United States Environmental Protection Agency | Office of Water Washington, D.C. | EPA 832-F-99-002 September 1999

Storm Water Technology Fact Sheet
Turf Reinforcement Mats

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.

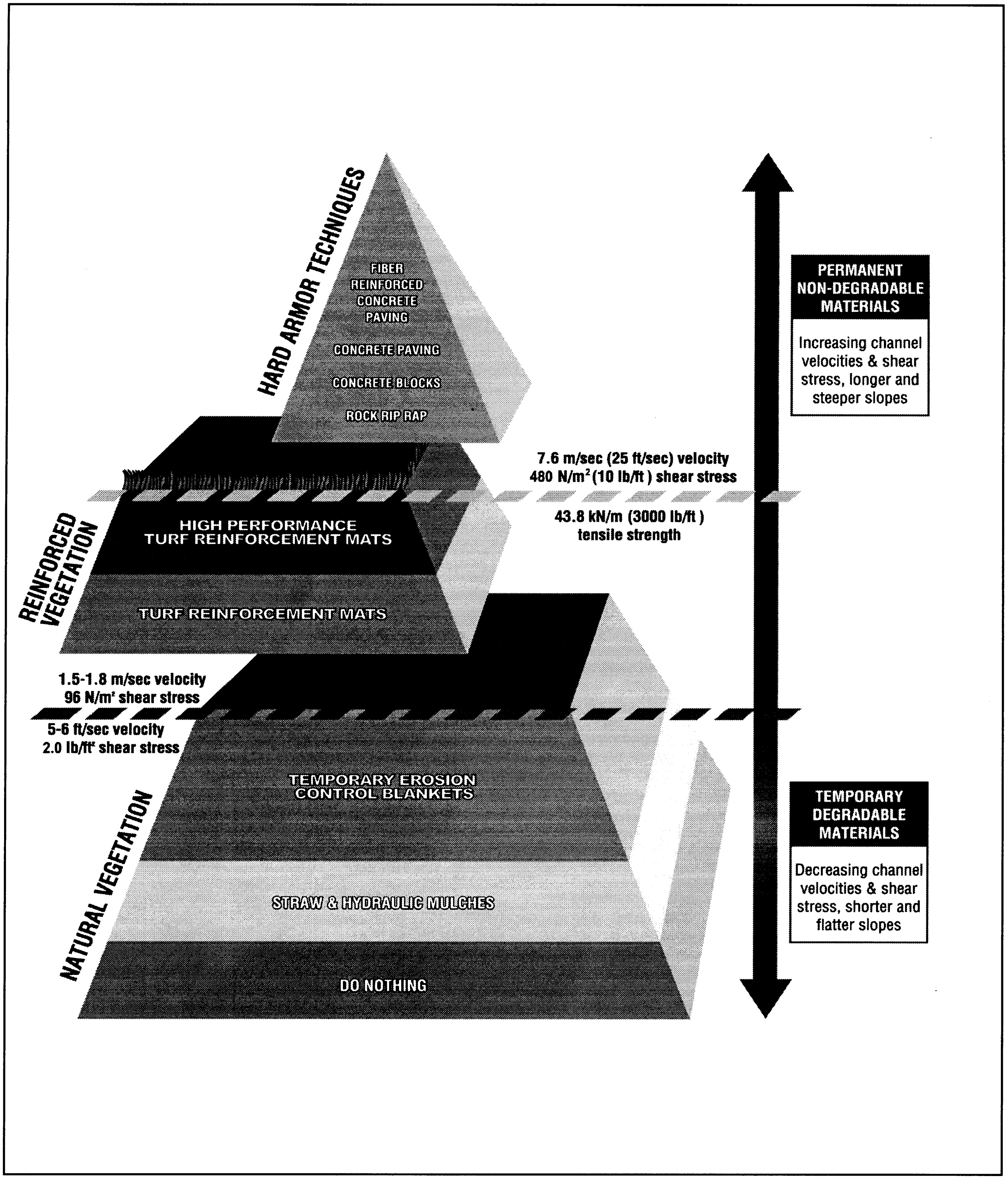
Traditionally, hard-armor erosion control techniques such as concrete blocks, rock riprap, and reinforced paving systems have been employed to prevent soil erosion in these highly erosive areas. Although these permanent measures can withstand great hydraulic forces, they are costly, and they do not provide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

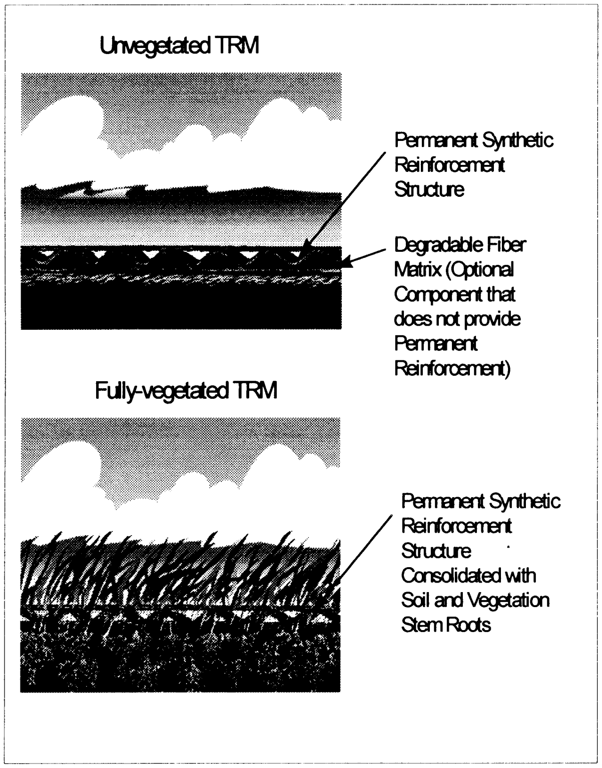
Vegetative seed selection is based on the geographic region of the project and site specific concerns. Sources of information on seed selection



Source: Synthetic Industries, 1998.

FIGURE 1 EROSION CONTROL TECHNIQUES

include: the U.S. Natural Resource Conservation Service (NRCS); various university extension services;and state transportation departments. The installation area may be seeded before or after the TRM is installed, depending on the matting construction and manufacturer's recommendations.



Source: Modified from North American Green, Inc., 1998.

FIGURE 2 THE STRUCTURE OF A TYPICAL TURF REINFORCEMENT MAT

APPLICABILITY

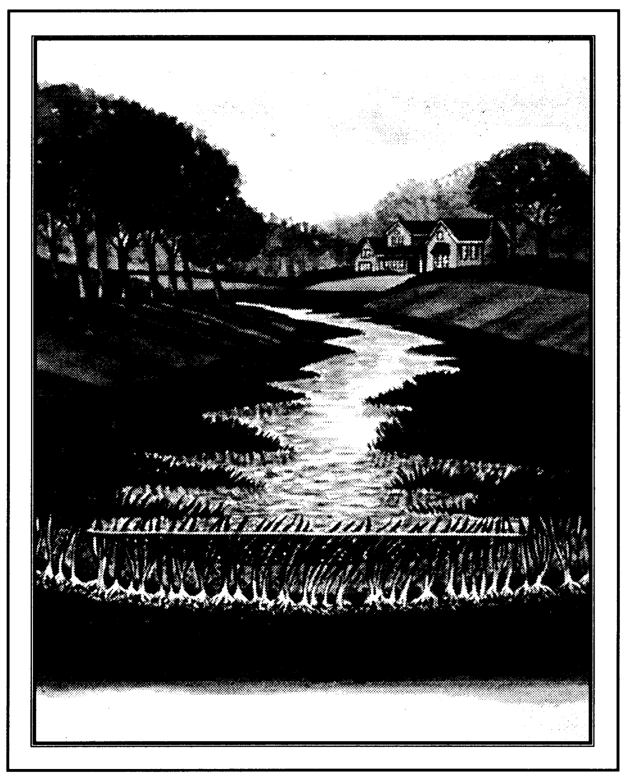
Turf reinforcement technology may be used in conjunction with temporary sediment and erosion control measures to re-establish and protect vegetation at construction sites. Sediment and erosion control measures, which are typical components of storm water pollution prevention plans, are designed to mitigate construction impacts on receiving waters. Commonly applied sediment and erosion control measures include photodegradable and biodegradable natural fiber blankets and hydraulic mulches. The use of TRMs allows vegetative cover to be extended to areas where site conditions would otherwise limit it. This helps to establish and maintain a continuous vegetative cover throughout the applied area. TRMs can be applied to most sites or structures where permanent erosion control is required. This technology has been effectively used in both urban and rural areas and in a variety of climatic conditions. Although most effective when used in fully vegetated areas, TRMs have been used to prevent erosion even in arid, semi-arid, and high-altitude regions with limited vegetative growth. In these areas, vegetation establishment is slow or difficult, and the TRM matrix is typically filled with native soils for protection (with the mat acting to prevent erosion permanently).

Under most climatic or environmental conditions, reinforced vegetation can protect:

- Surface water conveyance systems (see channel lining, Figure 3).
- Surficial erosion of slopes.
- Pipe inlets and outlets.
- Shorelines and banks.

ADVANTAGES AND DISADVANTAGES

TRMs are being used to control erosion and stabilize soil to control runoff from land-disturbing activities with steep slopes, and to prevent scouring in storm water detention ponds, water storage ponds, small open channels, drainage ditches, and runoff conveyance systems within parking lot



Source: Synthetic Industries, 1998.

FIGURE 3 TRMs AS PROTECTIVE CHANNEL LININGS

medians, and along streambanks and shorelines.

In addition to their use for new construction projects, TRMs have been used to retrofit existing hard armor systems. For example, in 1994, the City of Chattanooga, Tennessee, began a program to improve water quality by protecting aquatic habitat and reducing sediment transport to receiving water bodies. The City chose to retrofit existing concrete-lined storm water channels into vegetative swales. Depending on the hydraulic conditions of the application, the City chose to use both biodegradable rolled erosion control products and turf reinforcement mats. The City has retrofitted over 32 kilometers (20 miles) of storm water conveyance systems using this technique.

In addition to improving water quality, TRMs can provide aesthetic enhancement, especially in areas lacking vegetative growth. In the city of Louisville, Kentucky, TRMs are being used to stabilize soil for vegetation in Waterfront Park, an abandoned industrial area being converted into a recreational area (North American Green, 1998). In Waterfront Park, which is being developed on a hilly site adjacent to the Ohio River, TRMs not only control erosion, but they also make it possible for vegetative growth in the park setting

TRMs will perform well only within their specified design limitations. Some hydraulic and environmental conditions dictate that hard armor techniques are the most appropriate solution. In general, TRMs should not be used:

- To prevent deep-seated slope failure due to causes other than surficial erosion.
- When anticipated hydraulic conditions are beyond the limits of TRMs and natural vegetation.
- Directly beneath drop outlets to dissipate impact force (although they may be used beyond the impact zone).
- Where wave height may exceed 30 centimeters (1 foot) (although they may be used to protect areas up-slope of the wave impact zone).

To perform properly, the TRM must be installed properly and remain in proper contact with the ground. Critical points in conveyance system applications where mats can lose support include points of overlap between mats, projected water surface boundaries, and channel bottoms. The Erosion Control Technology Council (ECTC) publishes installation guidelines for both permanent and temporary rolled-erosion control products (Lutyens 1997).

DESIGN CRITERIA

Many state and local erosion and sediment control manuals, which assist developers in complying with state and local National Pollutant Discharge Elimination System (NPDES) programs, specify guidelines for TRM use and applicability. Additional design procedures for TRM use have been developed by the U.S. Federal Highway Administration (Chen and Cotton, 1988) and the American Association of State Highway and Transportation Officials (AASHTO, 1992). Most state transportation departments have a list of approved products meeting their minimum performance standards. These standards are typically based on physical properties of the product, such as mass per unit area, thickness, resiliency, porosity, and stiffness.

PERFORMANCE

TRMs provide water quality benefits by allowing the growth of vegetation in areas where impervious conveyance systems would otherwise be used. In general, the performance of TRMs is closely tied to the vegetative establishment and growth. In a laboratory study, Clary, et al. (1996) found that the presence of herbaceous vegetation enhanced sediment deposition and the channel restoration process in small-stream systems. Through experiments in a simulated small stream channel, Thornton, et al. (1997) found that the ability of vegetation to entrap and retain sediment increases with blade length and cross-sectional area of the vegetation, with retention rates ranging from 30 to 70 percent. The performance of vegetation in removing sediment and other pollutants depends on site-specific hydrologic conditions as well as the underlying soil types, the type of vegetation, the height and density of growth, and proper selection and installation of the TRM.

The performance of the TRM-lined conveyance system depends on the duration of the runoff event to which it is subjected. For short-term events, TRMs are typically effective at flow velocities of up to 50 meters per second (15 feet per second) and shear stresses of up to 380 Newtons per square meter (8 pounds per square foot) (Cabalka and Trotti, 1996). However, specific high-performance TRMs may be effective under more severe hydraulic conditions.

TRMs provide long-term water quality benefits by allowing the growth of vegetation in areas where impervious conveyance systems would otherwise be used. While they may reduce flow velocities, hard armor techniques do not remove pollutants as does natural vegetation. TRMs can be used in conjunction with temporary sediment and erosion control measures to assist communities in complying with state and local NPDES requirements. Additionally, TRMs provide a cooler substrate than traditional hard armor techniques, reducing water temperature increases that could otherwise impact aquatic life. Further, the vegetation itself provides wildlife and aquatic life habitat. The water quality benefits of TRMs depend on site conditions and the type and density of vegetation.

COSTS

In general, the installed cost of TRMs ranges from \$6 to \$18 per square meter (\$5 to \$15 per square yard). Factors influencing the cost of TRMs include:

- The type of TRM material required.
- Site conditions, such as the underlying soils, the steepness of the slope, and other grading requirements.
- Installation-specific factors such as local construction costs.

In most cases, TRMs cost considerably less than concrete and riprap solutions. For example, a project in Aspen, Colorado, used over 19,000 square meters (23,000 square yards) of TRMs to line channels for a horse ranch development project (Theisen, 1996). The TRMs were installed at a cost of \$9.90 per square meter (\$8.25 per square yard) (in 1996 dollars). This was substantially less than the \$24 per square meter (\$20 per square yard) estimate for the rock riprap alternative.

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ADDITIONAL INFORMATION

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