Profile®
Solutions for your Environment™

Restoring and Reinforcing Slopes in Houston's Hurricane Country

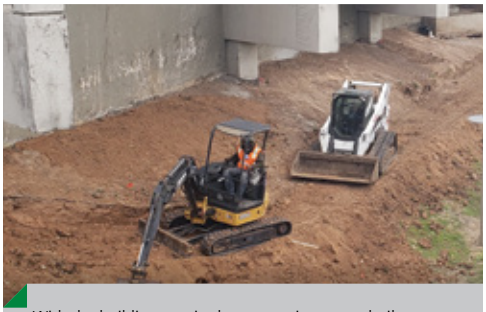
By using a green solution, the City of Houston was able to save money and prevent future damage to slopes along Buffalo Bayou.

Houston's Buffalo Bayou runs through downtown and right along the theater district – home to some of the most popular entertainment venues in the area, including the iconic Wortham Center for the Performing Arts. While the bayou adds to the overall artsy nature of the area, it can also be destructive during flood events. Nothing was as devastating, however, as Hurricane Harvey in 2017.

The storm dropped nearly 63 inches (1,600 mm) of rain, causing the bayou to rise more than 40 feet (12.2 m) above the mean water level, easily overtaking the slopes, flooding the lower levels of the Wortham Center and crashing into the base of the nearby Bayou Place complex. The current was so strong, the churn and scour of the water through the area undermined the top of the slope and the parking garage wall of Bayou Place, creating void spaces under the building that flooded the parking garage and basement. The damage was so intense, the building had to be shut down until stabilization and safety could be restored.

Once the flood waters receded, the city began looking at solutions to stabilize the building and reinforce the previously vegetated slopes.

Strong currents from Hurricane Harvey compromised the base of the Bayou Place complex, flooding the building and shutting those facilities down.

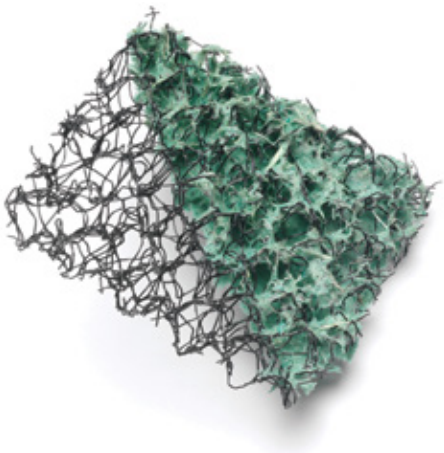


With the building repaired, construction crews built a path into the slope to bring materials to the site.

"We've always tried to use GreenArmor where riprap or hard armor might be prescribed simply because we think it's a better solution."

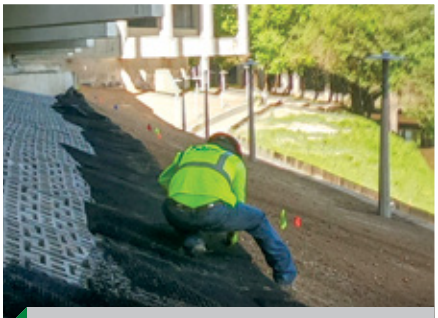
John Moss | Construction EcoServices

GreenArmor™ SYSTEM



Futerra® 7020 TRM

0.75" Thick
19 mm



Articulated concrete blocks were installed by hand, and the Futerra® 7020 TRM was anchored under the blocks as added protection against potential future flooding near the base of the building.

Finding a Green Solution

Based on the damage, Walter P. Moore Engineers, the engineer of record for the Wortham Center, originally planned to pave the slope around the building and create a hard armor solution. However, the project was slated to receive aid from FEMA, and the city quickly decided the cost of hard armor was prohibitive. That's when the firm approached Construction EcoServices to identify a green solution that could better withstand the rising floods from the bayou. Construction EcoServices has expertise in stormwater best practices, green infrastructure, slope stabilization and project management.

Construction EcoServices recommended installing the GreenArmor™ System from Profile® Products, a reinforced vegetation solution which offers a more aesthetically pleasing and environmentally superior means of protecting high-discharge waterways and steep slopes. The GreenArmor System combines engineering and agronomic excellence to create the most effective Green Design Engineering™ solution. The system begins with a Futerra® Turf Reinforcement Mat (TRM) which provides a permanent, lofty and open matrix. The mat is then hydraulically infilled with Flexterra® High Performance-Flexible Growth Medium® (HP-FGM®), the highest performing erosion control product on the market, to intimately bond soil and seeds while accelerating growth and root entanglement in the TRM. This system protects against elevated levels of hydraulic lift and shear forces while encouraging turf establishment and long-term root reinforcement.

"We've always tried to use GreenArmor where riprap or hard armor might be prescribed simply because we think it's a better solution," said John Moss with Construction EcoServices.

Not only does the GreenArmor System offer twice the erosion resistance of natural vegetation, it also costs 30 to 50 percent less than the cost of hard armor. After hearing the proposal, the city opted to approve this solution.

Before installation of the GreenArmor System could begin, Ashton Sawing and Drilling was hired to fill in the building's void spaces with 85 cubic yards (65 m^3) of flowable fill and repair the structure. Once the building was stabilized, articulated concrete blocks needed to be installed along the base of the building. In order to bring the material in, G-Tex Construction, experts in site work, excavation and grading, assisted in building a roadway along the slope for the skid steer. The workers hand-installed more than 3,000 articulated concrete blocks along the base of the building to 12 feet (3.7 m) down the slope as an added layer of protection. Underneath the blocks, the team installed Futerra® 7020 TRM in order to keep the consistency of the TRM down the slope. This put the elevation of the GreenArmor and the articulated blocks on the same level.

As the team placed the blocks and moved along the wall, workers were bringing in dirt to fill in the road. After the blocks were installed, the slope was re-graded in preparation for the GreenArmor System.

Installing the GreenArmor™ System

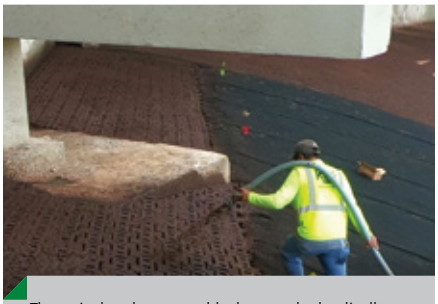
With the slope graded, Construction EcoServices worked with Profile Products to take a soil test to determine what adjustments, if any, needed to be made to assure a more favorable growing environment for faster, more complete and sustainable vegetation. The soil test revealed alkaline soils with a pH of 8.5 and low organic matter of 1.2 percent. Construction EcoServices determined they would need to apply ProGanics® Biotic Soil Media™ (BSM™), an Engineered Soil Media™ that accelerates the development of depleted soils with low organic matter, nutrient levels and limited biological activity. EcoServices also chose to apply several of Profile's ProPlus® Prescriptive Solutions, including Aqua-pHix™, JumpStart™ and BioPrime™. Aqua-pHix decreases pH of alkaline soils, JumpStart accelerates germination and vegetation establishment, and BioPrime features slow-release nitrogen and is designed to rejuvenate poor soils and enhance long-term vegetation sustainability.

"ProGanics is a game changer and we've had a lot of success with it especially when dealing with difficult-to-install topsoil or importing topsoil," Moss said. *"We're big fans of ProGanics and Profile. We don't distribute or use any other turf establishment products because we feel Profile's solutions are simply the best in the business.*

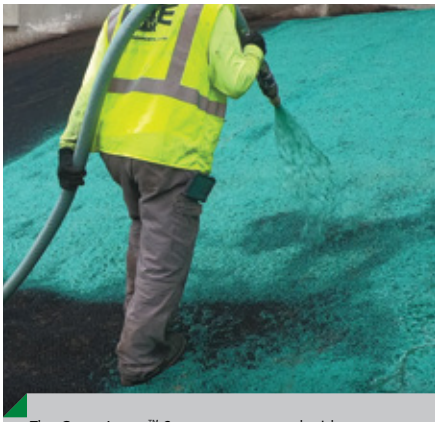
K-4 Environmental, the seeding subcontractor hired for the project, applied ProGanics BSM at a rate of 5,000 pounds per acre (5,600 kg/ha), Aqua-pHix at 10 gallons per acre (94 L/ha), JumpStart at 2.5 gallons per acre (23 L/ha), and BioPrime at 80 pounds per acre (90 kg/ha). However, due to the bayou's slopes, ranging from 4H:1V to 2H:1V, and the narrow access, it was impossible to park the hydroseeder along the slope to apply the products. Instead, the machine had to be parked on a bridge above the site, and the material had to be pumped through hoses from the machine. At times, the ProGanics BSM slurry had to be pumped more than 500 feet (152.4 m). This created a unique challenge to ensure that the hydraulic slurry would still properly flow through the machine.

With the soil amendments applied, K-4 Environmental then proceeded with installing the rest of the Futerra 7020 TRM, anchoring it at the transition point between the articulated block and the rest of the slope. The TRM was then infilled with Flexterra HP-FGM at a rate of 4,000 pounds per acre (4,480 kg/ha) mixed with Bermuda seed. In the shadier areas with the articulated blocks, K-4 Environmental filled the blocks with ProGanics BSM and Jasmine plants.

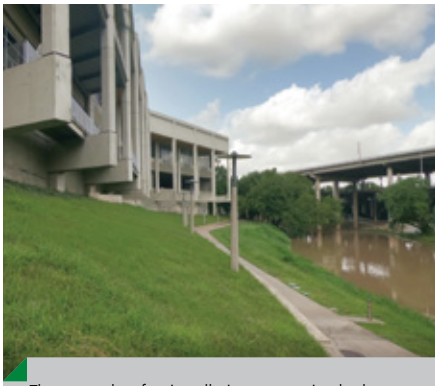
"The combination of the permanent TRM with Flexterra provided the added erosion control effectiveness that the site needed against velocities like those that Hurricane Harvey brought to the area," Moss said.



The articulated concrete blocks were hydraulically infilled with ProGanics® BSM™.



The GreenArmor™ System was capped with Flexterra® HP-FGM® for superior erosion control.



Three months after installation, vegetation had filled in on the slope and was thriving. Construction EcoServices was pleased with the results.

"I don't think there could have been a better confirmation of the design, execution and installation than having it tested by a tropical storm that soon after being built... There's no question that the GreenArmor System worked great."

John Moss | Construction EcoServices

Tropical Storm Imelda Tests the Solution

In follow-up inspections, Construction EcoServices reported that the site had good initial germination and within weeks had strong vegetation. The team was pleased with how the Bermuda filled in and felt confident in the work.

In September 2019, three months after application, the site went through its first real test when Tropical Storm Imelda dumped 42 inches (1,067 mm) of rain in Houston. The bayou once again briefly flooded over the slope and to the base of the Bayou Place garage. However, unlike with Harvey, the slope was not compromised.

While other buildings in the area took on water, the renovated area of the Wortham Center stayed dry. Even after the flood water had receded, the GreenArmor System held the slope in place and proved to be a viable solution. Moss attributes this success to the combination of Flexterra HP-FGM and the Futerra TRM.

"I don't think there could have been a better confirmation of the design, execution and installation than having it tested by a tropical storm that soon after being built," Moss said. *"I have to admit, I was sweating a little bit, but the outcome was exactly what we wanted, so no complaints. There's no question that the GreenArmor System worked great. Without that, we would have a damaged slope I'm sure to some degree. I think what this proves is that there's a green solution that can really perform well."*

During Tropical Storm Imelda, flooding overtook the site, stressing the reinforced slope and the integrity of the building.

When flood waters receded, the slope remained intact—proving the green solution was a viable one.

KEY PRODUCTS USED:

Futerra® TRM | ProGanics® BIOTIC SOIL MEDIA™ | Flexterra® HP-FGM® | ProPlus®

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