, non-degradable, synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix.*	0.5:1 (H:V)	≥ 2.0 lb/ft² (≥ 96 Pa)	≥ 14.0 lb/ft² (≥ 670 Pa)	≥ 250%	≥ 3,000 lbs/ft (≥ 43.8 kN/m)	≥ 3,000 lbs/ft (≥ 43.8 kN/m)	≥ 8.0 oz/yd² (≥ 271 g/m2)	≥ 0.25 in (≥ 6.35 mm)	≥ 80% @ 3,000 hrs

Climate Change – Increasing the Odds for Major Storm Events

Climate Change Has 'Loaded The Dice' On The Frequency Of 100-Year Floods

Maybe we need a new way to describe extreme weather events.

By Chris D'Angelo

So-called 100-year floods are becoming so common that the metric "is pretty much useless now as a baseline for an extreme event," said Marshall Shepherd, director of the atmospheric sciences program at the University of Georgia and a former president of the American Meteorological Society.

"We are in a new normal," he told HuffPost.

Study: Texas to See More Frequent 100-Year Rain Events

October 1, 2018

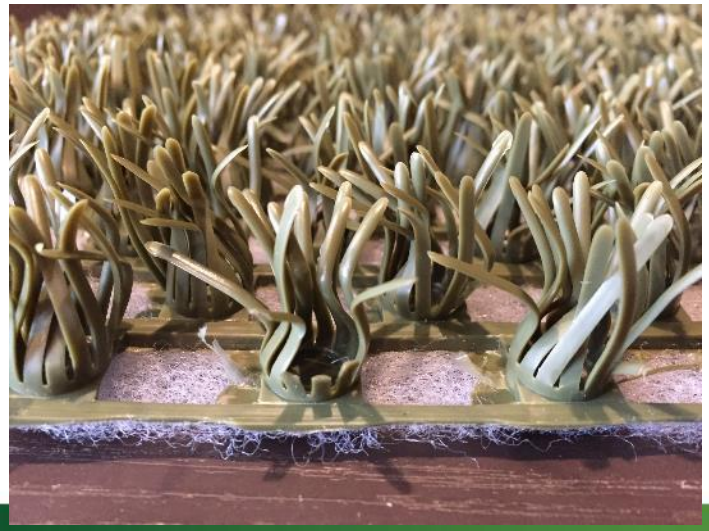
Decades of additional weather data have led federal officials to reconsider rainfall totals in Texas that define 100-year weather events and caution that extreme rainstorms will strike the state more frequently.

The National Oceanic and Atmospheric Administration on Sept. 27 released a study finding that in the Houston area, for instance, 100-year estimates increased from 13 inches to 18 inches for a 24-hour period. Rainfall previously classified as 100-year events are now more frequent 25-year events.

Earlier rainfall estimates provided by NOAA were based on data that in some cases are more than 50 years old.

Latest Innovation - Simulated Turf Erosion Control TRM (2019)

- 1 inch thick monolithic UV stabilized PE simulated turf structure:
- Engineered lightweight PET fabric backing retains fine soil particles and seed
- Easy to Maintain, Mowable Surface



Latest Innovation - Simulated Turf Erosion Control TRM

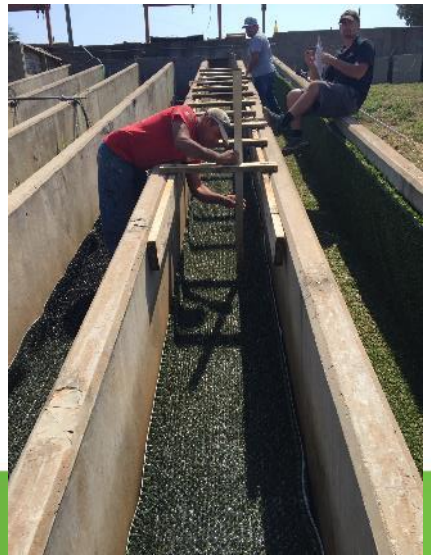
- Simulated Turf forms shear plane above soil surface to reduce erosive force on underlying soil
- Special engineered geotextile backing traps and retains fine soil particles beneath

Latest Innovation - Simulated Turf Erosion Control TRMs

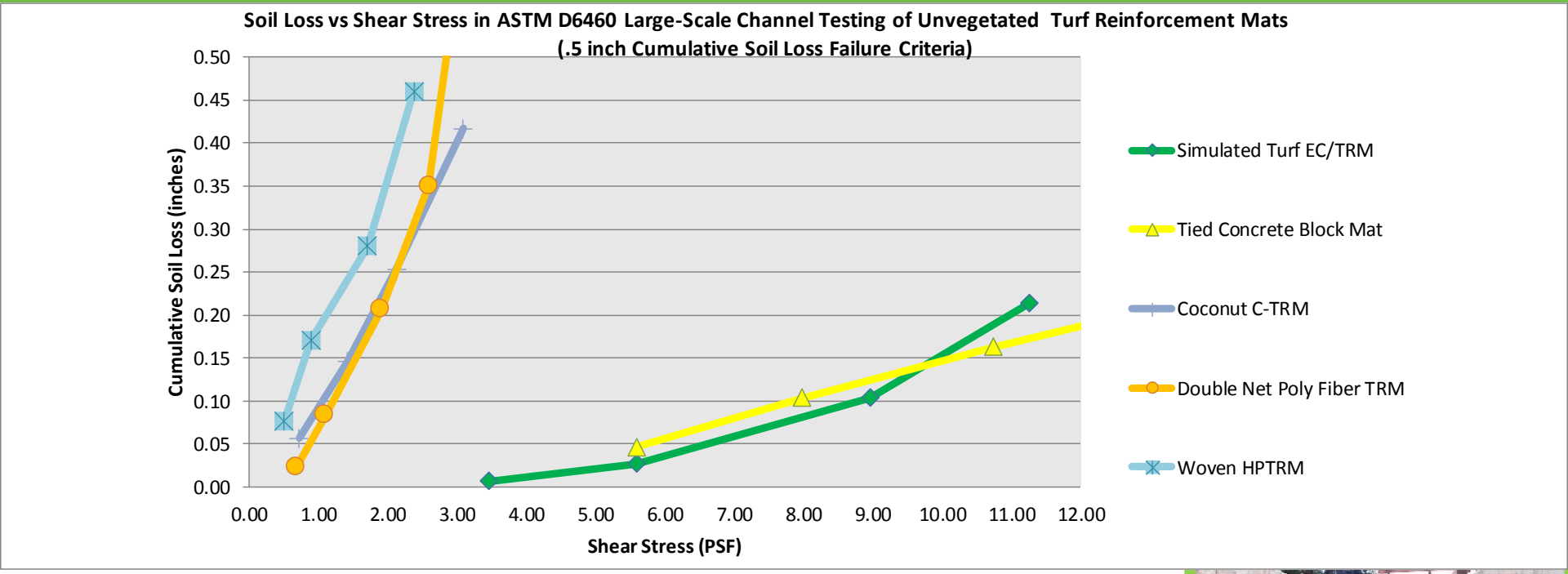
- ***Simulated*** **Turf protecting, establishing and permanently reinforcing *Natural* Vegetation to form a Hybrid Vegetative Armoring System**

Simulated Turf ECTRM Large-Scale Performance Testing

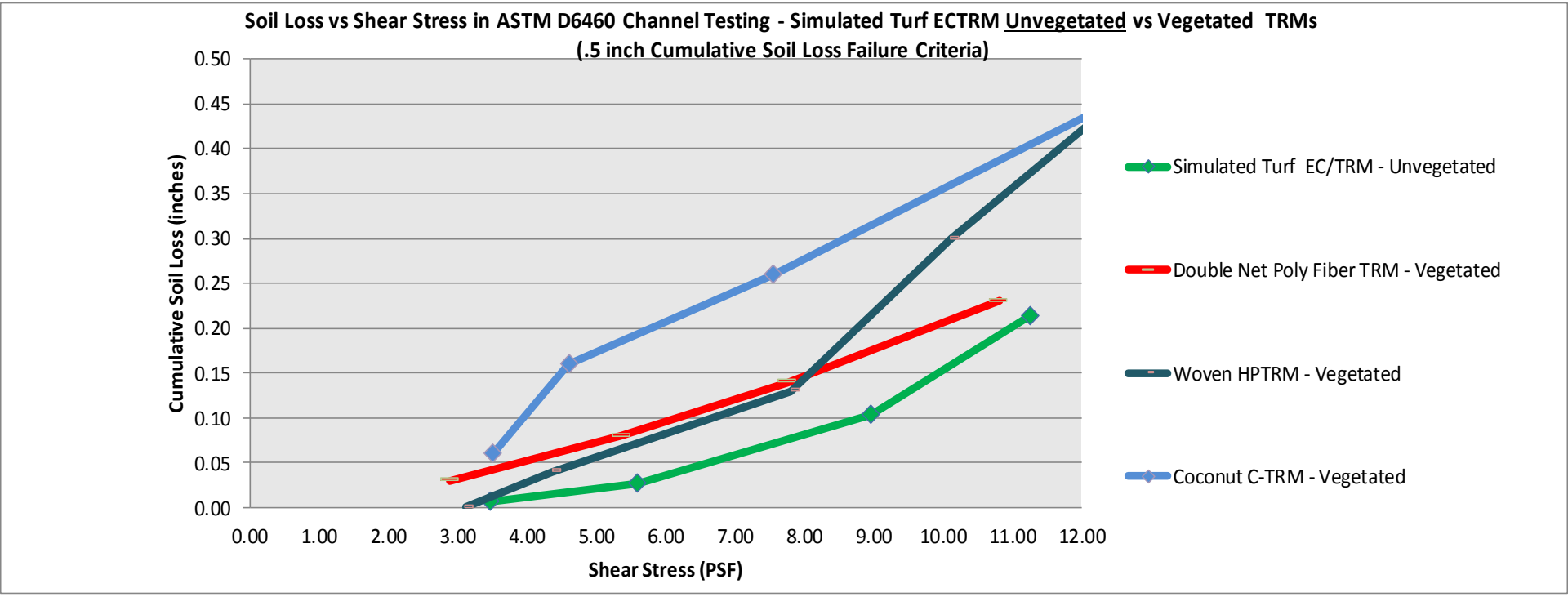
- Simulated Turf ECTRM immediate erosion control performance quantified in ASTM D6460 Large-scale Unvegetated Channel testing
  - 2ft wide x 40ft long channel flume, Loam soil bed on 20% gradient
  - Mats installed with 8 inch wire staples at 3.8/SY
  - 3 Separate test plots with (4) consecutive 30 min flow events per plot
  - Discharges up to approx 50 CFS
  - Velocity > 24 ft/sec
  - Shear Stress > 11 lbs/sf
- Average Cumulative Soil Loss – Approx **.2 Inches (ASTM failure point .5 inches)**
- **Unvegetated ShearForce10 DID NOT fail at highest achievable flow discharge**

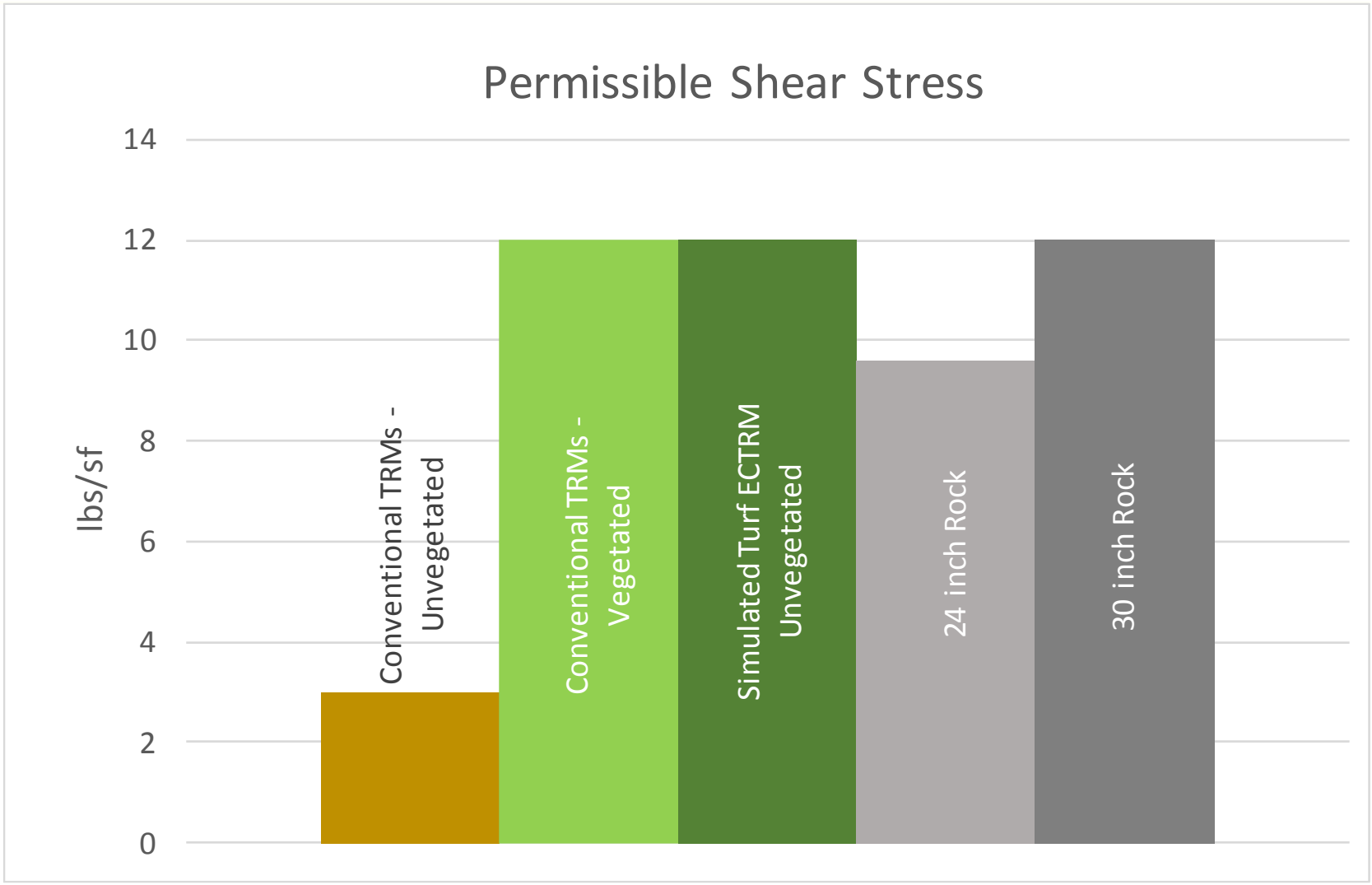


ASTM D6460 Test Results vs Conventional TRMs and Concrete Blocks



Unvegetated Simulated Turf ECTRM vs Vegetated TRMs




Permissible Shear Stress
lbs/sf
0
2
4
6
8
10
12
14
Conventional TRMs - Unvegetated
Conventional TRMs - Vegetated
Simulated Turf ECTRM Unvegetated
24 inch Rock
30 inch Rock

Simulated Turf ECTRM Typical Applications

- High flow channels and steep slopes requiring maximum erosion protection before, during and after vegetation establishment
- Moderate flow culvert outfalls, downchutes, and overflow structures
- Detention basins, pond/lake shorelines, streambanks and levees
- Overwinter project protection requiring several months of high performance erosion control without vegetation
- Projects where vegetation establishment may be slow and/or sparse (Arid climates, shady areas, continuously wet sites, poor soils)

Peabody Coal Streambank Stabilization Project

Simulated turf ECTRM Installed October 25 on seeded streambank

Peabody Coal Streambank Stabilization Project

Simulate turf protected streambanks through a two inch rainfall on Nov 1, which generated bank-overtopping flows. Note the grasses emerging thru mats in winter.

Peabody Coal Streambank Stabilization Project

Unusually heavy rains throughout the fall, winter and spring months flooded the stream channel on numerous occasions

Peabody Coal Streambank Stabilization Project

ECTRM effectively armored the streambanks through all flood events, sustaining a good stand of vegetation by April 30

Peabody Coal Streambank Stabilization Project

Without protection, some areas of the stream bed were scoured significantly. Note how the ECTRM held the bank toe with 2 inches or more of soil loss from the adjacent bed.

Coconut Erosion Control Blanket On Peabody Coal Streambanks

The two inch rainfall that occurred one week after installation severely damaged coconut erosion control blankets installed on other sections of the stream channel and initiated significant bank erosion

Many banks along the stream channel where coconut blankets had been installed were on the verge of collapsing by early spring due to severe undercutting

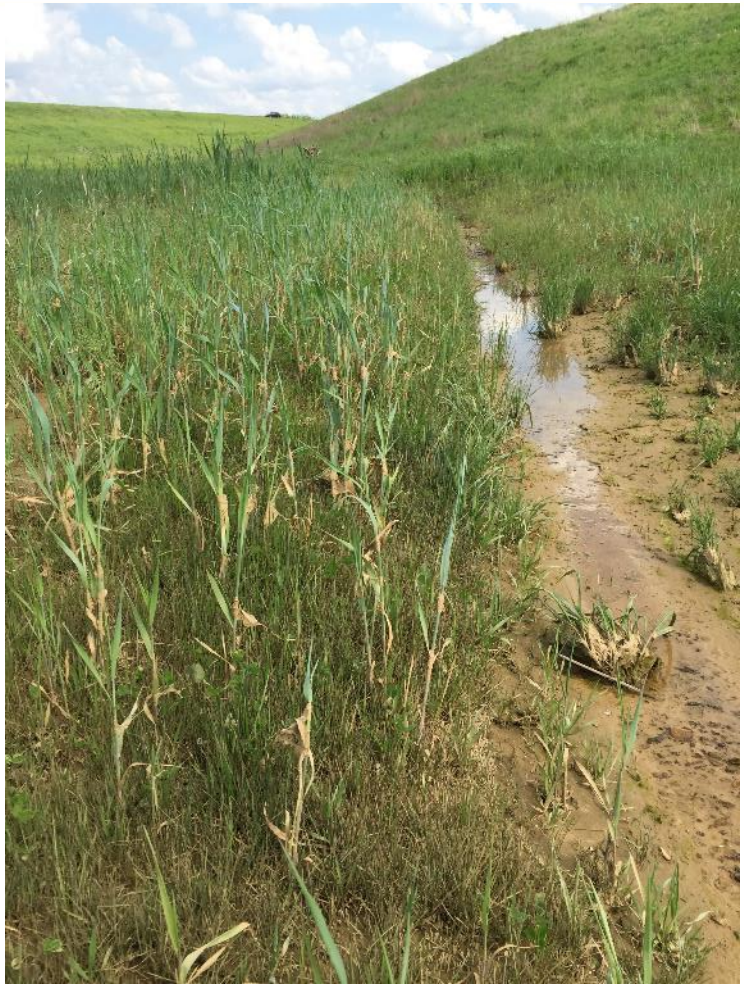
Peabody Coal Streambank Stabilization Project

April 30, note the distinct lines formed by the edges of the mats along the shoreline...

Peabody Coal Streambank Stabilization Project

…Where the ECTRM ends, so does the vegetation.

Peabody Coal Streambank Stabilization Project



ECTRM successfully stabilized the banks of the stream through the fall, winter and spring months, with vegetation now permanently reinforced against future flood events.

Simulated Turf ECTRMs Reduce Risk of Design Failure

- Many TRM manufacturers recommend designing with TRMs only in a fully vegetated state.
  - Many don't publish unvegetated permissible shear stress values for their TRMs
  - Determine suitability of TRM pre-vegetated protection by using discharge from a more frequent storm event (e.g. 2 year storm vs 100 year design storm)
  - Risk is on the designer if product fails before veg establishment
- Simulated Turf ECTRMs allow a more conservative design in an Unvegetated state, just in case…
  - that 100 Year Design Storm happens before vegetation establishment
  - vegetation fails to establish as planned.

TRM Summary

- ***Enable the use of more vegetation instead of hard armor for permanent erosion protection***
- ***Technology proven over nearly 50 years of lab testing and field use***
- ***Conventional TRMs offer a cost-effective solution in areas where:***
  - ***flow conditions generating more than 3 lbs/sf shear stress are <u>unlikely</u> to occur before vegetation establishment***
  - ***Vegetation growth and establishment will occur within 6 months***
- ***New simulated turf ECTRM provides a good solution in areas where:***
  - ***Flow conditions generating more than 3 lbs/sf shear stress are <u>likely</u> to occur before vegetation establishment***
  - ***Vegetation establishment may take longer than 6 months***

Thank You!

Questions?