Laguna Niguel, CA Nature Area Drainage Control with GCCM

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ABSTRACT

The City of Laguna Niguel, CA had experienced stormwater control issues on a hillside that is maintained for fire protection, weed abatement and erosion concerns. The city assessed their needs and evaluated several possible solutions. Based on a systematic analysis of their requirements and the capabilities of the solutions the city determined that a Geosynthetic Concrete Composite Mat (GCCM) was the option solution. This paper details the various regulatory requirements and specific site details along with the analysis performed by the city on a variety of possible solutions to the long-term maintenance of the hillside. The installation and design of the final GCCM solution are then presented.

INTRODUCTION

The City of Laguna Niguel in Orange County has its origins in the Rancho Niguel Mexican land grant, which was acquired in 1959 by the Laguna Niguel Corporation, to develop one of California's first master-planned communities, which has become predominantly a bedroom community. The city encompasses a total of 14.9 square miles—14.8 square miles of it is land and 0.05 square miles of it (0.35%) is water. The city land consists of mostly hilly terrain within the San Joaquin Hills. The average elevation is 400 feet; elevations range from near sea level to 936 feet at the summit of Niguel Hill in the southwest corner of the city.

The city continues to review and implement its stormwater management and urban runoff management programs to meet all regulations to protect the quality of water in its creeks that eventually discharge into the Pacific Ocean. The current layers of regulatory compliance, which continues to evolve, affecting the City of Laguna Niguel for the stormwater requirements include:

• Federal (The Federal Clean Water Act)
• California State (Porter-Cologne Water Quality Control Act)
• Regional (San Diego Regional Water Quality Control Board)
• The City of Laguna Niguel (Stormwater Runoff Control Ordinance – Section 6-3-400)

While these management programs can be time-consuming and costly for the city, the city sees them as an asset for the community and its preservation of the sensitive environment that surrounds it. The city’s public works department strives to enhance its program while maintaining or reducing its annual operation costs. One way it accomplishes this is to evaluate
current and new products and technologies to help support its requirements to monitor and improve the storm water and urban runoff water quality during the dry and wet seasons. Its typical evaluation for reviewing a product includes:

- Effectiveness/performance
- Overall cost (installation and maintenance)
- Functional Longevity
- Installation requirements
- Minimal disturbances to surrounding area
- Minimal long-term maintenance
- Functionality as system approach with other products
- Environmentally friendly
- Multiple solution uses (such as weed abatement, soil stabilization, hydraulic conditions, etc.)

BACKGROUND OF SPECIFIC RUNOFF AND EROSION ISSUE ALONG A HIKING TRAIL

The city has miles of hiking trails that have breathtaking views of the surrounding mountains, valleys and the ocean that are only accessible with small equipment along the hilly terrain (Figure 1).

The hillside is maintained for fire protection, weed abatement and erosion control, which requires strategic vegetation management including removal or maintenance to reduce the potential of fuel for a fire. These hillsides and trails can be point sources for erosion, soil stabilization and water quality issues during the winter months. The average cumulative rainfall is 15 inches, and in the 2016-2017 season it was 20 inches. The heavy rains arrive in January, which typically account for 30-50% of the total, and the rainfall and can be intense within a short time period. The soils of the San Juan formation are mostly clay.

To reduce erosion control, soil stabilization and runoff water quality issues while minimizing long term maintenance costs, the city decided to install a permanent drainage ditch to collect runoff water from the hillside and trail and direct it to storm inlet drains. This ditch would also
improve the safety of the trail from erosion rills and gullies. Existing storm inlets are shown in Figure 2.

![Figure 2](image)

**Figure 2.** Existing storm inlet drains with silt protection.

**DETERMINING THE MOST EFFECTIVE ARMORING PROTECTION FOR THE DRAINAGE DITCH**

The city reviewed several solutions for armoring the drainage ditch to meet the criteria for this project: overall installation and maintenance cost, erosion protection, water quality impact, minimum impact and disturbance to hiking trails or hillsides, increased water flow capacity, minimum disturbance to hikers and residents during construction, installation time, minimum long-term maintenance, aesthetics and safety. The solutions considered included:

- Turf Reinforcement Mat
- Rip-Rap
- Tied or Articulate Concrete Block Mat
- Shotcrete/Poured Concrete
- Fabric Formed Concrete
- Geosynthetic Concrete Composite Mat

Below is a summary of the results of reviewing each solution for this specific project.

**Turf Reinforcement Mat (TRM).** TRMs are geosynthetic products that create a holding capacity for the vegetation root system to increase its permissible shear force during movement or flow of water and to minimize erosion and water quality. TRMs require permanent dense vegetation established at all times. With the concerns of the constant vegetation maintenance, increased fuel for a fire, saturating the subsurface soils of the hillside (slope stability issues) and the risk of TRM entangling with wildlife, maintenance equipment and hikers, this option was immediately eliminated.

**Rip-Rap.** Rip-rap is typically used as an energy dissipater to slow water down. The size of rip-rap determined for this application was 6 inches to 12 inches. Using rip-rap would impact the hillside and hiking trail because the drainage ditch would require over-excavating to have the volume capacity to install the rip-rap and the anticipated flowrate of runoff water. The other main issues with rip-rap were the long-term maintenance for weed control and allowing water
from the drainage ditch to saturate the subsurface that could potentially cause instability for the slope and safety of hikers and their pets if they accidentally walked onto the rip-rap. Therefore, rip-rap was eliminated as an option.

**Tied or Articulate Concrete Block Mat.** Tied or Articulate Concrete Block Mats are used similarly to rip-rap as an energy dissipater. It is a manufactured concrete block formed to a certain shape that is secured together by its capability of interlocking or mechanically tying together by a grid or cable system. The thickness ranges from 2 inches to 12 inches. It was determined that the block mat has essentially the same concerns as rip-rap mentioned above and was eliminated as an option.

**Shotcrete/Poured Concrete.** Shotcrete or poured concrete was reviewed, but access to the site is limited and concrete trucks could not enter the trail. The trail has a single access point with limited width (a tight 10’), steep slopes and no place to turn around. So, any concrete or shotcrete work was deemed unfeasible.

**Fabric Formed Concrete.** Revetment mats are special woven fabrics that are sewn together to create pockets or envelopes to be filled with a pumpable fluid concrete mix. It met the criteria, eliminating water peculation and vegetation issues and was easy to install. However, the difficulty for the fabric form concrete was it required over-excavation and access for the pump truck at the site, so was eliminated from the options.

**Geosynthetic Concrete Composite Mat (GCCM).** A geosynthetic concrete composite mat (GCCM) is a flexible concrete-impregnated geotextile on a roll. When deployed, it hardens on hydration to form a durable, fiber-reinforced concrete layer. The material is 0.2 inches to 0.5 inches thick and weighs from 1.9 psf to 5.3 psf. The material met all the criteria and exceeded expectations, including no special contractor (in-house labor could install it), flame resistance (fire protection), no weather constraints during installation, easy-to-follow ground surface contours and minimum construction crew or equipment that would allow the hiking trail to be open during the installation. This product was selected for the project.

The GCCM product selected was Concrete Cloth™ fabric, manufactured by Milliken Infrastructure Solutions, LLC. What is so unique about this specific product was its ability to be used for multiple functions and applications besides armoring a drainage ditch including: slope protection, weed control, fire control, geosynthetic liner armoring, relining inverts of culverts, shoring line protection, and more. The city could inventory and use when they need it, especially when extreme rain storms occur, to minimize erosion and water quality issues at unexpected locations throughout the city limits. The GCCM material can be delivered to the site in large bulk rolls weighing nearly 3,500 lbs. The rolls can also be supplied in batch or man-portable sizes, which are less than 150 lbs. The lighter rolls can be transported by smaller equipment and installed without large equipment footprints. The size options are shown in Figure 3. A summary of comparative options is shown in Table 1.
GENERAL INSTALLATION PROCEDURES FOR CONCRETE CLOTH GCCM AT THE PROJECT SITE

The contractor, Ed Stewart & Associates, initially graded the trail to reverse the drainage toward the proposed trapezoidal gutter design (back toward the toe of the slope). To minimize excavation and construction time, the contractor manufactured a steel template to attach to the mini-backhoe and cut a trapezoidal gutter that provided a flat 8” at the bottom and a 1:1 side slope with a flat 6” on top (see Figure 4). The flat bottom was selected to allow for easy maintenance using a flat shovel to remove any silt, leaves or debris compared to a typical v-gutter shape. Once the gutter was cut, the contractor crews deployed the Concrete Cloth GCCM and laid it within the gutter. The crews used and deployed bulk rolls along the gutter, which minimized the number of overlaps of the GCCM fabric. At overlaps, crews used construction caulk or adhesive and screws. Once the GCCM was installed, the crew used a water tank attached to a pickup truck with a pump to hydrate it. The completed gutter is shown in Figure 5.
After the gutters were completed, the crews used Concrete Cloth GCCM to construct a pre-sediment basin to collect any accumulated sediment from the gutters before it entered the storm drain inlets. This allowed an area for staff to remove any sediment collected before it entered the storm drain system. The original area and completed basin can be seen in Figure 6.
Concrete Cloth GCCM was also used for the construction of mid-slope interceptor weirs to slow down sheet and concentrate flow from the steep hillside slopes to minimize erosion issues and create rills and gullies. Gravel geotextile bags were stacked 3 courses high and the GCCM was draped over to protect the geotextile bags from UV and abrasion to create a long-term structure that could be removed with minimal effort. The weirs are shown in various stages of construction in Figure 7. The city used to replace gravel bags and/or fiber rolls annually and hoped that the use of a GCCM would eliminate the need for this annual chore.

![Figure 7. Sand bags used to form weirs were armored and made permanent with GCCM.](image)

**CONCLUSION**

The Concrete Cloth GCCM provided the city with a product that was easy to handle, easy to install, and performs equivalently to regular concrete construction. The site limitation required creative thinking, and the “EUREKA” moment was when the city staff came across Concrete Cloth GCCM over the weekend, reached out to Milliken staff on Monday and the rest is history. In addition to the speed of construction, the project was completed with a highly reduced cost compared to the initial budget estimate, and the City Council was very pleased with how the project was accomplished. The city completed another project with GCCMs following the completion of the trail project. GCCMs are now a tool in the staff’s tool box and supported by management for use as needed.