

High flows and Overtopping



Salix 

Building with Nature

Description

Introduction to Reinforced Vegetation

Vegetation, and in particular grasses and herbaceous plant species, are a robust, cost effective, sustainable and highly flexible erosion control solution for the protection of soils.

However, vegetation has limiting thresholds, at which stems will break away, plants will be

physically plucked and as a result underlying soils will become exposed.

Surface erosion will be the result and this can in turn lead to shallow slope failures and in extreme situations, deeper slope failures.



Vegetation alone is not enough to prevent erosion in extreme flows

Plain Grass Cover Limiting Flow Velocities compared to reinforced vegetation	10 hour flow duration	50 hour flow duration
Plain grass poor cover*	2m/s	1 m/s
Plain grass good cover *	3m/s	2m/s
Salix V-Max C350 **	6m/s	5.6m/s
Salix V-Max C500 **	7.6m/s	6.9 m/s
Salix V-Max P550 **	7.6m/s	6.9 m/s

* From CIRIA 116 Design of Reinforced Grass Waterways

** From independent third party large scale flume testing & UK actual overtopping events

Once flow duration extends above 10 hours then these performance figures will start to fall in line with extending duration.

A mature strand of vegetation will fail at relatively low thresholds where flow velocities are high and/or durations are over 10 hours.

However, the resistance of vegetation can be greatly increased by using a high performance Turf Reinforcement Mat (sometimes know as a TRM or 3D Geomat).

Not only can reinforcing vegetation increase the flow velocities that vegetation can withstand substantially, but reinforcement can also greatly increase the duration that grasses can perform at these higher levels.

Reinforced vegetation can comfortably outperform large rock rip-rap and can often replace concrete mats and revetments in many applications.

Reinforced vegetation represents the most sustainable option for high flow banks and over topping applications, being low carbon, quick to install and easy to repair and maintain.

It is also far more flexible and environmentally friendly than rock or concrete solutions to high flow situations.

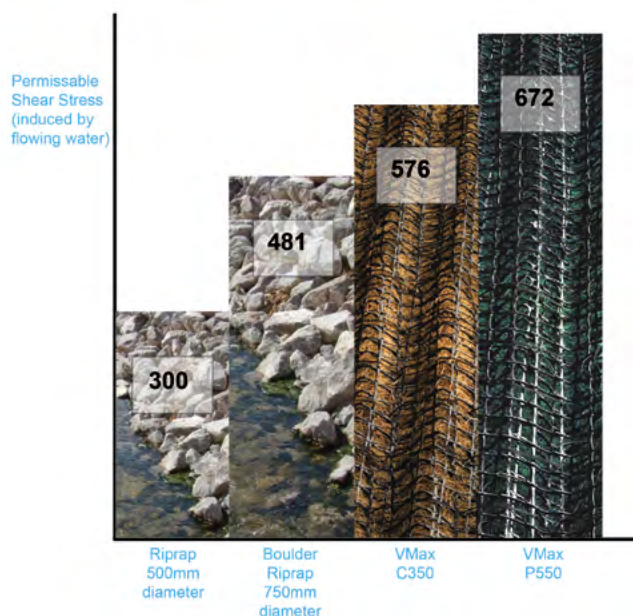
CO2 Comparisons** Total CO2 (in tCO2)

V-MAX High Performance TRM	5
Rip Rap (double layer D70cm size)	35
ArmorFlex (14cm deep)	23

A 400m2 revetment sourced within 100km of site. Based on real life project Lower Goat Bridge, Canada.

** includes materials, transport & installation

Vegetated Erosion Control Product Performance



Spillway & Flood Bank Products

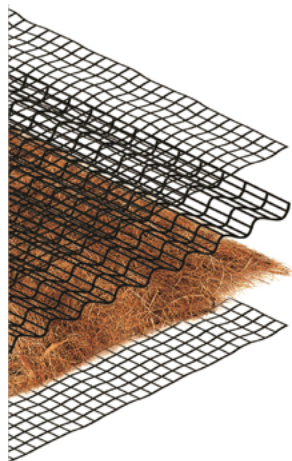
Salix VMax C350



The original C-TRM (Composite Turf Reinforcement Mat).

A high tensile strength, 16mm deep high strength 3D skeleton Geomat with additional benefit of a coir fibre composite layer. The 3D skeleton follows best practice thickness as concluded in CIRIA 116 Design of Reinforced Grass Waterways for enhanced reinforcement. The coir fibre layer provides additional erosion control performance during the grass establishment period, as well enhancing vegetation germination and establishment rates by over 300%.

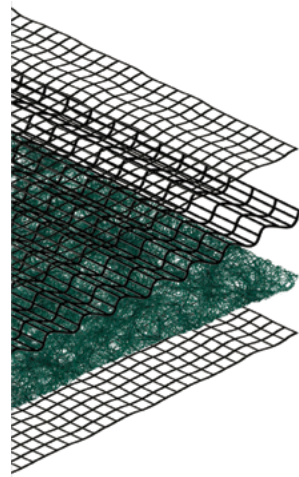
Salix VMax C500



A new hybrid product with the performance of P550 but with a coir fibre core layer.

A high tensile strength, 22mm deep high strength 3D skeleton Geomat with additional benefit of a coir fibre composite layer. The 3D skeleton follows best practice thickness as concluded in CIRIA 116 Design of Reinforced Grass Waterways for enhanced reinforcement. The coir fibre layer provides additional erosion control performance during the grass establishment period, as well enhancing vegetation germination and establishment rates by over 300%.

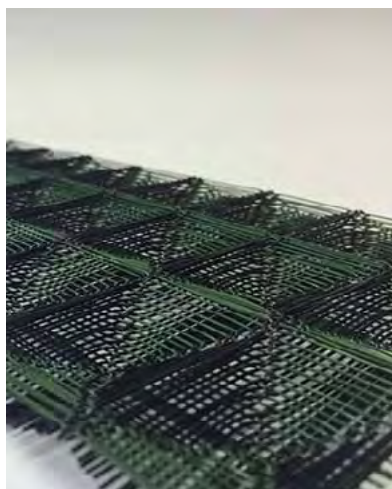
Salix VMax P550



A high tensile strength, 22mm deep high strength 3D skeleton Geomat with additional benefit of a PP fibre composite layer.

The 3D skeleton follows best practice thickness as concluded in CIRIA 116 Design of Reinforced Grass Waterways for enhanced reinforcement. The PP fibre layer provides additional erosion control performance during the grass establishment period, as well enhancing vegetation germination and establishment rates by over 300%.

Salix T-Max Woven



The new generation of woven TRM's have very high performance levels but are often difficult to vegetate on site without extensive ground preparation and soil infilling.

As such, this super high strength TRM is often pre-vegetated (see Shear Stress Turf), so that it arrives on site fully vegetated and ready to receive the highest flows possible for a reinforced grass. The high tensile strength means that the Woven T-Max is ideal to be used with earth anchors in high flow applications where shallow soil slips or geomat lifting are potential issues.

Salix Shear Stress Turf Options



Shear Stress Turf a pre-established TRM Geomat developed by Salix, with all Salix TRM solutions compatible to be grown off site and delivered to site fully vegetated.

Ideal for projects where high flows or over topping are likely to occur within 2 years of installation (this is the time taken for grass to be fully mature) or where vegetation is likely to be slow or difficult to establish.

Salix Rock Mattresses



Pre-filled Rock Mattresses are a robust and permanent revetment for use on spillways for hydraulic jump zones, lake and reservoir shorelines, streams and river banks.

They are cost-effective revetments that are suitable alternatives to rock rip rap and gabions in many scour applications, preventing erosion whilst allowing natural vegetation to establish

Hydraulic Jump Zone



Salix Rock Roll Mattresses are an ideal interface between hard and soft revetments and are often used in concentrated flow applications and hydraulic jump zones.

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The high tensile strength net tubes provide greater resistance to individual stone movement under extreme high flow conditions.

As such, greater hydraulic performance can be achieved compared to wire mattress options. The smaller angular stone in the rock roll mattress can easily be vegetated by introducing a surface dressing of topsoil in on top of the mattress.

Increased performance in the hydraulic jump zone can be achieved by anchoring with the Terra-Lock earth anchors.

Spillway & Flood Bank Projects



Conwy FAS - multiple high flow events

Conwy FAS on site validation

Shear Stress Turf P (P550) was installed knowing that there would be a high likelihood of overtopping within weeks of installation.



Shear Stress Turf after dozens of overtopping events

These reinforced banks have undergone dozens of overtopping events with design flow velocities over 6m/s flow. No other reinforced vegetation solution has been so openly and thoroughly tested and validated in a real life overtopping and high flow situation.



C350 above Rock Rolls and willow



One year on

River Ebbw

The project was to stabilise over 800 metres of steep riverbank composed of highly erodible colliery shale. Initial proposals looked at the extensive use of large blockstone to stabilise the bank.

Salix wanted to explore the possibility of using greener and more cost effective bioengineering methods which would provide underlying engineering stability whilst providing an ecological resource and improving the visual landscape.

Bank gradient 1 in 1.5 Slope length 10-15m
Water depth (1:100) 4m Velocity (1:100) 4.2m/sec Discharge (1:100) 80 cumecs

The toe of the bank was protected using a combination of Rock Rolls and living willow brushwood faggots. The upper bank was protected using two high performance erosion control mats, Salix P550 and Salix C350.

Spillway & Flood Bank Projects



Rock mattress tie in detail at hydraulic jump zone with C350

Sandwich Flood Defence Scheme

The £21.7 million flood defence scheme involved works on 16 individual reaches of the river and it reduced the risk of tidal flooding to 488 homes and 94 commercial properties in Sandwich.



Spillway six months on

Salix supplied 120,000m² of C350 to protect the spillway slopes.

Potential duration of overtopping for the spillway was around 6 hrs, therefore a permanent, high performing reinforced vegetative solution was required.



Loch Garry installation of P550 on spillway

Loch Garry

At Loch Garry spillway the P550 was used because it is an easy to install, reinforced 3D geotextile grid that vegetates quickly whilst that important 3D structure protects the underlying soil and delicate root and stem systems.



One year on

The site works were at a location 1500 feet above sea level and were undertaken during a summer heatwave. The project was completed on time, within budget with zero accidents.

Salix Terra-Lock™ System



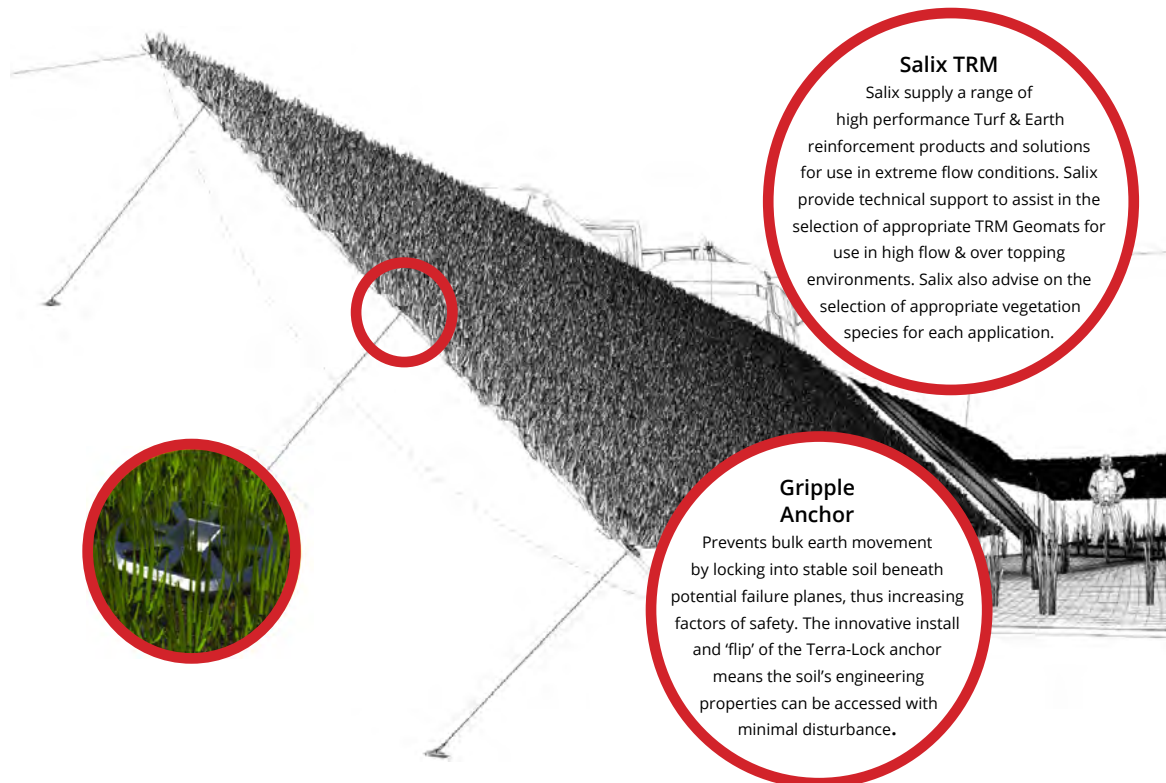
Salix TeRM ("Turf & earth Reinforcement Mat" Solutions) combine Salix's high performance TRM's with Gripple earth anchors to provide the highest possible erosion control performance of any reinforced grass solutions available.

If shallow soil slips are a potential issue or where Geomat lifting is likely (extreme high flow velocities or under wave action), a TeRM solution is the most resilient solution to ensure that a reinforced vegetation solution will perform in the long term under extreme flows.

How it works

The Salix Terra-Lock System gains its stability by coupling key engineering principles with specifically designed products to successfully utilise the natural properties of on-site materials.

Gripple's innovative 'grip' and 'pull' technology is complemented by anchor systems and TRM (Turf Reinforcement Matting) to deliver a comprehensive, trusted solution.



Salix TRM

Salix supply a range of high performance Turf & Earth reinforcement products and solutions for use in extreme flow conditions. Salix provide technical support to assist in the selection of appropriate TRM Geomats for use in high flow & over topping environments. Salix also advise on the selection of appropriate vegetation species for each application.

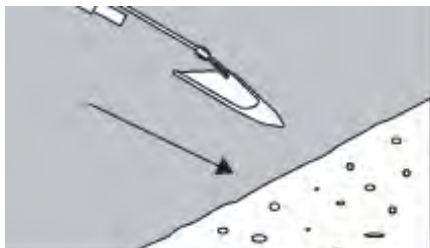
Gripple Anchor

Prevents bulk earth movement by locking into stable soil beneath potential failure planes, thus increasing factors of safety. The innovative install and 'flip' of the Terra-Lock anchor means the soil's engineering properties can be accessed with minimal disturbance.

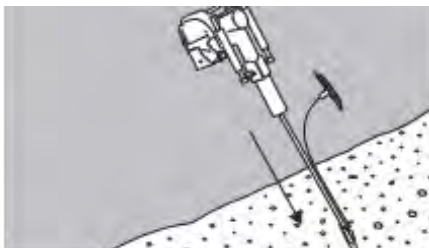
Water Management

Salix offers a design service ensures the correct TRM can be installed. The TRM reduces surface erosion from water and air, while its permeability prevents undermining of the structure.

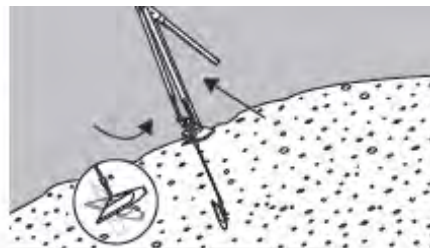
The Earth-Vegetation-TRM composite allows for a large increase in the allowable shear stresses from erosion which prevents excessive soil loss. The anchors then transfer shear forces deep into the ground to ensure a secure and stable system.



Drive:
Insert Drive Tool through the anchor and place against surface.



Use GPD to install the anchor at the required depth.



Lock:
Use JackJaw to remove Drive Tool and load lock system.

Statement on Large Scale Testing & UK validation

Many companies publish performance data for vegetation that is reinforced with various Geomats.

Many are based on bench scale tests results, or taken from incorrectly extrapolated data or from actual events where the TRM

geomat did not mechanically fail, but where no mention is made that all the vegetation layer was stripped and catastrophic erosion occurred from under the TRM.

Salix only use data from third party, independent, large scale flume testing and UK and/or UK topping and high flow events.

Product Name	Maximum Permissible Un-Vegetated Performance	Maximum Permissible Fully Vegetated Performance	Permissible Shear Stress (Fully Vegetated) Short Duration Flow (in PA)	Permissible Shear Stress (Fully Vegetated) Long Duration Flow (in PA)	Description
Salix C350	3.2m/s	6m/s	480	576	
Salix C500	3.8m/s	7.6m/s	672	632	
Salix P550	3.8m/s	7.6m/s	672	632	
Salix Woven TRM	NA	7.6m/s	766	NA	
Salix TeRM Solution	3.8m/s	7.6m/s	672	632	Increases resistance of surface protection and reduces shallow slip potential

* All products can be pre-grown off site so that they are delivered to site with mature vegetation performance levels (See: Shear Stress Turf)

More economical and aesthetically pleasing than rock riprap, articulated concrete blocks or poured concrete, the Salix range of TRM reinforced grass solutions are the most trusted, highest performing and most highly validated solution available for high flow and over topping applications.

In conclusion, Salix V-Max Geomat solutions are a proven method of reinforcing vegetation so that it can withstand extremely high flow events, over a long duration events and without significant damage to the vegetation or loss of underlying soils.

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