Establishment, Enhancement and Reinforcement of Vegetative Solutions

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THERE HAS NEVER BEEN A BETTER TIME TO GO GREEN

STEP OUT OF THE STONE AGE...
As these EPA Fact Sheets indicate, Vegetative Cover and Vegetated Swales are Best Management Practices.

Vegetative Cover and Vegetated Swales always the best first option for erosion prevention and storm water runoff quality.
We’ll start with a quick overview of the design protocols for those applications.
Erosion resistance of Channel lining is determined by:

Velocity Approach
(represented as foot or meter per second)

Tractive Force Approach
(represented as “shear stress” lb/psf or Pascals)
Hydraulic Channel Design Concepts:

1. Estimate maximum velocity expected in channel

2. Determine maximum permissible velocity of channel liner

3. Incorporate an acceptable factor of safety.

One Option: Velocity Approach

\[ V_a < V_p \]
Hydraulic Channel Design Concepts

TRACTIVE FORCE (SHEAR STRESS) DETERMINATION

• Y = Unit Weight of Water, 62.4 lb/cubic ft

• D = Maximum Depth of Flow, ft

• S = Slope or Channel Gradient, ft/ft
Maximum permissible velocity and shear stress values for channel liners are determined through independent flume testing.
"Determine whether the permissible velocity design method or the shear stress method will be used"
Erosion Resistance of Slope Treatments is generally determined by:

- Length of Slope
- Steepness of Slope
- Soil Conditions
USDA: RUSLE Equation
(Revised Universal Soil Loss Equation)

\[ A = R \times K \times LS \times C \times P \]

\( A = \) Tons per Acre per Year of Eroded Sediment
$A = R \times K \times LS \times C \times P$

$R =$ Rainfall Runoff Erosivity Factor

$K =$ Soil Erodibility Factor

$LS =$ Topographic Factor

$C =$ Cover Management Factor

$P =$ Support Practice Factor

$C =$ Cover Management Factor

= what you put on the slope. Geosynthetic?
Erosion Prevention Performance

RESEARCH FACILITIES CAN QUANTIFY PRODUCT PERFORMANCE AND MEASURE SEDIMENT LOSS

Erosion control is installed in test plots…

…test plots are tilted to desired slope…

…desired storm event is simulated…

…eroded soil is measured vs bare soil control plot.
# Better Erosion Prevention Performance

Low “C” Factors and High Percentage of Effectiveness

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5. Testing conducted on fully cured matrix.
6. Cover or “C” Factor determined from comparison of treated slope vs. bare slope condition. The “C” Factor is the component of the Modified Universal Soil Loss Equation (MULSE) that measures the erosion control effectiveness of a product. % Effectiveness = One minus “C” Factor times 100%.
Bench Scale Testing
TRI/Environmental Example

- Bench Scale Rainfall Simulator
- Endorsed by Blanket Manufacturers
- Make sure you are comparing apples to apples
The Traditional Range of Techniques

Channels:
- 5-6 fps Velocity
- 1.00 to 2.00 lbs/sf

Shear Stress
Slopes = ?

Permanent materials for more demanding Applications

Temporary materials for less demanding Applications
The Traditional Range of Techniques (manufactured options):

“Do Nothing” Approach w/manufactured options = Seed Only
The Traditional Range of Techniques

Channels:
- 5-6 fps Velocity
- 1.00 to 2.00 lbs/sf Shear Stress

Slopes = ?

Permanent materials for more demanding Applications

Temporary materials for less demanding Applications
Standard Hydraulic Mulches:

1) 100% Cellulose-50lb-Made from 100% recycled paper - 50lbs/150 gallons water (most economical)

2) 70%-30% Wood/Paper -50lb.-Hardwood fiber enhances water holding capacity of mulch to help aid in seed growth (economical) 50lbs/125gallons of water.

3) 100% Woodfiber- 50lb Made from 100% Hardwood Fiber will hold close to 12 times it's weight in water to help aid in seed growth as well to reduce need of watering. 50lbs/100 gallons of water.

4) BFM or Bonded Fiber Matrix-50lb. Made up of continuous elongated Wood Fiber strands held together by a water resistant bonding agent. Rivals use of erosion control blankets 50lbs per 100 Gallons of water.
HYdraulically Applied Blankets

Hydraulically applied blankets should not be used in areas of concentrated flow (e.g. channels).

A Bonded Fiber Matrix (BFM) can be an effective method of stabilizing steep slopes when used properly. BFMs make use of a cross-linked hydrocolloid tackifier to bond thermally processed wood fibers. Application rates vary according to site conditions. For slopes up to 3H:1V the BFM should be applied at a rate of 3,000 lb/acre. Steeper slopes may need as much as 4,000 lb/acre. In any case, manufacturer’s recommendations should be followed.

BFMs should only be used when no rain is forecast for at least 48 hours following the application. This is to allow the tackifier sufficient time to cure properly. Once properly applied, a BFM is typically 90% effective in preventing accelerated erosion. **Bonded Fiber Matrix should not be applied between September 30 and April 1.**

Other fiber matrices that have been shown to be effective in preventing erosion on disturbed surfaces may be used in accordance with manufacturer’s recommendations if sufficient supporting documentation is provided.
Spray-on Products

Slope Protection Guidelines by Product Category
The Traditional Range of Techniques (manufactured options):

Channels:
- 5-6 fps Velocity
- 1.55 to 2 lbs/sf Shear Stress

Slopes = ?

Permanent materials for more demanding Applications

Temporary materials for less demanding Applications
EROSION CONTROL BLANKETS - There are many varieties of Erosion Control Blankets on the market. They range from rolls of natural and artificial materials, which are typically installed by hand, to liquid, spray-on, materials which make use of a bonding agent to hold natural or artificial fibers in place until vegetation becomes established. Erosion control blankets should be used on all slopes that are 3H:1V or steeper and where potential exists for sediment pollution to receiving surface waters. Since rock slopes pose little, if any, potential for erosion, cut slopes in competent bedrock and rock fill slopes need not be blanketed. Erosion control blankets should be used for all seeded areas within 50 feet of a surface water (100 feet of a special protection water) regardless of slope.
There are a wide variety of Rolled Erosion Control Products (RECPs)

- Wood Fiber
  - With Net or Net-less!
- Excelsior
  - Single and Double Net
- Straw
  - Single Net, Double Net
- Strawberry/Coconut
  - Double Net, Bio-Net
- Coconut
  - Double Net, Bio-Net
- Biodegradable Net
  - Single Net, Double Net
- Organic and Synthetic Jute
- High Strength Coir Fiber

DEP requires slopes $\geq 3:1$ you MUST use erosion blankets
Establishing and maintaining intimate contact with the soil is the definition of a successful TRM application.

Loss or lack of intimate contact with the soil is the definition of a failed TRM application.
Installation

Anchors: Frequency and Patterns

Anchor patterns are determined by steepness of slopes and channel beds

1 Anchor / yd²

1 1/2 Anchor / yd²

2 Anchor / yd²

2 1/2 Anchor / yd²
Staples and staple patterns....very important and should be shown in details.
STANDARD CONSTRUCTION DETAIL #11-1
Erosion Control Blanket Installation

BLANKET EDGES OVERLAPPED 4" (MIN.) AND STAPLED.
INSTALL BEGINNING OF ROLL IN 6" x 6" ANCHOR TRENCH, STAPLE, BACKFILL AND COMPACT SOIL.
STARTING AT TOP OF SLOPE, ROLL BLANKETS IN DIRECTION OF WATER FLOW
PREPARE SEED BED (INCLUDING APPLICATION OF LIME, FERTILIZER, & SEED) PRIOR TO INSTALLATION OF Blanket.
REFER TO MANUFACTURER'S RECOMMENDED STAPLING PATTERN FOR STEEPNESS AND LENGTH OF SLOPE BEING BLANKETED.

THE BLANKET SHOULD NOT BE STRETCHED; IT MUST MAINTAIN GOOD SOIL CONTACT.
OVERLAP BLANKET ENDS 6" (MIN.) WITH THE UPSLOPE BLANKET OVERLAYERING THE DOWNSLOPE BLANKET (SHINGLE STYLE). STAPLE SECURELY.

Seed and soil amendments shall be applied according to the rates in the plan drawings prior to installing the blanket.

Provide anchor trench at toe of slope in similar fashion as at top of slope.
Typical temporary blanket application:

1. Application area is smoothly graded and seeded.
2. Blankets placed and anchored over seeded final grade.
3. Established vegetation provide permanent erosion protection.
4. Water bars were incorporated to move water laterally into the woods, effectively shortening the slope length.
Netting or stitching can cause bridging over irregularities in final soil grading and sometimes maintenance issues.
A recent development in ECBs are net-less blankets to eliminate those concerns.
Another recent development in Erosion Control Blankets is wide widths (15.5 foot shown) and rolled edges.
The 15' wide blanket eliminates seams and reduces labor to provide both enhanced performance and cost effectiveness.
Fiber Rolls & Wattles

• Composition
  – An open weave containment netting or fabric filled with straw, coconut and wood excelsior fibers or compost
  – “Rolled up” straw, coconut and wood excelsior fiber erosion control blankets

• Sediment Retention Devices (SRDs)
• Slope Interruption Devices (SIDs)
A Flexible Growth Medium (FGM) has the added component of ½ inch long, crimped manmade fibers which add a mechanical bond to the chemical bond provided by BFMs. This increases the blanket’s resistance to both raindrop impact and erosion due to runoff. Unlike BFMs, a flexible growth medium typically does not require a curing time to be effective. Properly applied, an FGM may be as much as 99% effective.
Hydraulically Applied ECBs: Flexible Growth Medium (FGM)
Flexible Growth Medium (FGM)

Engineered, Three-Dimensional Composite of Wood Fibers, Interlocking Crimped Man-Made Fibers, Particles of Super-Absorbent Co-polymer and Cross-linked Hydro-Colloid Binders.
Easy to Install
Mix into hydro-seeder, add seed and fertilizer and other amendments, shoot from hose or cannon.
Cost Effective

Budget Costs Per Square Yard - In Place*

- Bonded Fiber Matrix
  - $0.85 - $1.10

- Flexible Growth Medium
  - $1.10 - $2.00

- Erosion Control Blankets**
  - $1.20 - $2.50 and up

*National averages are listed, local prices may vary but relationship to other methods remains the same.

**Does not include final grading and raking associated with blankets applications.
Better Intimate contact with the Soil
Better soil and sediment management

Blankets

Netting or stitching of blankets can bridge over irregularities in final soil grading

Flexterra has no netting or stitching to bridge over irregularities in final soil grading
Savings on Site Preparation

Tracking without back-blading is best preparation!
### Better Erosion Prevention Performance
Low “C” Factors and High Percentage of Effectiveness

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Spray-on Products

Slope Protection Guidelines by Product Category

Industry standards, not New York State based.
Enhanced Performance vs Other Spray-on Products

Slope Protection Guidelines by Product Category
Easy to monitor
...area directly above slope collected drainage into concentrated flow, Flexterra will not perform well with concentrated flow...

...area directly above slope collected drainage into concentrated flow, Flexterra will not perform well with concentrated flow...

...soils berm and super silt fence diversion built...

...composite image of drainage area above slope...
Easy to Repair

FGM shot into rills after diversion was built, no rolling up blankets, re-grading and seeding or replacement of blankets.
Safety can be a critical factor in roadside erosion control applications. Hydraulic applications require less manpower and keeps workers out of harms way.
No Netting on Top
Eliminate maintenance, safety and animal trapping issues
When should I specify FGM?

- Cost effective option to blankets
- Slopes up to 1:1
- When getting grass is a priority
- Requires no curing / drying time
- Poorly graded soils
- Not for concentrated flow areas

Where should I specify FGM?

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FGM Slope Residential Development Slope.
FGM Road Side Slope.
Basin slope application.
Steep slope application.
Slag pile remediation on top of 18” soil cover.
One form of PAM powder is specifically tailored for controlling soil erosion.

The powder can be applied in dry form.
The degree of the interaction depends on both the properties of the polymer and the electrolyte properties of the soils.

One blend fits all!
Basin prior to PAM treatment.

Basin after PAM treatment.

Water collected in subsequent events was clear.
Here is an example of the dry powder Pam treatment in a basin.
Here is an example of the dry Pam treatment.
PAM powder can also be mixed with sand for dry applications using basic equipment.
Sample collected from this spot upslope from basin.
Discharge from PAM test plot

Discharge from basin
The PAM powder, or emulsion, can be mixed into a hydro-seeder for hydraulic application.
Hydraulic PAM applications
What Does PAM Do?

• Strengthens soil cohesion
• Preserves surface roughness
• Increases viscosity slightly
  Reduce particle detachment
• Flocculates suspended solids  Reduces
  sediment transport
• All these preserve pore continuity
  Maintains higher infiltration
The USDA has years of research into PAM.

PAM Research Project

This is your irrigated furrow.

This is your furrow on PAM!

www.nwisrl.ars.usda.gov/pampage.shtml
PAM Enviro-Safety (<10ppm)
Anionic, 12-15 Mg/mole, <0.05%AMD

- EPA & FDA OK’d for food/water etc. uses
- An animal feed additive (not assimilated)
- No known toxicities in soil/water (even at more than 10x NRCS rates)
- No PAM accumulation in crops
- No negative plant effects at these rates
- PAM soon is a Carbon skeleton in soil
- Small AMD content safe/quickly degraded
PAM Costs Offset By:

- Easier irrigating, better infiltration
- Less furrow reshaping/cultivating
- Less pond construction & cleaning
- Less soil respreading
- Weed/Disease Containment
- Yield/quality improvement
Implications of Microbe Removal from Runoff

- Soil-borne plant disease epidemiology
  - Less disease spread in your field
  - Less spread downstream in return flows
  - Potentially less need for pesticides

- Manuring less prone to coliform losses
  -- Reduced hygiene threat to public waters

![Bar chart showing Total Microbes (µg C ml⁻¹ H₂O)]
Degradable ECBs are effective to the performance limits of natural vegetation:

Channels:
- 5-6 fps Velocity
- 1.55 to 2 lbs/sf Shear Stress

Slopes = ?

Permanent materials for more demanding Applications

Temporary materials for less demanding Applications
Riprap
Poured concrete linings
Gabion “Reno” mattresses
Grout filled geosynthetic forms
And other less traditional...
...forms of armor
Post Construction Erosion Prevention: Permanent Products

- Turf Reinforcement Mats (TRMs)
- High Performance Turf Reinforcement Mats (HPTTRMs)
- Transition Mats
- Articulating Concrete Blocks (ACBs)
Turf Reinforcement Mats (TRMs) address performance limits that were traditionally addressed with hard armor.
Turf Reinforcement Mats (TRMs)
Reinforce Turf to Extend the thresholds of vegetation.
Turf Reinforcement Mat (TRM) Technology is recognized and accepted as a Best Management Practice (BMP) to improve water quality.

DESCRIPTION

This fact sheet describes the use of turf reinforcement mats (TRMs). TRMs combine vegetative growth and synthetic materials to form a high-strength mat that helps to prevent soil erosion in drainage areas and on steep slopes. TRMs are classified as a "soft engineering practice," in contrast to concrete and riprap, which they may replace in certain erosion control situations.

High-volume and high-velocity storm water runoff can erode soil within open channels, drainage ditches, and swales, and on steep exposed slopes, increasing the transport of sediments into receiving waters. Water quality impacts of increased sediment load include the conveyance of nutrient and pesticide pollutants, disruption of fish spawning, and impairment of aquatic habitat.

Traditionally, hard-armor erosion control techniques such as concrete blocks, rock riprap, and reinforced paving systems have been employed to prevent soil erosion in these highly erosive areas. Although these permanent measures can withstand great hydraulic forces, they are costly, and they do not provide the pollutant removal capabilities of vegetative systems.

TRMs enhance the natural ability of vegetation to permanently protect soil from erosion. TRMs are composed of interwoven layers of non-degradable geosynthetic materials such as polypropylene, nylon and polyvinyl chloride (PVC) netting, stitched together to form a three-dimensional matrix. They are thick and porous enough to allow for soil filling and retention. In addition to providing scour protection, the mesh netting of TRMs is designed to enhance vegetative root and stem development. By protecting the soil from scouring forces and enhancing vegetative growth, TRMs can raise the threshold of natural vegetation to withstand higher hydraulic forces on stabilization slopes, streambanks, and channels. In addition to reducing flow velocities, the use of natural vegetation provides particulate contaminant removal through sedimentation and soil infiltration, and improves the aesthetics of a site.

TRMs offer high shear strength, resistance to ultraviolet (UV) degradation, and inertness to chemicals found in soils. Figure 1 illustrates the applicability of TRMs within the spectrum of available erosion control techniques. Temporary erosion control blankets and mats, also shown in Figure 1, eventually leave vegetation unprotected and unreinforced, and should only be used to establish vegetation under mild hydraulic situations.

TRMs, unlike temporary erosion control products, are designed to stay in place permanently to protect seeds and soils and to improve germination. TRMs can incorporate natural fiber materials to assist in establishing vegetation. However, the permanent reinforcement structure of TRMs is composed of entirely non-degradable synthetic materials. The structure of a typical TRM is illustrated in Figure 2. A variety of ground-anchoring devices can be used to secure TRMs, including: u-shaped wire staples, metal pins, and wood or plastic stakes. Appropriate ground anchoring devices are chosen based on site-specific soil and slope conditions.

Vegetative seed selection is based on the geographic region of the project and site specific concerns. Sources of information on seed selection
Installation of the Turf Reinforcement Mat (TRM) provides a structural element to vegetation.
Vegetation establishment provides reinforced turf with higher thresholds...

Non-Reinforced Side Slopes (ECB Biodegrades)

TRM Reinforced Channel Bottom
Reinforced turf clearly prevents erosion better than non-reinforced turf.
Mostly Stitch Bonded Fiber Matrix
Extruded Nylon
Installation

ECBs generally use 6”x 1”x 6” 11 Gauge U shaped Staples

TRMs generally use 8”x 1”x 8” 9 Gauge U shaped Staples
Installation: Anchors

For hard or rocky soils, heavy duty 6” nails with washers can be used to anchor TRMs.

For sandy soils 12” or 18” geotextile pins with washers may be used.
Non Soil-filled TRM Application

- Protects soil and seed from sun burnout and rain drop, wind, sheet/channel flow erosion during germination
- Provides permanent “Soft Armor” layer of protection
- Green color provides immediate aesthetic benefits
- Engineer’s discretion

Soil surface:
Fine graded and seeded

TRM installed on top of seeded final grade
For Slopes... (Seeded Under Blanket)
Permanent TRMs provide a significant benefit if vegetation does not establish as anticipated.
For slopes, and...
Channels (TRM in place and then vegetated after soil filling)
Example of turf reinforcement with roots growing into TRM.
Blowing compost has also proven to be a very efficient and effective method of soil filling. Soil or compost filling or “loading” may be useful where smooth final grading be difficult.
Turf Reinforcement Mats (TRMs) address performance limits that were traditionally addressed with hard armor.

When higher factors of safety, more demanding applications or survivability become issues, a High Performance TRM (HPTRM) is an option.
High Performance Turf Reinforcement Mats
(HPTRMs)

Higher factors of Safety: HPTRM characteristics will provide higher factors of safety than conventional TRMs.

More Demanding Applications: HPTRM has expanded the use of geosynthetics into new areas such as pipe outlets, continuous flow channels, wave attack environments, etc.

Survivability: HPTRM unsurpassed strength will provide resistance to physical stresses from installation, rubber tired vehicles, foot traffic, etc.
High Performance Turf Reinforcement Mats (HPTRMs) come also may also differ in their composition.
High Performance Turf Reinforcement Mat (HPTRM)

Superior 4000 lb/ft Tensile Strength
(6 months)...
or soil-filled...
High Performance TRMs will provide higher factors of safety than standard TRMs (6 Months after in this shot)
Other Applications unique to HPTRM are
Channels with continuous flows

(notice no scour off the bottom of the channel).
Allowing establishment of wetland vegetation or “Wetland Swale”.
TRMs and HPTTRMs and were both used to protect this railroad embankment.
The flow from the sides of the track caused concern for the slope face
TRM was used for slope face protection

HPTRM was used for concentrated flow downchute

Vegetation is well established three months after installation
Subgrade preparation for hydraulically stable HPTRM design
Reduced Right of Way.

For the same volume of water, a Turf Reinforcement Mat lined channel will require less Right-of-Way than a Riprap lined channel.
Completed installation, within existing right-of-way, after 6 months. Traditional rip-rap application would have required a much wider footprint.
TRMs saved the PTA over $20.00 per square yard...
...over $100,000.00 on this project of just over 5,000 sq yds.
...And other challenging environments such as wave attack environments, etc. (sixth months)
18 Months...
Goose Rocks Beach, Maine
Woven HPTRM was used to protect sand dunes between the rock revetment and beach front homes
Re-vegetated HPTRM dunes between the rock revetment and beach front homes
Re-vegetated HPTRM dunes between the rock revetment and beach front homes
Anchored Reinforced Vegetation System (ARVS)

- A combination of a High Performance Turf Reinforcement Mat (HPTRM) and Earth Percussion Anchors

The most advanced flexible armoring technology available.
Nine Weeks of Vegetation
Project Material Cost $30,000/sy @ 23.00/sy Vs Reno Mattresses @ $79.00/SY
Cost Effective

Cost Per Square Yard - In Place

Turf Reinforcement
Mat $5-$20

Rip Rap
$25-$60

Concrete Lining
$40-$80
Environmentally Friendly

TRMs prevent erosion and enhance water quality through filtration and infiltration
Reduced Cost of Excavation..

For a given volume of water, the required amount of excavation can be reduced by using a TRM (Turf Reinforcement Mat).

- Standard Riprap Cross Section
  - Requires Undercut Excavation

\[1.5 \text{ to } 2.0 \times d_{50}\]

- Standard TRM Cross Section
  - Reduces Undercut Excavation
Reduced Site Disturbance

By reducing the undercut excavation, one roll of LANDLOK® or PYRAMAT® can eliminate as many as...

Seven Trucks Required to Remove the Over-Excavated material, and...

Five Trucks Required to Bring in the Riprap.
Reduced Right of Way.

For the same volume of water, a Turf Reinforcement Mat lined channel will require less Right-of-Way than a Riprap lined channel.

Standard Riprap Cross Section
(Requires a minimum width for thickness for Riprap lining)

Standard TRM Cross Section
(Requires less Width for TRM lining)
Reduced Slope Cuts...

For the same volume of water, a Turf Reinforcement Mat lined channel can provide a flatter slope face.

Standard Riprap Cross Section
(May require steeper cut to slope face)

Turf Reinforcement Mat (TRM)

Standard TRM Cross Section
(Requires less Width for TRM lining)
Increased Channel Capacity.

For a given channel cut, a TRM lining will allow the same amount of water to run wider and shallower, reducing velocity and shear stress, or...

Standard Riprap Cross Section
(Riprap takes up space in channel)

1.5 to 2.0 $\times d_{50}$

TRM Cross Section
(TRM lining leaves more space in channel)
Increased Channel Capacity.

1.5 to 2.0 \times d_{50}

Standard Riprap Cross Section
(Riprap takes up space in channel)

...the same channel cut will provide a greater flow capacity to convey more water.

Turf Reinforcement Mat (TRM)

TRM Cross Section
(TRM lining leaves more space in channel)
Aesthetics, Safety, Vandalism, Maintenance and Pest Control. Riprap applications are eyesores that are dangerous, easy to vandalize, difficult to maintain and tend to breed vermin and snakes.
Aesthetics, Safety, Vandalism, Maintenance and Pest Control

TRMs provide a safe, aesthetically pleasing finished application that is hard to vandalize, easy to maintain and will not breed vermin and snakes.
… and Aesthetically Pleasing

Safe, Clean, Easy to Maintain, Resistant to Vandalism and Not Conducive to Breeding Vermin and Snakes.
Thermal Pollution Reduction

Riprap lined channels store thermal energy...
which then heats storm water runoff...
this creates thermal pollution in areas that are sensitive to slight temperature variations, such as trout streams and cold water fisheries.
Thermal Pollution Reduction

TRM lined channels will not store thermal energy or create thermal pollution
TRM and HPTRM technology can help turn this...
…into this
SOIL CONTACT: Establishing intimate contact with the final soil grade is essential for any successful TRM installation

ANCHORS: Proper anchor selection, frequency and pattern is another essential aspect of successful TRM installation

ANCHOR TRENCHES: Protecting the integrity of the TRM with proper termination anchor trenches is the final essential issue in successful TRM installation
Proper preparation is important

The key to a successful TRM installation is to “Establish and maintain intimate contact with the soil surface” and not let water undermine the application.

Template for cutting uniform channel

Initial anchor trench

Longitudinal anchor trench

Uniform subgrade
Intimate Contact with Soil Sub-grade

Establishing and maintaining intimate contact with the soil is the definition of a successful TRM application.

Loss or lack of intimate contact with the soil is the definition of a failed TRM application.
STANDARD CONSTRUCTION DETAIL # 6-1 Vegetated Channel

OVERCUT CHANNEL 2" TO ALLOW BULKING DURING SEED BED PREPARATION.

EXCAVATE CHANNEL TO DESIGN GRADE AND CROSS-SECTION.

SOIL BACKFILL

LONGITUDINAL ANCHOR TRENCH

INTERMITTENT CHECK SLOT

LONGITUDINAL ANCHOR TRENCH

PREPARE SOIL AND APPLY SEED BEFORE INSTALLING BLANKETS, MATS, OR OTHER TEMPORARY CHANNEL LINER SYSTEM.

FLOW

ISOMETRIC VIEW

Lining*

LONGITUDINAL ANCHOR TRENCH (TYP)

(LOOKING DOWNSTREAM)

CHANNEL CROSS-SECTION

* SEE MANUFACTURER'S LINING INSTALLATION DETAIL FOR STAPLE PATTERNS, AND VEGETATIVE STABILIZATION SPECIFICATIONS FOR SOIL AMENDMENTS, SEED MIXTURES AND MULCHING INFORMATION.
Initial anchor trench detail

Longitudinal anchor trench detail
Steeper channel beds or erodible soils require consideration of check slots.
Installation

Intermittent check slot detail

Help to anchor mat and provide protection from problem spots running the length of the mat installation.
Finished check slot installation results in a number of segmented installations.
Proper installation techniques lead to optimum channel performance.
Scour Prevention
Transition Mats

A high value, low environmental impact & economical solution to surface flow protection needs.

Light-weight and portable mats protect surfaces from damage caused by concentrated or sheets flows, vehicles, equipment and pedestrians.
Scour Prevention Transition Mats provide resistance to the erosive forces that can be generated at these transition areas.
Example of Scour Prevention Transition Mat application.
Example of Scour Prevention Transition Mat application.
Culvert Outfall Areas

Scour Prevention Transition Mat Protected Outfall

Scour in Unprotected Outfall
Spillways & Down Chutes
Swales & Drainage Ditches
Overflow Structure: 6 months later.
CELLULAR CONFINEMENT SYSTEMS are three-dimensional, honeycombed sheets, mats, or interlocking structures filled with soil, gravel, concrete, or other material. They are used to stabilize the surface of cut and fill slopes, streambanks, or natural slopes. They may also be used to increase the load-bearing capacity of a roadway or to create a permeable pavement system. The honeycomb-shaped cells encapsulate and prevent erosion of the infill material, making it an appropriate method of stabilizing high volume or high velocity channels.

Manufacturer’s recommendations should be followed regarding application, slope limits, installation procedure and appropriate fill material. It is important that the cells be properly anchored in order to prevent deformation or sliding of the panel. Therefore, cellular confinement systems should not be used where soil or rock conditions prevent installation of the anchoring pins in the required pattern.

When filling the cells, care should be taken to avoid damaging them. Limit drop heights to 3 feet or less.
3-D Geoweb System

The Container
- 3 Sizes
- 5 Depths
- 5 Section Lengths

The Content
- Topsoil
- Aggregates
- Concrete
- Engineered Fill

Other Components
- Geo-Items
- Tendons
- Anchors
CCS cells and panels are available various heights.
A Cellular Confinement System (CCS) is an engineered, expandable, polyethylene, honeycomb-like cellular structure.
Infill options for the CCS include free draining soil, sand, stone, concrete or mixtures of soil with sand and/or stone.
Vegetated CCS Testing w/TRM

Installing anchors with tendons in the CCS section
Vegetated CCS Testing w/TRM
Vegetated CCS Testing w/ TRM

Early grass establishment through the Geoweb / TRM system
Vegetated CCS Testing w/TRM

- Full vegetation growth

- Grass cut to 6 inches to better replicate typical field height prior to placement in the flume.
Vegetated Geoweb Testing w/TRM
Vegetated CCS Testing w/TRM

Setting the vegetated test box in the CSU hydraulics flume
Vegetated CCS Testing w/TRM

Trial 7
Slope = 2:1
(26.5 Degrees)

Q = 108 cfs

Max
Velocity of
27 ft/s

Max Shear
Stress of 16
psf
Vegetated CCS Testing w/TRM

TEST PARAMETERS

• Per ASTM D6460
  – ECB Standards
  – Performance Threshold is Soil Loss < 1/2 inch

• Blade density above 300 blades/sqft
Vegetated CCS Testing w/TRM

**IMPRESSIVE RESULTS**

Slope = 2:1  
(26.5 Degrees)

Max Velocity of 29 ft/s

Max Shear Stress of 16 psf

Essentially Zero Soil Loss (0.05”) – 1/10 of ASTM D6460 Threshold of 0.5 Inches
Thank you

THERE HAS NEVER BEEN A BETTER TIME TO... GO GREEN

STEP OUT OF THE STONE AGE...