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Evaluation of Various Perimeter Barrier Products

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Construction activities entail substantial disturbance of topsoil and vegetative cover. As a result, stormwater runoff and erosion rates are increased significantly. If the soil erosion and subsequently generated sediment are not contained within the site, they would have a negative off-site impact as well as a detrimental influence on the receiving water body. In this study, replicable large-scale tests were used to analyze the ability of products to prevent sediment from exiting the perimeter of a site via sheet flow. The goal of these tests was to compare products to examine how well they retain sediment and how much ponding occurs upstream, as well as other criteria of interest to the Illinois Department of Transportation. The products analyzed were silt fence, woven monofilament geotextile, Filtrexx Siltsoxx, ERTEC ProWattle, triangular silt dike, sediment log, coconut coir log, Siltworm, GeoRidge, straw wattles, and Terra-Tube. Joint tests and vegetated buffer strip tests were also conducted. The duration of each test was 30 minutes, and 116 pounds of clay-loam soil were mixed with water in a 300 gallon tank. The solution was continuously mixed throughout the test. The sediment-water slurry was uniformly discharged over an 8 ft by 20 ft impervious 3:1 slope. The bottom of the slope had a permeable zone (8 ft by 8 ft) constructed from the same soil used in the mixing. The product was installed near the center of this zone. Water samples were collected at 5 minute intervals upstream and downstream of the product. These samples were analyzed for total sediment concentration to determine the effectiveness of each product. The performance of each product was evaluated in terms of sediment removal, ponding, ease of installation, and sustainability.</td></tr>
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Members of the Technical Review Panel (TRP) were the following:

- Michael Brownlee, TRP Chair, Illinois Department of Transportation
- Michael Copp, Illinois Department of Transportation
- Kenneth Crawford, Illinois Department of Transportation
- Michael Denne, Illinois Department of Transportation
- Stephanie Dobbs, Illinois Department of Transportation
- Dan Salsinger, Hanes Geo Components

EXECUTIVE SUMMARY

Construction activities entail earthmoving operations that involve substantial disturbance of topsoil and vegetative cover. As a result, stormwater runoff and erosion rates are increased significantly. Improperly managed construction areas have been regarded as the land management practice with the highest soil erosion rate. If the soil erosion and subsequently generated sediment are not contained within the construction site, they would have a negative off-site impact as well as a detrimental influence on the receiving water body.

Tests were performed at the Erosion Control Research and Training Center (ECRTC) at the University of Illinois at Urbana-Champaign. These tests analyzed the ability of products to prevent sediment from exiting the perimeter of a site via sheet flow runoff. The goal of these tests was to compare the products to examine how well they reduce sediment leaving as sheet flow runoff and how much ponding occurs upstream of the product, as well as other criteria of interest to the Illinois Department of Transportation. The products analyzed in testing were silt fence, woven monofilament geotextile, Filtrexx Siltsoxx (compost log), ERTEC ProWattle, triangular silt dike, sediment log, coconut coir log, Siltworm, GeoRidge, straw wattles, and Terra-Tube. Considering the product application in the field, a joint is inevitable for the perimeter barrier. Thus, the joint performance of one damming product (ERTEC ProWattle) and one filtering product (sediment log) was tested. The performance of vegetation buffer strips was also evaluated with buffer widths of 5 ft, 10 ft, and 15 ft.

The duration of each test was 30 minutes, and 116 pounds of clay-loam soil were initially added to 250 gallons of water. The solution was continuously mixed throughout the duration of the test. The sediment-water slurry was uniformly discharged over an 8 ft by 20 ft impervious 33% slope. At the bottom of the slope, a permeable zone (8 ft by 8 ft) was constructed from the same clay-loam soil used in the mixing. The product to be tested was installed near the center of this zone. Water quality samples of 250 ml were collected at 5 minute intervals upstream and downstream of the installed product, starting at 5 minutes and ending at 30 minutes, for a total of 12 samples per test. These samples were analyzed for total sediment concentration (TSC) and turbidity.

In this study, product evaluation was mainly based on the technical performance (relative TSC reduction and sediment retention efficiency [SRE]), ease of installation and removal, material costs, environmental savings and sustainability, and product failures. Products were categorized as either damming or filtering based on upstream ponding condition and downstream flow rate. Among the products tested, woven monofilament geotextile, Filtrexx Siltsoxx, ERTEC ProWattle, and triangular silt dike were deemed to be damming products. Sediment log, coconut coir log, Siltworm, GeoRidge, straw wattles, and Terra-Tube were characterized as filtering products. The damming products tended to outperform the filtering products in terms of greater relative TSC reduction and SRE. The triangular silt dike performed the best among all products tested in terms of the highest relative TSC reduction. ERTEC ProWattle had the highest calculated SRE, given the SRE value for the triangular silt dike was not obtained. Filtrexx Siltsoxx performed better than most products tested at retaining sediment upstream while reducing sediment concentration downstream. GeoRidge and Curlex sediment logs were the only two filtering devices that showed SRE and relative TSC reductions similar to or better than that of the silt fence. Coconut coir log and Terra-Tube had somewhat good

performance in sediment retention or improving water quality downstream, while Siltworm and straw wattles had significantly lower technical performance compared to that of the silt fence. In addition, a sleeve joint was recommended for use with the sediment log and ERTEC ProWattle. Vegetated buffer strips with 10 ft width (or higher) also performed relatively well for sediment trapping.

None of the products tested exhibited major product failures under the manufacturer's suggested installation procedure. However, silt fence, sediment log, Siltworm, straw wattles, and Terra-Tube encountered undercutting to some extent in several tests. Silt fence, woven monofilament geotextile, and Filtrexx Siltsoxx ranked among the most difficult to install and remove. As such, these products would have increased labor costs associated with practical usage. In terms of sustainability, filtering devices are more sustainable overall than damming devices, because all filtering devices (except GeoRidge) were composed of degradable, naturally occurring materials while the main part of damming devices is nondegradable fabric.

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CHAPTER 1: INTRODUCTION

The erosion of topsoil from bare lands often leads to sediment ending up in water bodies, causing numerous negative effects. Of the activities leading to topsoil erosion, sedimentation, and subsequent water body impairments in the United States, construction activities rank among the highest. Construction sites have sediment runoff rates typically 10 to 20 times higher than agricultural lands (EPA, 2018). These elevated rates are likely because construction activities often entail earthmoving operations that involve the disturbance of topsoil and the removal of vegetative cover. As a result, stormwater runoff and erosion rates are increased significantly.

In order to mitigate erosion and runoff at construction sites, there are several best management practices (BMPs) that have been recommended by the US Environmental Protection Agency and other environmental organizations. BMPs that seek to minimize erosion provide some means of keeping soil in place or preventing it from being exposed to erosion-causing processes. In contrast, BMPs that are used to limit eroded soil or sediment from being deposited off-site involve practices and technology that dam or filter stormwater runoff as it exits the site. By preventing sediment from leaving the construction site, it is not deposited as a contaminant in waterways, and it can be properly reused or hauled off-site. Two of the most widely accepted practices and technologies for preventing off-site deposition of sediment via sheet flow are vegetated buffer strips (VBSs) and sediment perimeter barriers (SPBs). The former works by maintaining or introducing a strip of vegetation on the downstream perimeter of a construction site, while the latter typically involves a synthetic material designed to retard the flow of sediment-laden runoff, filter the runoff, or produce some combination of the two.

During the time frame of this research, the most commonly used and widely accepted standard SPB product in the state of Illinois is the silt fence. However, the silt fence has numerous issues specific to Illinois weather, and several newer products for sediment retention on construction sites have entered the market. While some of these products have been subjected to testing regarding their effectiveness in concentrated flow situations, they are currently untested and unproven under a standardized sheet flow testing method. This study was intended to use a field-scale testing protocol to evaluate SPB product performance under Illinois weather and soil conditions in a sheet flow scenario. The outcomes indicate whether these products have merit as SPB products on Illinois construction sites and should be recommended by the Illinois Department of Transportation.

CHAPTER 2: OBJECTIVES

The purpose of this study was to investigate several products for sediment retention as sediment perimeter barriers and provide recommendations to the Illinois Department of Transportation (IDOT) based on the performance tests and analysis. The analysis was based on several criteria, such as the quantity of sediment retained, extent of ponding effects, and the ease of installation and removal of the product.

The specific objectives of the project were as follows:

- Conduct a field experiment and collect samples to analyze the effectiveness of various perimeter barrier products.
- Review and suggest proper installation techniques for the products.
- Examine water samples, specifically for turbidity and sediment concentration upstream and downstream of the products.
- Quantify the sediment retained by various products to compare their efficacy.
- Provide data and recommendations to assist IDOT in deciding which products can be used as SPBs specific to Illinois weather.

CHAPTER 3: METHODOLOGY

PRODUCT INTRODUCTION AND INSTALLATION

Eleven products, including the industry standard (silt fence), were tested at the Erosion Control Research and Training Center (ECRTC) at the recommendation of the project's Technical Review Panel. These sediment perimeter barriers (SPBs) retain sediment in two ways: (1) by creating impoundment upstream, which helps settle the sediment, and (2) by allowing sediment-laden water to go through and be filtered by the product. Many SPBs perform in both ways in the field. Products that mainly function by the first method are categorized as damming devices. Products that mostly function by the second method are categorized as filtering devices. Damming products tend to create deeper and more extensive ponding upstream than filtering products. There is an obvious difference in upstream and downstream flow rate for damming products. Damming devices tend to slow the runoff and gradually let the runoff pass through the product, resulting in a lower downstream flow rate. However, for filtering devices, the downstream flow rate is similar to the upstream rate.

Damming Products

Damming devices typically experienced ponding upstream of the product and water backlogging about 4 ft or the entire length of the upstream end of the "installation zone." The time to ponding subsidence took an average of 1 hour or more after the test concluded.

Silt Fence (IDOT-approved Fabric)

The silt fence impounds stormwater and promotes the removal of solids by means of sedimentation and, to a lesser degree, filtration (Barrett, 1995). Unfortunately, the effectiveness of silt fence installations can be jeopardized due to improper installation and structural instability (Stevens, 2005). Common structural components associated with the silt fence include geotextile filter fabric, reinforcement, and vertical support structures. In this study, the geotextile used was an IDOT-approved fabric, and vertical support structures were 2 in. by 2 in. wooden stakes. Wire reinforcing was used to support the filter fabric (Figure 1). The silt fence has a water flow rate of 8 gpm/ft^2 (Silt Fence Spec Sheet, 2018). Bugg et al. (2017) found the trenching method of silt fence installation may be more reliable than the slicing method when installed correctly. The installation method in this study was similar to methods I and III illustrated by Bugg et al. (2017).

Figure 1. Photo. Silt fence (IDOT-approved fabric).

The installation method is as follows:

- Wooden stakes with 4 ft spacing were stapled to the fabric.
- A 6 in. deep by 6 in. wide trench was dug.
- Wooden stakes were hammered into the ground until the bottom of the fabric was able to be folded in the 6 in. wide trench.
- The trench was backfilled to secure the bottom of the fabric into the ground.
- Land surface near the silt fence was compacted by hand tamper.

Woven Monofilament Geotextile

The woven monofilament geotextile fabric (Figure 2) has a similar configuration to the silt fence. It is designed to prevent sediment from passing through the fabric while letting water pass. The product tested in this study was TerraTex® EP-12, which is more porous than the standard IDOT silt fence fabric with a water flow rate of 145 gpm/ft2 (TerraTex® EP-12 Spec Sheet, 2020). It has fewer clogging issues than the silt fence in terms of permeability. The installation method is the same as the silt fence.

A. Upstream

B. Downstream

Figure 2. Photo. Woven monofilament geotextile.

The installation method is as follows:

- Wooden stakes with 4 ft spacing were stapled to the fabric.
- A 6 in. deep by 6 in. wide trench was dug.
- Wooden stakes were hammered into the ground until the bottom of the fabric was able to be folded in the 6 in. wide trench.
- The trench was backfilled to secure the bottom of the fabric into the ground.
- Land surface near the product was compacted by hand tamper.

Filtrexx Siltsoxx (Compost Log)

Filtrexx Siltsoxx is a 3D tubular device comprised of patented filter media encased in a polypropylene Filtrexx mesh. Filter media is a composted organic product recycled and manufactured from locally or regionally generated organic, natural, and biologically based materials. The Filtrexx Siltsoxx fabric and compost materials used in this study were obtained from Filtrexx International in Grafton, Ohio. The products come in various diameters: 5 in., 8 in., 12 in., 18 in., and 24 in. A 12 in. diameter product was used in this study. The knitted polypropylene mesh had a 3/8 in. opening. (Filtrexx Siltsoxx, 2020). The filter media material used was yard trimmings compost with a particle size distribution of 100% < 2 in., and 50% > 3/8 in. (Keener, 2007). Filtrexx Siltsoxx was suggested to be installed with trenching and soil backfilling because of frequent undercutting issues as a rolled product. However, considering the increased product weight, the Filtrexx Siltsoxx tested in this study was heavy enough (12–30 lb/ft) to have decent ground contact. Therefore, no trenching or backfilling was applied to Filtrexx Siltsoxx in this study.

A. Upstream

B. Downstream

Figure 3. Photo. Filtrexx Siltsoxx (compost log).

The installation method is as follows:

- Any large rocks or debris were removed from the installation area.
- The product was placed in the installation area.
- Three 2 in. by 2 in. wooden stakes with 4 ft spacing were hammered through the product into the ground 1 ft deep to secure the product in place.
- The upstream edge of the product was pressed to fortify ground contact.

ERTEC ProWattle

Manufactured by ERTEC, ProWattle (Figure 4) is a freestanding L-shaped, high-density polyethylene (HDPE) polymer matrix shell with a 350 micron HDPE particle filter on the inside. ProWattle comes in 7 ft sections of either 6 in. or 10 in. height. In this study, the height of the tested product is 10 in. The product is intended to spread and reduce water velocity while providing particle filtration. The product is made from 90% recycled materials and may be reused multiple times for a functional life of over 4 years (ERTEC ProWattle, 2019).

A. Upstream

B. Downstream

Figure 4. Photo. ERTEC ProWattle.

The installation method is as follows:

- A 1–2 in. deep by 4–6 in. wide trench was dug.
- The base flap of the product was secured by two 6 in. nails with the same interval in the trench for each segment.
- The product was reinforced by three wooden planks behind the vertical section with 4 ft spacing.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.

Triangular Silt Dike

The triangular silt dike (Figure 5) is manufactured by the Triangular Silt Dike Company, Inc. and contains triangular urethane foam wrapped in geotextile fabric. The product comes in a 7 ft length segment with multiple heights (5 in., 8 in., and 10 in.). The product tested in this study was 10 in.

high. The product was designed with protective aprons on both sides of the barrier to prevent erosion and product failure (Triangular Silt Dike, 2020).

A. Upstream

B. Downstream

Figure 5. Photo. Triangular silt dike.

The installation method is as follows:

- A 4 in. deep trench was dug to fold the apron upstream.
- Five staples were used to secure the apron in the trench.
- Six staples were used to secure the apron downstream with a configuration of two rows and three columns.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.

Filtering Products

Filtering devices typically produce minimal to no ponding upstream. Even if a product resulted in some ponding upstream of the product, the magnitude was much lower than that of damming devices, and the ponding never spanned the length of the product. The ponding typically subsided less than an hour after the test, and the downstream flow rate was similar to the upstream rate.

Sediment Log

Manufactured by American Excelsior, Curlex sediment logs (Figure 6) are made of curled excelsior wood fiber rolls of various diameters. The curled fibers are designed to be self-interlocking to filter runoff. Sediment logs are designed to be biodegradable, providing temporary flow interruption (American Excelsior, 2019). In this study, a sediment log with a 12 in. diameter was tested with wooden stakes at 45° and 90° angles.

A. Upstream

B. Downstream

Figure 6. Photo. Sediment log.

The installation method is as follows:

- A 6 in. deep by 12 in. wide trench was dug, and the product was placed in the trench.

- Three wooden stakes were hammered 12–24 in. into the ground at a 45° or 90° angle toward the flow with 4 ft spacing. The product was supposed to be penetrated by the stakes.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.
- The upstream edge of the product was pressed to fortify ground contact.

Siltworm

Manufactured by Siltworm, Inc., Siltworm (Figure 7) is another rolled perimeter barrier product designed to filter runoff. The product is manufactured from a photodegradable geotextile outer sleeve filled with a proprietary blend of 100% recycled, kiln-dried hardwood. Two dimensions of Siltworm are produced with 9 in. and 12 in. diameters. Although the installation procedure for Siltworm is similar to the sediment log, trenching is not needed for Siltworm, as per instructions by Siltworm, Inc. In this study, a 12 in. product was tested with 45° angle staking downstream to pin the product on the ground.

A. Upstream

B. Downstream

Figure 7. Photo. Siltworm.

The installation method is as follows:

- Any large rocks or debris were removed from the installation area, and the product was placed on the ground.
- Three wooden stakes were hammered 12–24 in. into the ground downstream at a 45° angle toward the flow with 4 ft spacing.

Coconut Coir Log

The coconut coir log (Figure 8) is a biodegradable fiber roll made of a mixture of mattress coconut coir surrounded by outer coir twine netting. Coir logs are designed to filter runoff and provide a temporary (2 to 5 year) perimeter barrier. The product comes in a variety of diameters; a 12 in. coconut coir log was tested in this study.

A. Upstream

B. Downstream

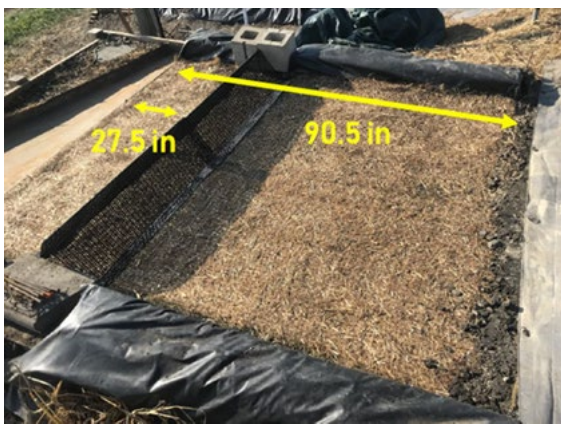
Figure 8. Photo. Coconut coir log.

The installation method is as follows:

- A 3 in. deep by 12 in. wide trench was dug, and the product was placed in the trench.
- Three wooden stakes were hammered downstream 12–24 in. into the ground at a 90° angle with 2 ft spacing.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.
- The upstream edge of the product was pressed to fortify ground contact.

GeoRidge

GeoRidge is a permeable plastic berm manufactured by Nilex, Inc. and is designed for erosion and sediment control (Figure 9). GeoRidge plastic dams are made of a durable, UV-stabilized HDPE. GeoRidge dams are intended to reduce water velocity, spread water over a wider area, trap sediment, and aid in vegetation establishment. According to the manufacturer's specifications, the product should be removed once vegetation is established. GeoRidge dams should be used in conjunction with an erosion control blanket (GeoRidge, 2020).



A. Upstream

B. Downstream

Figure 9. Photo. GeoRidge.

The installation method is as follows:

- A trench was dug upstream to fold the blanket by using staples and backfilling.
- The erosion control blanket was stretched out to cover the installation area.
- GeoRidge dams were placed on the blanket and connected to each other by aligning holes and anchoring nails.

Straw Wattles

Straw wattles are made of a mesh casing with straw fibers inside, in the shape of a log (Figure 10). This product is meant to be laid perpendicular to the flow of water, where it acts as a temporary dam that slows the flow of water, allowing the sediment to have more time to settle. It can also act as a filter to remove sediment that passes through from the water. In this study, a 12 in. product was tested. The installation method for straw wattles is the same as the sediment log.

A. Upstream

B. Downstream

Figure 10. Photo. Straw wattles.

The installation method is as follows:

- A 6 in. deep by 12 in. wide trench was dug, and the product was placed in the trench.
- Three wooden stakes were hammered 12–24 in. into the ground at a 45° or 90° angle toward the flow with 4 ft spacing. The product was supposed to be penetrated by the stakes.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.
- The upstream edge of the product was pressed to fortify ground contact.

Terra-Tube

Terra-Tube is a light, rolled product (Figure 11). It is designed to trap, filter, and treat sediment-laden runoff while reducing hydraulic energy. It is engineered composites consisting of wood fibers, man-made fibers, and performance-enhancing polymer encased in heavy-duty cylindrical tubes. The installation procedure for Terra-Tube is similar to the sediment log and straw wattles (Terra-Tubes Brochure, 2020).

A. Upstream

B. Downstream

Figure 11. Photo. Terra-Tube.

The installation method is as follows:

- A 6 in. deep by 12 in. wide trench was dug, and the product was placed in the trench.
- Three wooden stakes were hammered 12–24 in. into the ground at a 45° or 90° angle toward the flow with 4 ft spacing. The product was supposed to be penetrated by the stakes.
- The trench was backfilled, and disturbed soil was compacted by hand tamper.
- The upstream edge of the product was pressed to fortify ground contact.

JOINT PERFORMANCE INTRODUCTION AND INSTALLATION

Perimeter barriers will inevitably need joints, as they cover a considerable length that cannot be covered with a single section of product. A joint normally has a negative influence on the performance of perimeter barriers, as it is considered a weak point. Therefore, it is important to find a proper way to make a joint when a perimeter barrier is going to be applied. In this report, one damming product (ERTEC ProWattle) and one filtering product (sediment log) were tested for joint performance evaluation.

ERTEC ProWattle

There is only one way to make a joint for ERTEC ProWattle. A joint is made by sliding the end of one product into the end of another one (Figure 12). A joint between two ERTEC ProWattle segments is simple to make and requires no additional tools or equipment.

Figure 12. Photo. ERTEC ProWattle joint.

Sediment Log

There are three ways to make a joint for a sediment log: overlapping, butt ends, and sleeving (Figure 13). Overlap and sleeve joints are both 1 ft long. For the sleeve joint, the joint formation process is similar to that of ERTEC ProWattle. First, the interior materials (wood fibers) were removed from a 1 ft section at the end, and then the netting was slid to contain one end of another product. For the butt ends joint, cable zip ties were used to connect two segments. Stakes were installed at a 45° angle for all joint performance tests.

A. Overlapping

B. Butt ends

C. Sleeving

Figure 13. Photo. Sediment log joint.

EVALUATION CRITERIA

Technical performance represents how well the product retains sediment upstream and improves water quality downstream. For the purposes of this report, technical performance specifically refers to the relative reduction in total sediment concentration (TSC) between upstream and downstream water quality samples as well as sediment retention efficiency (SRE).

Because of the inherent difficulties with achieving the exact same average upstream TSC in large-scale testing, relative TSC reduction is preferred over absolute TSC reduction as a metric for technical performance. The formulas to calculate absolute and relative TSC reduction are given in Figures 14 and 15.

$$Absolute\ TSC\ reduction = average\ upstream\ TSC - average\ downstream\ TSC$$

Figure 14. Equation. Equation for absolute TSC reduction.

$$Relative\ TSC\ reduction = 100\% \times \frac{average\ upstream\ TSC - average\ downstream\ TSC}{average\ upstream\ TSC}$$

Figure 15. Equation. Equation for relative TSC reduction.

Turbidity is prone to be affected by homogeneity of the water samples. Homogeneity for each test is not easy to achieve completely because of many factors such as the intensity of shaking samples and depth of the nozzle entering the sample for extraction. For this reason, turbidity was not used as a primary parameter in the technical performance.

Retained sediment volume (RSV) refers to the amount of sediment trapped upstream of the product, which was computed using a 3D scanner and SURFER software. The testing area upstream of the product was scanned by a 3D scanner before and after the test. Elevation measurements obtained by the 3D scanner were fitted to a 3D surface by Kriging interpolation. The volume was approximated by the trapezoidal rule method of integration. RSV is equal to the difference in volume pre-scan and post-scan. Similar to the relative calculation for TSC reduction, SRE is preferred over RSV because of the inevitable deviation in the sediment loadings. The equation used for SRE is displayed in Figure 16.

$$Sediment\ retention\ efficiency = 100\% \times \frac{retained\ sediment\ volume \times bulk\ density}{sediment\ loading}$$

Figure 16. Equation. Equation for sediment retention efficiency.

TESTING PROTOCOL

Field Site Soil and Testing Apparatus

To test the sediment retention of perimeter barrier products, a testing protocol was developed according to ASTM D7351 (ASTM, 2018). Figures 17 and 18 reflect the profile schematic and plan view of the testing apparatus. The apparatus was implemented using a berm and water supply pond at ECRTC (Figure 19). A polyethylene tarp was used as an impervious area, and a 300 gallon stock tank with a 3 in. semi-trash pump was used as the mixing equipment.

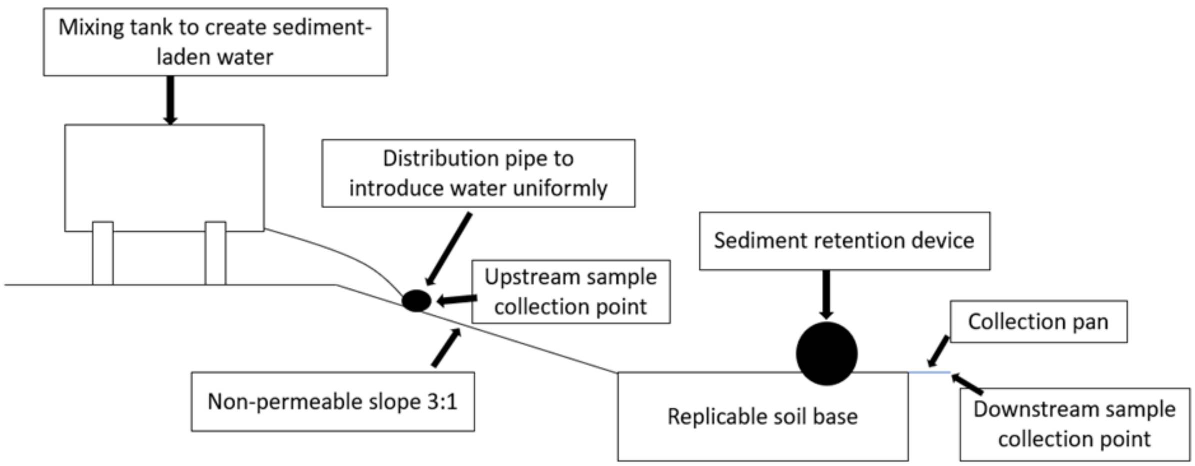


Figure 17. Graph. Profile schematic of testing apparatus.

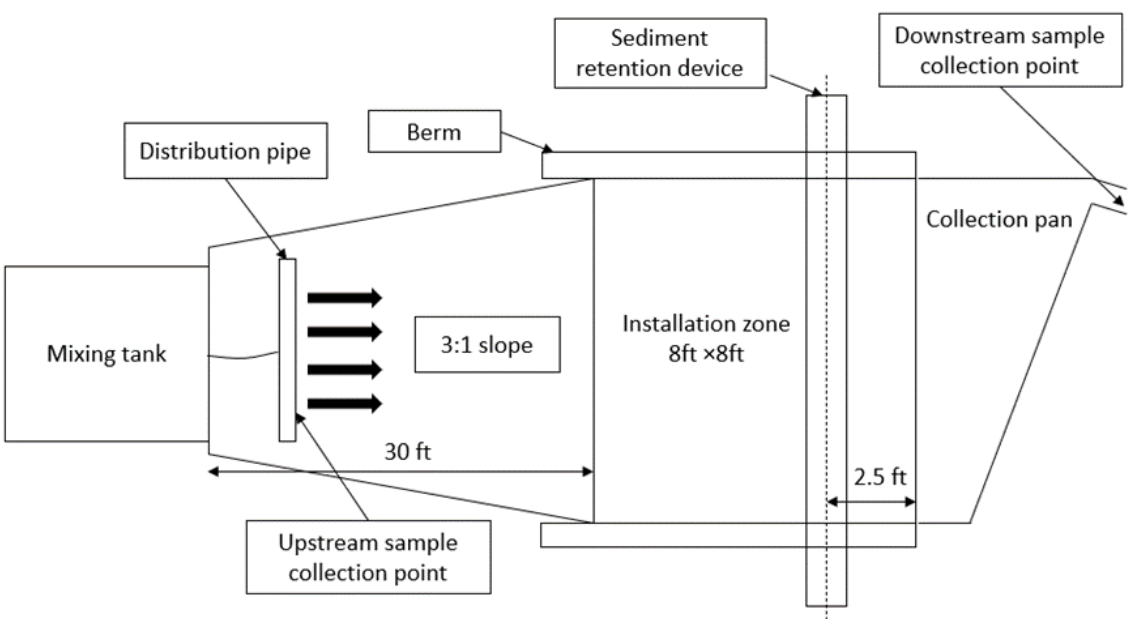


Figure 18. Graph. Plan view of testing apparatus.

Figure 19. Graph. ECRTC testing facility for perimeter barrier products.

Storm Event Simulation

The testing protocol reflects soil and weather conditions typically found on construction sites around Illinois. In the test standard, sediment-laden water is created by mixing 5,000 lb of water and 300 lb of soil in a mixing tank of sufficient size. Water quantities are based on a 10 year, 6 hour storm event (4 in.), commonly used for sizing sediment control ponds. Total volume is then determined based on a 25% occurrence within a 30 minute peak storm window, with a 50% infiltration rate and a contributing area of 100 ft by 20 ft. The theoretical contrition area takes into account a 98 ft maximum sheet flow length and a 20 ft typical sediment retention device section. Soil weight is calculated using the modified universal soil loss equation (MUSLE), with a K-factor for sandy-silt equal to 0.041, an LS factor of 0.46 for 2%–10% slope at 98 ft, and C- and P-factors of 1.

Sediment and water quantities for this study were adjusted to reflect a smaller theoretical contribution area. The testing facility at ECRTC has a width of 8 ft. Calculations for MUSLE were adjusted to represent this smaller width, resulting in a new contribution area of 100 ft by 8 ft to ensure proper sediment and water loading to each SPB product. The newly calculated soil loading was 116 lb, and the new water quantity was calculated to be 2,100 lb. All results in this study were based on this storm event. If the identity, duration, or frequency of storms change, then different results could be expected.

Discharge Calibration

To calibrate the flow out of the mixing tank, a 2 in. ball valve attached to a dispersion pipe (Figure 20) was used to discharge the flow at a specified rate. The flow valve was adjusted to the appropriate rate using predetermined volume marks on the mixing tank corresponding to measured volumes for a given interval.

Figure 20. Photo. Dispersion pipe attached to ball valve/mixing tank.

Test Setup

The total duration of the test was 30 minutes, and 116 pounds of clay-laden soil was added to 250 gallons of water in the 300 gallon mixing tank. The sediment-laden water was mixed using external circulation with a 3 in. semi-trash pump and a garden rake (Figure 21). Continuous mixing with the pump and garden rake were used to prevent settling.

Figure 21. Photo. Sediment mixing setup.

Sample Collection

Water quality samples were collected upstream and downstream of the product (Figure 22). Samples were collected in 17 oz. jars every 5 minutes until the 30 minute mark.

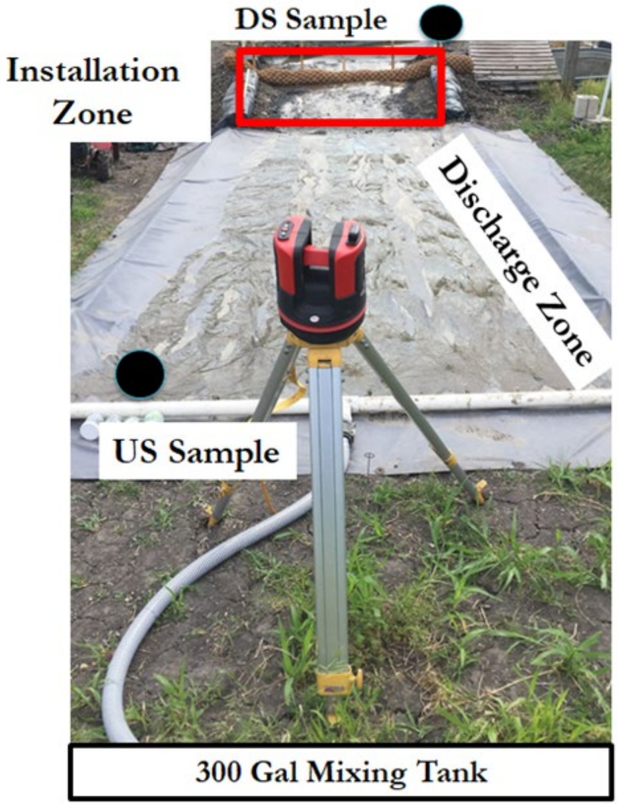


Figure 22. Photo. Testing apparatus with laser distance meter and sampling locations.

Additional data to quantify the sediment retained were taken by scanning the upstream area of the installation zone with a laser distance meter (Figure 22). The retention scanning was performed before and after the test to quantify the amount of sediment retained in the upstream area.

Laboratory Analysis

Collected samples were taken to a lab to measure total sediment concentration and turbidity in nephelometric turbidity units. To visualize and relate elevation changes to retained sediment volume, the scan data was analyzed using Microsoft Excel and SURFER 3D.

Total sediment concentration analysis is based on ASTM D3977 (ASTM, 2013). As samples were acquired during the experiment, they were organized based on time duration, from initial to final. The samples were taken to the lab where they were initially weighed (W1) (Figure 23). Jars were then placed in an oven at 98°C for 48 to 72 hours to evaporate the water. Once the water evaporated, the bottles containing soil residues were weighed again (W2) (Figure 24). The bottles were washed and weighed (W3). The weight of the soil residue was obtained by subtracting W3 from W2 (W4 = W2 − W3).

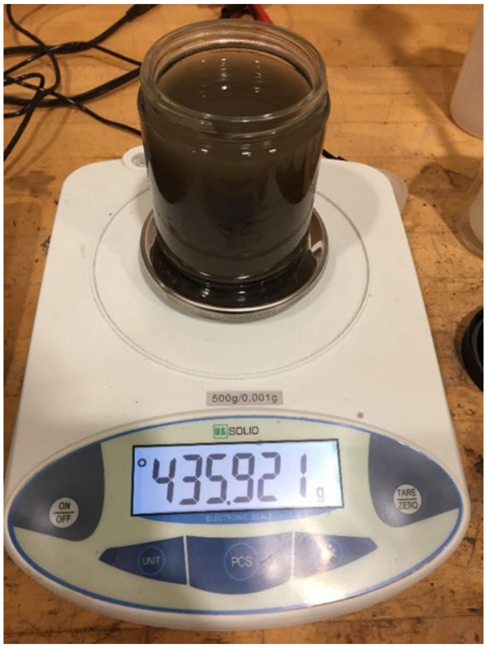


Figure 23. Photo. Water/sediment sample weighing (W1).

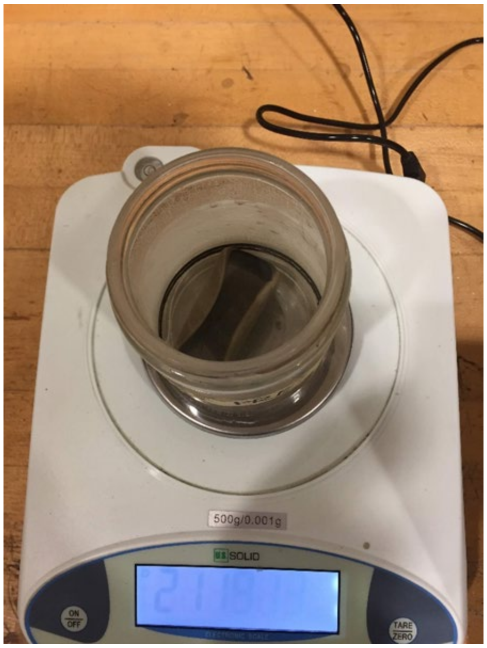


Figure 24. Photo. Dried sediment sample weighing (W2).

CHAPTER 4: OBSERVATIONS

DAMMING PRODUCTS

While the damming products performed well overall, the main concern with these products was the risk of clogging, undercutting, and/or overtopping. The fine sediment from the clay-loam soil easily clogged most materials, creating an even greater damming effect. Increased water pressure enhanced the risk of undercutting in products like the silt fence and woven monofilament geotextile. If the selected size of the product is not enough, then the backlogged water upstream could overtop products like Filtrexx Siltsoxx, ERTEC ProWattle, and triangular silt dike.

Silt Fence (IDOT-approved Fabric)

At the beginning of the test, water appeared to pass through the IDOT-approved fabric well. However, as the test continued and ponding gradually increased, the fabric clogged substantially (Figure 25). The clogging further exacerbated the amount of ponding, and the hydrostatic pressure of the ponded water caused undercutting. This occurred despite efforts to ensure the compaction of the trench backfill. By the end of the experiment, ponding was observed in the entire installation zone, and clogging of the product equated to minimal outflow compared to outflow from the undercutting. The limited outflow caused ponding to remain for 4 hours after the test ended.

Figure 25. Photo. Clogging of silt fence during testing.

Woven Monofilament Geotextile

The woven monofilament geotextile proved to have better flow rates than the IDOT-approved silt fence fabric. However, the product still caused some clogging and ponding when subjected to sheet flow conditions (Figure 26). Undercutting of woven monofilament occurred less frequently and to a lesser extent than the silt fence.

Figure 26. Photo. Woven monofilament geotextile flow.

Filtrexx Siltsoxx (Compost Log)

Filtrexx Siltsoxx proved to drain considerably better than the silt fence. The product had a consistent flow rate once ponding reached a certain height (Figure 27-A). The weight of the product ensured good ground contact, and no undercutting was observed. The ponding depth was almost 8 in., which could cause overtopping for the 8 in. high product, while it was apparent that the 12 in. log would have an unlikely probability of overtopping when subjected to a similar testing condition.

A. Flow draining out of the bottom of Filtrexx Siltsoxx

B. Ponding upstream

Figure 27. Photo. Filtrexx Siltsoxx observation.

ERTEC ProWattle

ERTEC ProWattle performed similarly to Filtrexx Siltsoxx in terms of ponding and filtering. The product had a consistent ability to let water pass through, while still producing some ponding (Figure 28-A). The 10 in. ProWattle was sufficiently high for the test condition, while a product with a lesser height (6 in.) would likely be overtopped. This product appeared to have excellent filtering capabilities, and it took the least time of all damming products for ponding to subside.

A. Ponding height upstream within 1 hour of ending the test

B. ERTEC ProWattle filtering capabilities

Figure 28. Photo. ERTEC ProWattle observation.

Joint performance for ERTEC ProWattle was also tested (Figure 29). The joint provided a quick path for runoff, which can decrease the sediment trapping efficiency. Impoundment was still obvious upstream during the test; however, it helped to drain the water quickly after the test.

Figure 29. Photo. ERTEC ProWattle with junction test.

Triangular Silt Dike

The triangular silt dike performed very well but had the most severe upstream ponding among the products tested (Figure 30). The duration to ponding subsidence is the longest among the tested products. Table 1 provides an insight on the measured depths of ponding over time after the test.

A. Upstream

B. Downstream

Figure 30. Photo. Triangular silt dike observation.

Table 1. Ponding Depth

Time	Right after the test	30 min later	1 hr later	2 hr later	4.5 hr later	6.5 hr later
Ponding depth	3.8 in.	2 in.	1.2 in.	0.8 in.	0.4 in.	< 0.4 in.

FILTERING PRODUCTS

All filtering products tested were 3D log in nature except GeoRidge. A few filtering products also created ponding similar to damming products. However, the ponding depth and extent were several magnitudes lesser compared to damming products. Downstream flow rates were higher for the filtering products than damming products. The main concern with these rolled log products was the ability to maintain good ground contact throughout the test. Attention to staking and ground preparation were key for successful performance of these products.

Sediment Log

The biggest issue with this product was maintaining good ground contact in between stakes. Staking the product through the aspen wood fiber was also difficult. To achieve the necessary ground contact, staking was applied at 45° angles. However, undercutting was still observed (Figure 31-A). Obvious impoundment was observed during the test right before the product, but the ponding depth and extent were limited in nature (Figure 31-B) compared to damming products.

A. Undercutting still occurred in spite of 45° angle staking

B. Impoundment right before the product

Figure 31. Photo. Sediment log observation.

Coconut Coir Log

The coconut coir log performed very similarly to the sediment log. They both played a role in retaining sediment upstream by creating small impoundment upstream of the product and filtering sediment-laden water (Figure 32). Despite ponding right before the product, this product was still listed as a filtering device because ponding depth and area were much less than the damming devices. In addition, they both had undercutting issues due to poor ground contact.

Figure 32. Photo. Small-scale impoundment right before the product.

Siltworm

Siltworm was another rolled product that had difficulty maintaining good ground contact. Without trenching, the irregular-shaped material inside the filter sock would not conform to the underlying ground. Although 45° angle staking was used to pin the product on the ground, water was still able to undercut the product in a few locations.

Figure 33. Photo. Percolating water under Siltworm, rather than through it.

Straw Wattles

Undercutting occurred in a similar fashion as the sediment log. Small-scale impoundment immediately before the product was not as much as for the sediment and coconut coir logs, which is negligible in this case (Figure 34). Additionally, the materials-like straw pieces are easily taken off and mingled with runoff. The permeability seemed higher than other rolled products, which caused a higher water flow rate. There was no significant difference observed between different staking angles.

Figure 34. Photo. Almost no ponding upstream.

Terra-Tube

The observations for Terra-Tube were almost similar to the observations for the sediment log and straw wattles, as all three products are lightweight in nature. However, undercutting (Figure 36) was more evident with Terra-Tube than the sediment log and straw wattles because of its low weight compared to the other products. The product performance with staking at 90° and 45° angles were evaluated. Undercutting was observed on the upstream side for 90° angle stakes, but the water did not cut through the entire trench streamwise. Undercutting occurred through the entire trench streamwise for 45° angle stakes. This product was somewhat different from sediment log and straw wattles despite a similar shape. Terra-Tube was more rigid, which makes its contact with the ground easily affected by staking.

A. Undercutting upstream

B. Undercutting downstream

Figure 35. Photo. Undercutting for Terra-Tube.

GeoRidge

GeoRidge was a unique product in that it required the installation of an erosion control blanket underneath. Water entering the installation zone infiltrated the erosion control blanket well before reaching the product (Figure 34-A) throughout the duration of the test. The observation indicated that the blanket may be doing most of the sediment removal rather than GeoRidge. Because little or no ponding was achieved during the tests (Figure 34-B), it was difficult to attribute any of the performance statistics to GeoRidge under the testing conditions.

A. Water passed underneath the blanket

B. GeoRidge slowed down water velocity

Figure 36. Photo. GeoRidge observation.

CHAPTER 5: RESULTS AND DISCUSSION

DAMMING PRODUCTS

Overall, the damming products performed better than the filtering products in terms of sediment retention. The downstream sediment concentrations ranked as well, if not better, than that of the silt fence.

Silt Fence (IDOT-approved Fabric)

Figure 37 presents the average TSC values. The downstream TSC values for the silt fence appeared to be fairly constant throughout the test, indicating a consistent reduction in TSC between upstream and downstream samples. There was a spike in TSC for the 30 minute sample, which could correspond to an increase in coarser grain sediment leaving the mixing tank. Because the downstream grab sample did not have a similar spike, the coarse material was likely retained by the silt fence. Figures 38 through 40 highlight a decrease in downstream TSC values for other damming devices similar to the silt fence in nature. It is likely that the silt fence would see the same pattern if it were not for the spike in upstream TSC between 25 and 30 minutes.

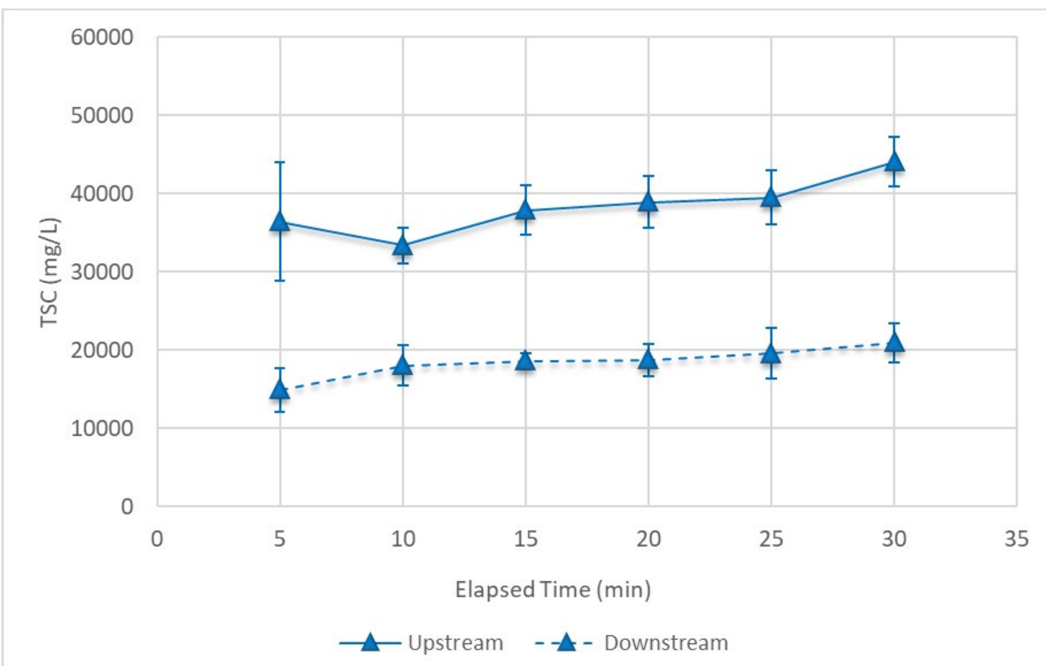


Figure 37. Graph. Average sediment concentrations for silt fence (IDOT-approved fabric).

Woven Monofilament Geotextile

The average TSC values for the woven monofilament geotextile showed a somewhat similar trend, in that the upstream sample's TSC increased as time elapsed (Figure 38). However, the mix appeared to have equilibrated at the 15 minute mark, reaching a maximum value slightly higher than that of the silt fence. The downstream TSC values continued to increase slightly from the 15 minute mark to the

20 minute mark, at which point they evened out and even declined from the 25 to 30 minute mark. This indicated a slight lag in the TSC values between the upstream and downstream samples due to the ponding nature of the woven monofilament. The increase in ponding throughout the test allowed the finer sediment to settle out of the solution such that the downstream TSC values decreased as time elapsed. Overall, the performance of the woven monofilament geotextile was similar to that of the silt fence.

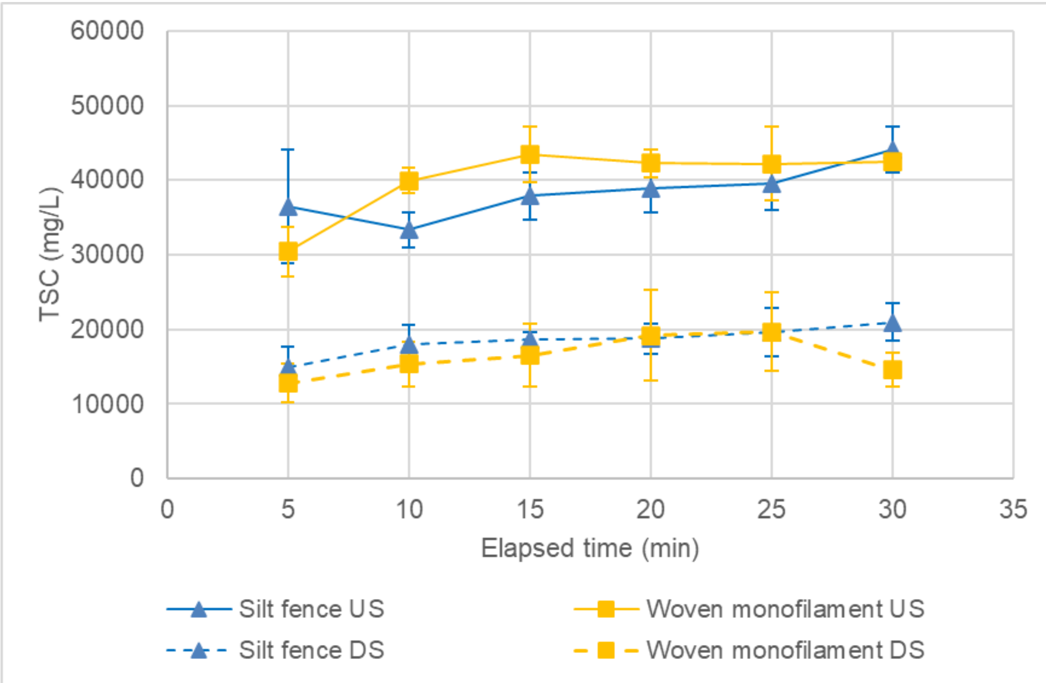


Figure 38. Graph. Average sediment concentrations for woven monofilament geotextile.

Filtrexx Siltsoxx (Compost Log)

The compost log test results showed a similar trend to that of the woven monofilament fabric. The upstream TSC values were fairly uniform throughout the test (Figure 39). Likewise, the downstream TSC values were roughly constant and different from the upstream values. The main difference between the compost log and silt fence was lower downstream TSC values for the compost log. Like woven monofilament, there was a slight decrease in downstream TSC seen between the 25 and 30 minute mark, representative of the damming nature of the product. The downstream TSC values showed the same trend, as upstream TSC values changed within the first 5 minutes. This indicated Filtrexx Siltsoxx performed similarly to a filtering product at the beginning of the storm event. During this duration, sediment was more likely to be trapped in Filtrexx Siltsoxx rather than subsidence upstream. The upstream TSC values increased slightly as time went by, and downstream TSC values were constant. At this point, Filtrexx Siltsoxx started to perform as a damming product.

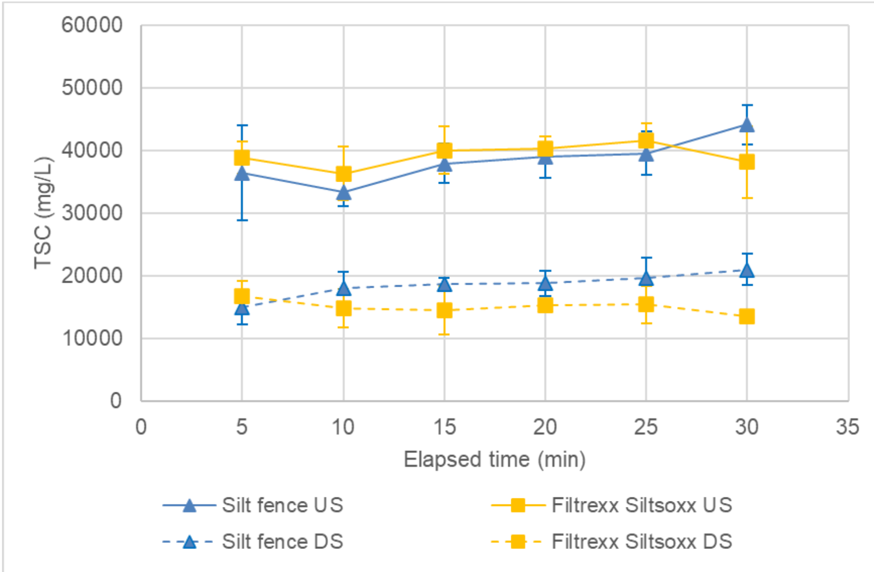


Figure 39. Graph. Average sediment concentrations for Filtrexx Siltsoxx.

ERTEC ProWattle

Upstream TSC values were comparable to the values for other tested products. ERTEC ProWattle maintained a relatively constant difference between upstream and downstream TSC values (Figure 40). The downstream values were lower than those of the silt fence. The downstream TSC values were similar at 25 and 30 minute samples, which was different from the woven monofilament or Filtrexx Siltsoxx with a sharp decrease after 25 minutes. This meant upstream sediment-laden water still infiltrates through ERTEC ProWattle with a constant rate at the end of the test, even after the test. This result accorded with the observation in Chapter 4 that ERTEC ProWattle took the least time of all damming products for ponding to subside.

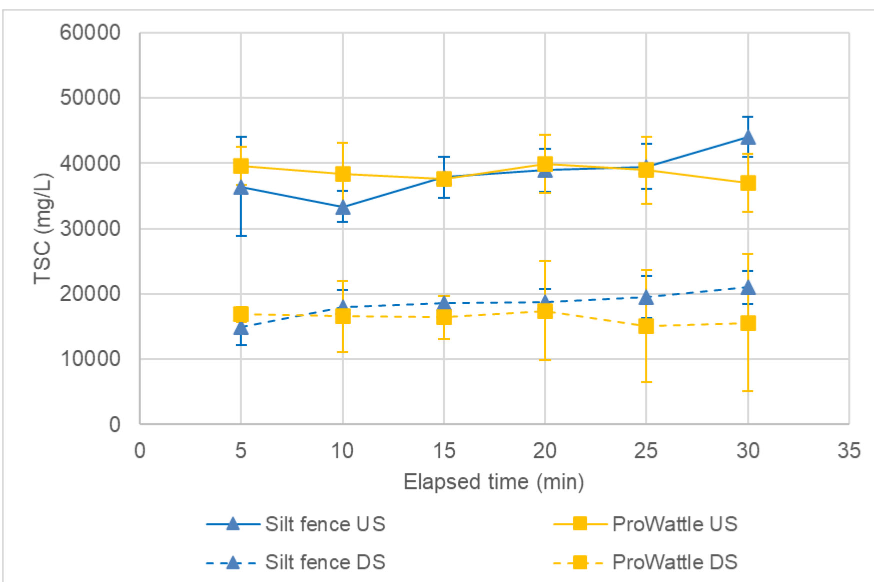


Figure 40. Graph. Average sediment concentrations for ERTEC ProWattle.

Triangular Silt Dike

Upstream TSC values were slightly higher compared to other tests. The triangular silt dike had the lowest downstream TSC values. Before 20 minutes, the downstream TSC trend was in accordance with the upstream TSC trend. However, downstream TSC values continued going down even though the upstream TSC value was going up. This represented the ponding was high enough for sediment to settle down upstream even though runoff was still coming. Even if the upstream sediment concentration was a little bit higher, the downstream concentration was still much lower than that of the silt fence, which meant the triangular silt dike performed very well in reducing sediment concentration downstream.

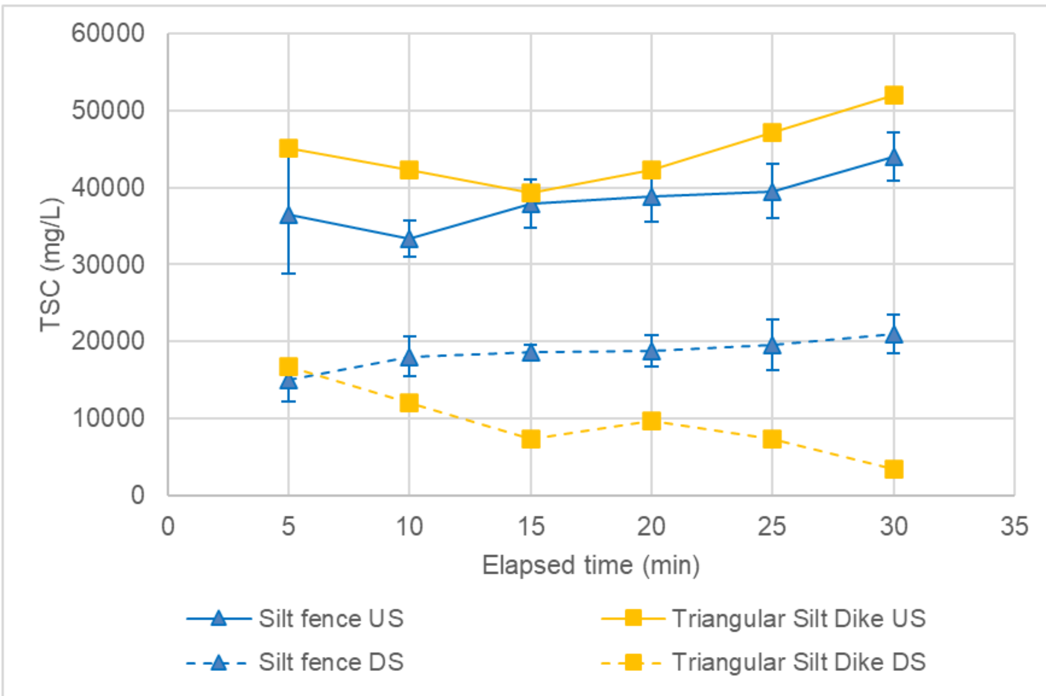


Figure 41. Graph. Average sediment concentrations for triangular silt dike.

FILTERING PRODUCTS

In general, the filtering products performed worse than the silt fence except for the sediment log (45° angle) and GeoRidge. The sediment log with 45° angle staking was the best-performing rolled filtering product. GeoRidge performed well in terms of easy installation, equivalent TSC reduction, and better sediment retention.

Sediment Log

As seen in Figure 42, the downstream TSC trend was the same as the upstream TSC trend for the 90° angle staking, which reflected the nature of filtering products that runoff parameters upstream affect downstream runoff pattern directly. There was not enough time for the sediment to settle upstream, so the average downstream TSC values for sediment log were somewhat higher than those of damming products reported in Figures 38 through 41.

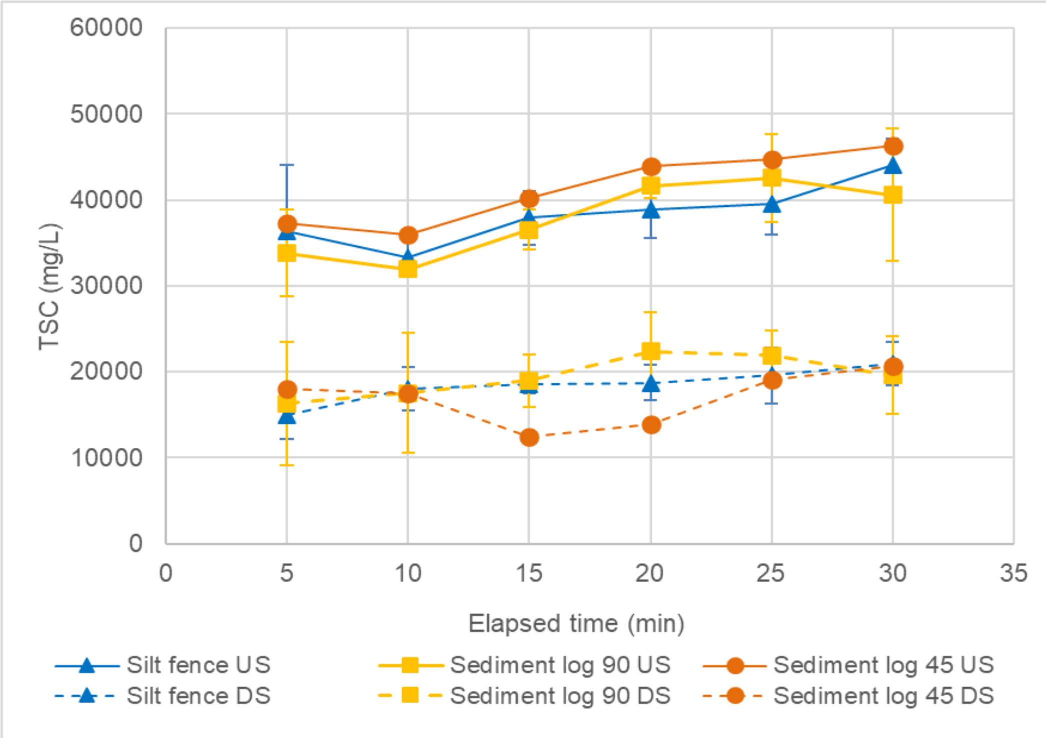


Figure 42. Graph. Average sediment concentrations for sediment log.

In addition, stakes with a 45° angle were applied to make better ground contact. During the 15 to 20 minute duration, the flow rate went down even though the upstream sediment concentration was still going up (Figure 42). This may be the reason why downstream sediment concentration during the 15 to 20 minute duration was lower than other times. Even if upstream TSC values were a little higher, the downstream TSC values were still similar to that of the silt fence. Overall, 45° angle staking really helped to improve water quality downstream in terms of lower TSC values downstream.

Straw Wattles

Downstream TSC values for straw wattles with 90° angle staking were observed to be higher than those of the silt fence (Figure 43). Straw wattles have poor ground contact and a high permeability. In addition, 45° angle staking was conducted. Sediment loading in this test was much lower than usual, which could explain why most of the downstream TSC values were lower than those of the silt fence (Figure 43). Overall, a 45° angle did not play an influential role in improving downstream water quality. The current stake spacing for rolled material was 4 ft. Less spacing (2 ft) could be a potential solution to improve the product's performance.

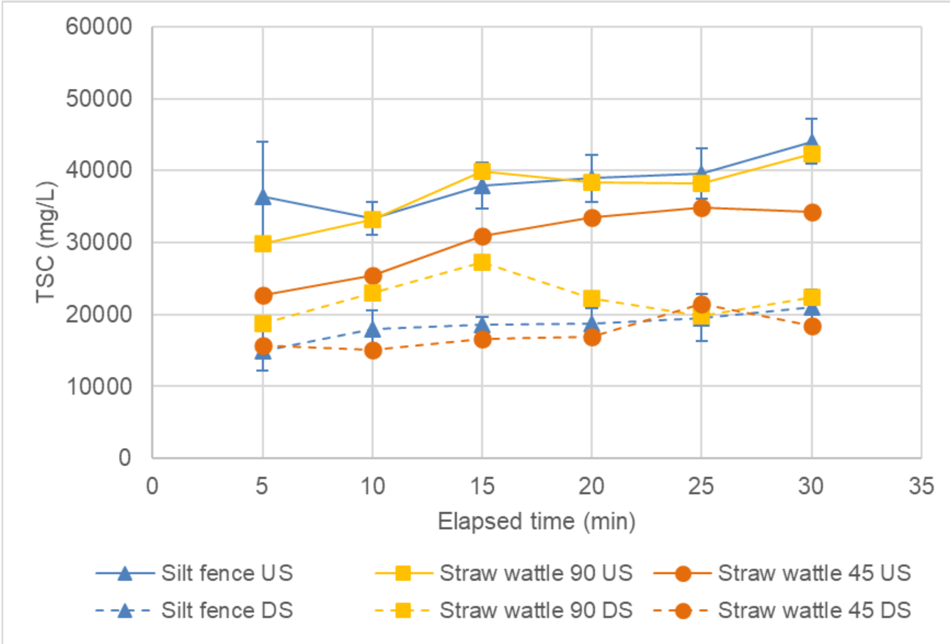


Figure 43. Graph. Average sediment concentrations for straw wattles.

Terra-Tube

For 90° angle staking, the downstream TSC values were lower than those of the silt fence (Figure 44). Downstream TSC values' changing trend almost followed that of the upstream, which reflected the nature of this product as a filtering device. Undercutting did not occur through the whole trench, only at a few locations, so the sediment could be trapped in the trench. This is also reflected by lots of sediment stuck on the bottom of Terra-Tube.

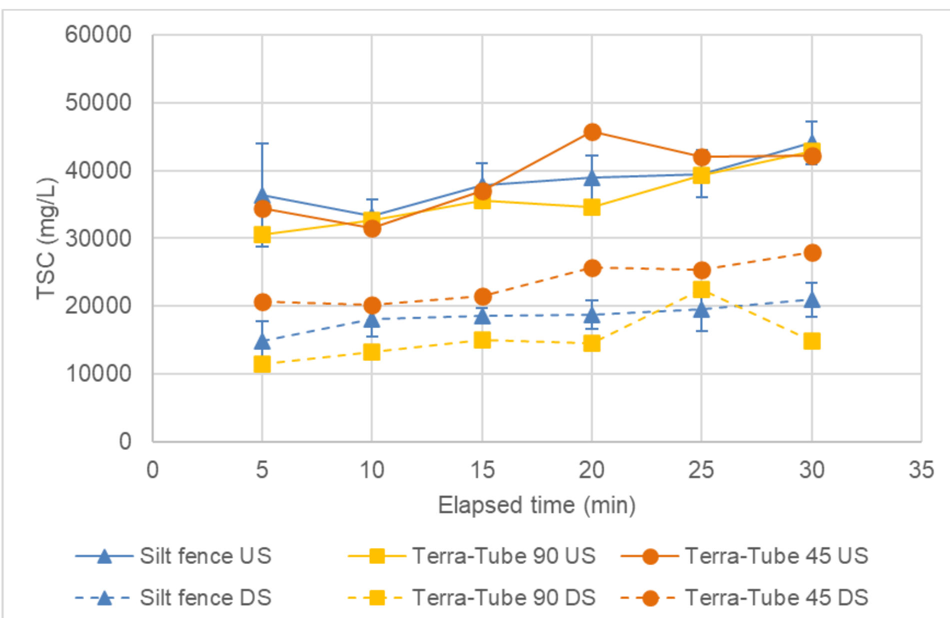


Figure 44. Graph. Average sediment concentrations for Terra-Tube.

To get better ground contact, stakes at 45° angles were applied. Contrary to the expectation, the sediment concentration downstream was higher than those of the silt fence as well as Terra-Tube with 90° angle stakes (Figure 44). A reasonable explanation could be undercutting was exacerbated even after changing the stake angle. Because of the shape of the product and the nature of the material, stakes at 45° angles could cause obvious tilt up on the front side, which further causes poor contact with the ground.

Coconut Coir Log

The downstream sediment concentration for the coconut coir log was always a bit higher than that of the silt fence during the entire test. Overall, the coconut coir log performed similarly to the silt fence in terms of downstream TSC values and trend (Figure 45).

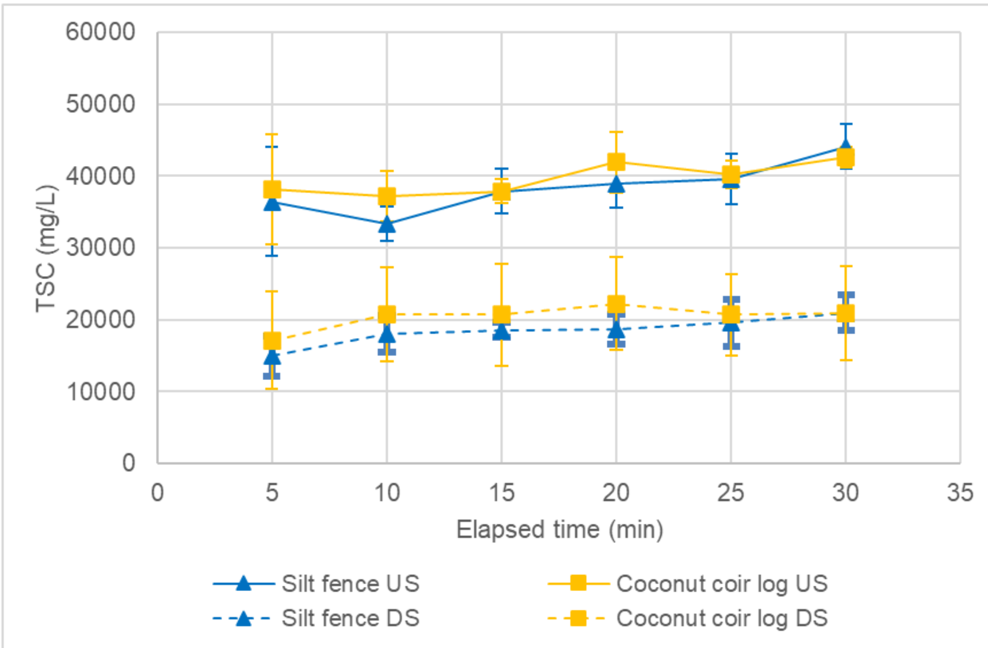


Figure 45. Graph. Average sediment concentrations for coconut coir log.

Siltworm

For Siltworm, the downstream TSC values kept increasing during the first 20 minutes, indicating the performance of the product worsened as more and more sediment-laden water was introduced upstream. After 20 minutes, the downstream values appeared to have reached a steady state. The changing trend of downstream sediment concentration almost followed the changing upstream trend, which was the nature of filtering devices (Figure 46). Overall, this product produced higher downstream TSC values than those of the silt fence at all periods during the test. Undercutting was likely occurring even if 45° angle stakes were applied. Because Siltworm did not call for trenching, it may be the reason the product did not perform like the other rolled materials (sediment log, coconut coir log, straw wattles, and Terra-Tube). Trenching and soil backfilling may improve the product's performance.

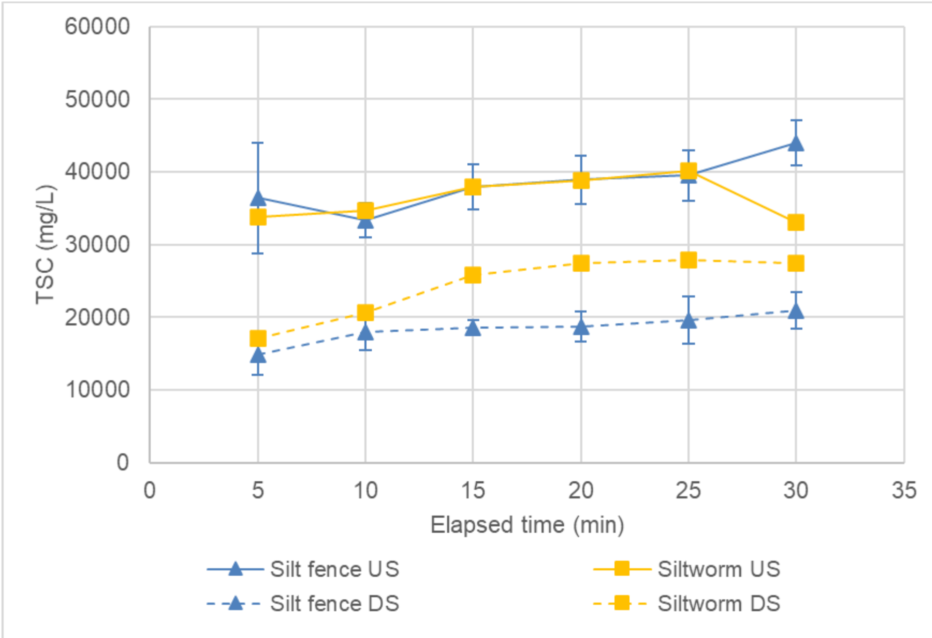


Figure 46. Graph. Average sediment concentrations for Siltworm.

GeoRidge

Overall, GeoRidge had a similar downstream TSC value compared to the silt fence. However, upstream sediment loading during this test was higher than usual (Figure 47). Therefore, the performance of GeoRidge could be considered better than that of the silt fence based on TSC reduction. The erosion control blanket played a crucial role in sediment retention and downstream water quality improvement.

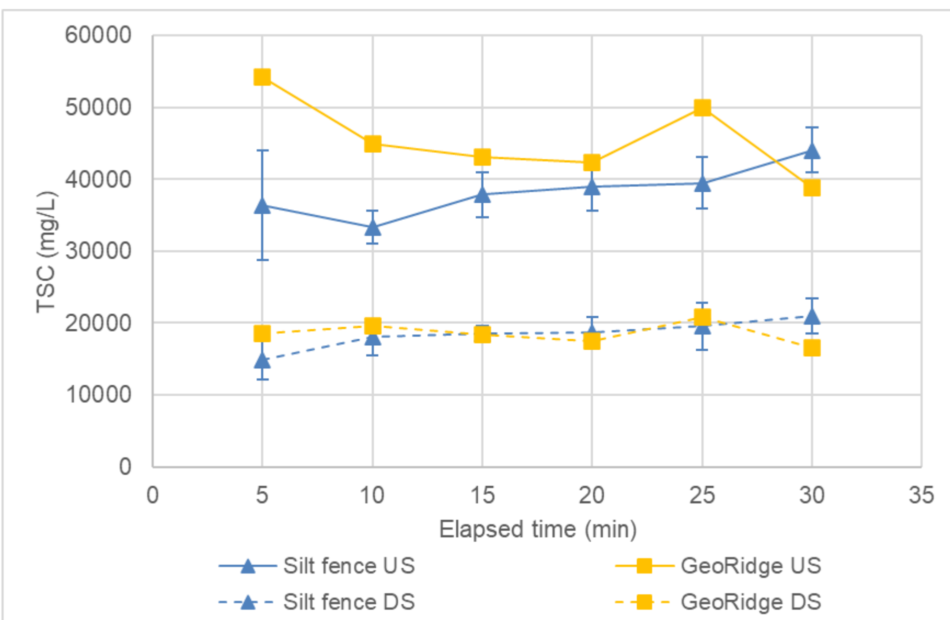


Figure 47. Graph. Average sediment concentrations for GeoRidge.

JOINT PERFORMANCE

ERTEC ProWattle with Joint

TSC values upstream for ERTEC ProWattle with a joint were higher than most tests, especially after 15 minutes. This could be why TSC values downstream were higher than those of the silt fence (Figure 48). The performance of ERTEC ProWattle with a joint could be considered the same as the silt fence in terms of TSC reduction. ERTEC ProWattle without a joint had lower downstream TSC values. This observation was in accordance with the expectation that joints were likely to reduce the effectiveness of TSC reduction. It should also be noted that the joint in ERTEC ProWattle helped to drain the ponding upstream.

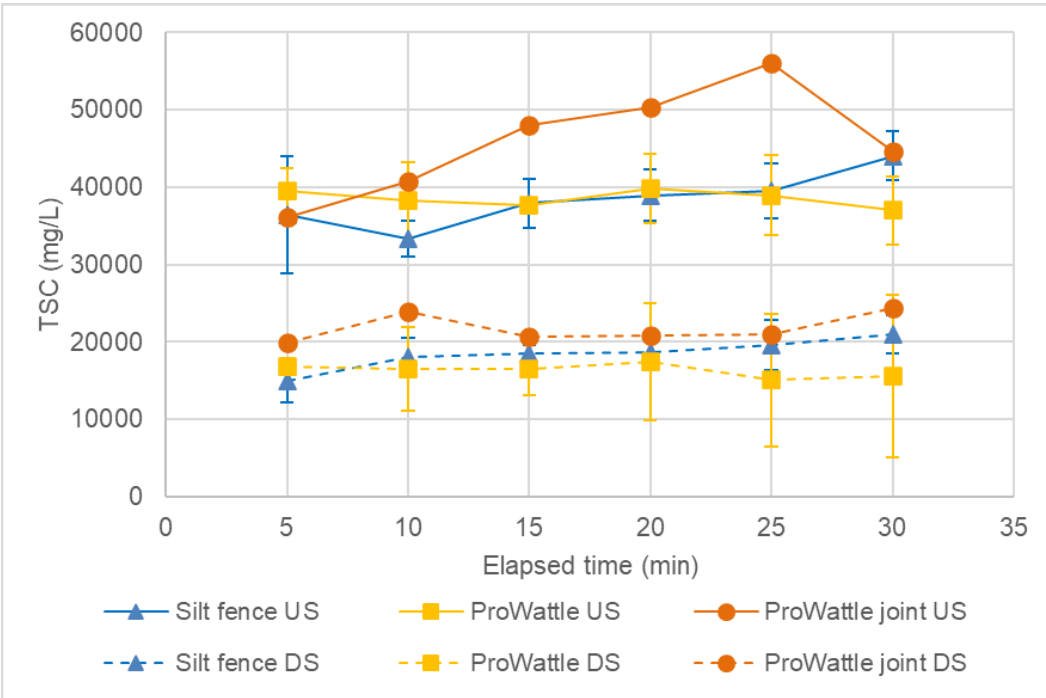


Figure 48. Graph. Average sediment concentrations for ERTEC ProWattle with joint.

Sediment Log with Joint

Three kinds of joints (overlap, butt ends, and sleeve) were tested with stakes at 45° angles. Figure 49 compared the average downstream TSC values of sediment logs with and without the joint. The results showed the overlap joint had the worst performance among all the joints due to the highest downstream sediment concentration. The butt ends joint had somewhat poor performance. Based on the average downstream sediment concentration, the sleeve joint was preferred. The performance of the sleeve joint was even better than the one without a joint when 90° angle staking was applied.

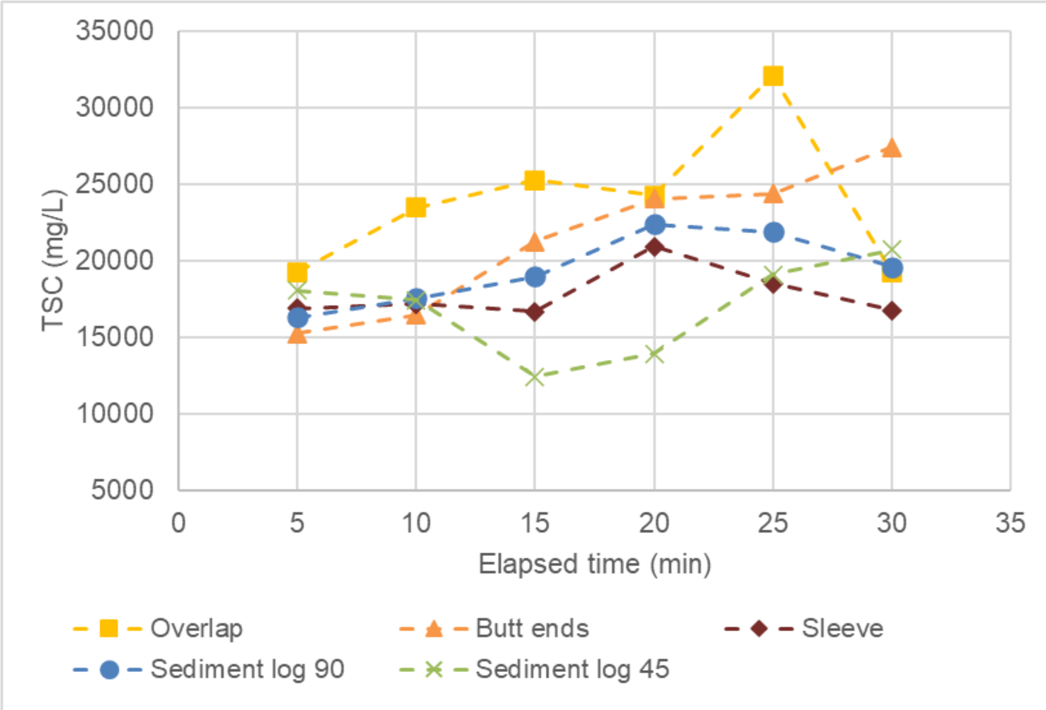


Figure 49. Graph. Average downstream sediment concentrations for sediment log with a joint.

PRODUCT COMPARISON BASED ON RELATIVE TSC REDUCTION

Figure 50 summarizes the comprehensive performance of each product. Table 2 presents the average TSC values for each product when subjected to the same testing condition. Moreover, all products were classified from A to E, based on the relative TSC reduction. To conduct the multiple-criteria decision analysis, each product was offered a score with respect to relative TSC reduction.

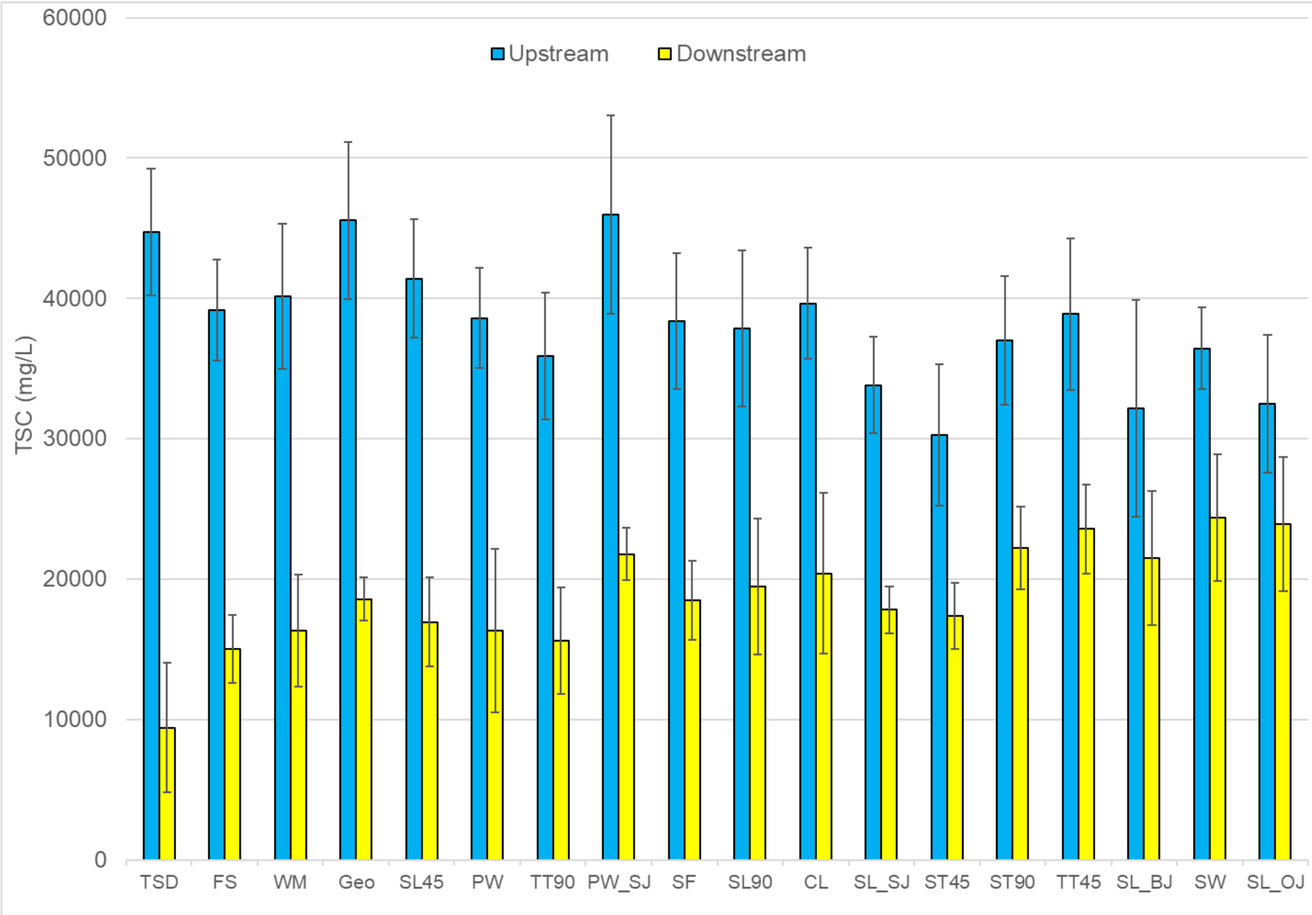


Figure 50. Chart. Comparison of average sediment concentration of perimeter barrier products.

*TSD: triangular silt dike, FS: Filtrexx Siltsoxx, WM: woven monofilament geotextile, Geo: GeoRidge, SL45: sediment log with 45° angle staking, PW: ERTEC ProWattle, TT90: Terra-Tube with 90° angle staking, PW_SJ: ERTEC ProWattle with sleeve joint, SF: silt fence, SL90: sediment log with 90° angle staking, CL: coconut coir log, SL_SJ: sediment log with sleeve joint, ST45: straw wattles with 45° angle staking, ST90: straw wattles with 90° angle staking, TT45: Terra-Tube with 45° angle staking, SL_BJ: sediment log with butt ends joint, SW: Siltworm, , SL_OJ: sediment log with overlap joint.

Table 2. Average Sediment Concentrations of Perimeter Barrier Products

Rank	Product ID*	Installation	Upstream TSC (mg/L)	Downstream TSC (mg/L)	Relative reduction	Class	Score
1	TSD	Normal	44728±4495	9420±4608	78.94%	A	4
2	FS	Normal	39174±3582	15004±2423	61.70%	B	3
3	WM	Normal	40145±5187	16357±3991	59.26%	B	3
4	Geo	Normal	45554±5616	18581±1528	59.21%	B	3
5	SL45	45° angle	41408±4221	16941±3163	59.09%	B	3
6	PW	Normal	38581±3563	16333±5824	57.67%	B	3
7	TT90	90° angle	35896±4530	15283±3775	57.42%	B	3
8	PW_SJ	Sleeve Joint	45973±7053	21775±1866	52.64%	C	2
9	SF	Normal	38371±4858	18479±2803	51.84%	C	2
10	SL90	90° angle	37863±5569	19462±4862	48.60%	C	2
11	CL	Normal	39657±3987	20420±5716	48.51%	C	2
12	SL_SJ	Sleeve Joint	33833±3432	17821±4642	47.33%	C	2
13	ST45	45° angle	30285±5051	17374±2331	42.63%	D	1
14	ST90	90° angle	36988±4571	22227±2964	39.91%	D	1
15	TT45	45° angle	38873±5388	23576±3191	39.35%	D	1
16	SL_BJ	Butt ends joint	32146±7720	21493±4784	33.14%	E	0
17	SW	45° angle	36437±2927	24378±4498	33.10%	E	0
18	SL_OJ	Overlap Joint	32477±4920	23937±4763	26.30%	E	0

*TSD: triangular silt dike, FS: Filtrexx Siltsoxx, WM: woven monofilament geotextile, Geo: GeoRidge, SL45: sediment log with 45° angle staking, PW: ERTEC ProWattle, TT90: Terra-Tube with 90° angle staking, PW_SJ: ERTEC ProWattle with sleeve joint, SF: silt fence, SL90: sediment log with 90° angle staking, CL: coconut coir log, SL_SJ: sediment log with sleeve joint, ST45: straw wattles with 45° angle staking, ST90: straw wattles with 90° angle staking, TT45: Terra-Tube with 45° angle staking, SL_BJ: sediment log with butt ends joint, SW: Siltworm, , SL_OJ: sediment log with overlap joint.

PRODUCT COMPARISON BASED ON SEDIMENT RETENTION EFFICIENCY

Leica 3D DISTO and SURFER software were used to measure and calculate retained sediment volume upstream of the products. Kriging interpolation methods was used to generate the surface based on elevation data obtained from Leica 3D DISTO. The trapezoidal rule was applied for the retained sediment volume calculation according to pre- and post-scan models. Table 3 lists the results. Sediment weight is obtained by multiplication of sediment volume and bulk density. Efficiency is calculated by the ratio of retained sediment weight and sediment loading (52.06 lb). The post-test scan for the triangular silt dike was not obtained because of unexpected rain events. Nonetheless, there was no doubt that the triangular silt dike would be rated highly based on the observation. Products were classified and scored according to sediment retention efficiency for multiple-criteria decision analysis. The visualizations of sediment retention upstream are listed as 3D surface figures in Appendix A.

Table 3. Sediment Retention Efficiency Evaluation

Rank	Product*	Specification	Volume (cc)	Sed Weight (kg)	Efficiency (%)	Class	Score
1	PW	Normal	28939	47.75	91.72	A	4
2	FS	Normal	23713	39.13	75.16	B	3
3	SL45	45° angle	21509	35.49	68.17	B	3
4	CL	Normal	19993	32.99	63.37	C	2
5	PW_SJ	Sleeve Joint	22089	36.45	60.81	C	2
6	Geo	Normal	21677	35.77	59.68	C	2
7	SL90	90° angle	17860	29.47	56.61	D	1
8	TT45	45° angle	17365	28.65	55.04	D	1
9	WM	Normal	17246	28.46	54.66	D	1
10	SL_SJ	Sleeve Joint	16511	27.24	52.33	D	1
11	SF	Normal	16024	26.44	50.79	D	1
12	SW	45° angle	14323	23.63	45.40	E	0
13	ST90	90° angle	13928	22.98	44.14	E	0
14	ST45	45° angle	10609	17.50	40.65	E	0
15	TT90	90° angle	12724	20.99	40.33	E	0
16	SL_OJ	Overlap Joint	12217	20.16	38.72	F	0
17	SL_BJ	Butt end joint	9301	15.35	29.48	F	0

*PW: ERTEC ProWattle, FS: Filtrexx Siltsoxx, SL45: sediment log with 45° angle staking, CL: coconut coir log, PW_SJ: ERTEC ProWattle with sleeve joint, TSD: triangular silt dike, Geo: GeoRidge, SL90: sediment log with 90° angle staking, TT45: Terra-Tube with 45° angle staking, WM: woven monofilament geotextile, SL_SJ: sediment log with sleeve joint, SF: silt fence, SW: Siltworm, ST90: straw wattles with 90° angle staking, ST45: straw wattles with 45° angle staking, TT90: Terra-Tube with 90° angle staking, SL_OJ: sediment log with overlap joint, SL_BJ: sediment log with butt ends joint.

PRODUCT ANALYSIS

Silt Fence

- Sediment retention: The silt fence was able to trap half of the sediment under a certain storm event in this study. As a damming device, its sediment retention efficiency (50.79%) was not high, which was the least among all damming devices and even worse than some filtering devices. The main reason was a frequent undercutting issue.
- Downstream water quality: The product was also able to reduce half of the amount of total sediment concentration. Its TSC relative reduction is the least among all damming devices, even worse than some filtering devices. The main reason was a frequent undercutting issue as well.
- Ease of installation/removal: This product was difficult to install because of the need for proper trenching, staking, and tightness between stakes. If the product was not installed correctly, then severe undercutting would occur. Because the fabric is not degradable, removal of the product is necessary and energy consuming.
- Ponding: The product was prone to clogging, leading to immediate ponding after the test started. Ponding further exacerbated the flaws in the product by increasing the chance of undercutting.

- Product failure: Undercutting was the biggest potential problem with the silt fence. The poor porosity of the material created significant ponding. Extreme ponding put a considerable amount of stress on the product as the water level rose, which would lead to increased chances of failure. In addition, inadequate backfilling caused undercutting between stakes.

Woven Monofilament Geotextile

- Sediment retention: The woven monofilament geotextile was effective as it trapped slightly more sediment than the silt fence. However, it still has the second-lowest sediment retention efficiency (54.66%) compared with other damming devices. Despite obvious impoundment, the woven monofilament geotextile did not clog like the silt fence.
- Downstream water quality: Compared with sediment retention performance, the woven monofilament geotextile performed well in improving downstream water quality, considering its nearly 60% TSC relative reduction. Lower undercutting due to higher water flow rate helped the product continually maintain its function to reduce sediment concentration downstream.
- Ease of installation/removal: This product was quite difficult to install because of the need for proper trenching, staking, and tightness between stakes. Undercutting would occur if any part of the installation process were neglected. Because the fabric is not degradable, removal of the product is necessary and energy consuming.
- Ponding: Ponding was apparent, but less than that of the silt fence.
- Product failure: Undercutting could be a serious issue with the woven monofilament geotextile if not installed correctly. Poor placement of the product in the trench and poor compaction would lead to undercutting and erosion around the stakes.

Filtrexx Siltsoxx (Compost Log)

- Sediment retention: Filtrexx Siltsoxx was quite effective as it trapped more sediment than the other products tested, except for the triangular silt dike and ERTEC ProWattle. Despite a high level of ponding, Filtrexx Siltsoxx could handle sediment load and filter it efficiently. Observations during the test showed that this product was a significant improvement over the standard silt fence.
- Downstream water quality: Filtrexx Siltsoxx was quite effective in reducing TSC downstream. Its relative TSC reduction was slightly more than 60%, which ranked second among all products tested.
- Ease of installation/removal: Filtrexx Siltsoxx was somewhat tricky to install. The excessive weight of the product made it difficult to maneuver. More than one person was required when working with a segment with a 12 in. diameter. Once the product was in place, the installation was simple because it did not require trenching and backfilling. Filter media should be dispersed and incorporated with soil as an amendment after construction activity has been completed. However, the mesh netting material needs to be removed

because it is generally polypropylene. The mesh netting may be left on-site if it is photodegradable or biodegradable.

- Ponding: Ponding was apparent but less than that of the silt fence. Ponding depth receded to less than 1 in. within an hour of ending the test, but the final ponding would not drain under gravity.
- Product failure: No product failures were observed in this study. The unit weight of the product is influential in avoiding undercutting by maintaining good ground contact. A 12 in. high product is unlikely to be overtopped, but an 8 in. product has a risk of overtopping in a similar condition as in this study.
- Contamination concern: A potential contamination issue due to a washout from the compost materials is a rising concern. Although some pathogens (fecal coliform, E. coli, and salmonella) and unwanted seeds could be destroyed by thermophilic temperatures of 122 to 140°F (50 to 60°C) during the composting process (Robert, 2000), pathogens were present in composts produced in Washington, Oregon, and California (Brinton, 2009). However, a study from Cornell University reported that most composts used in the study would have passed the biological safety testing applicable to sewage sludge composts (Bonhotal, 2008). Therefore, there are still some disputes, and results depend primarily on facility conditions and specific processing. If this product is selected as a SPB, it is recommended to verify parameters of interests of feedstocks in-process and compost products at the point of sale according to Test Methods for the Examination of Composting and Compost (TMECC) guidelines issued by USDA and US Composting Council (Thompson, 2002). It is also recommended to do further research to examine downstream water samples in terms of the concentration of contaminants.

ERTEC ProWattle

- Sediment retention: ERTEC ProWattle was the most effective at retaining sediment upstream. The sediment retention efficiency is up to 91.72%. Ponding continued to increase steadily throughout the test, but the product maintained filtering capabilities. The only way to join this product was to use a sleeve joint, which resulted in a slight decrease in sediment retained volume. However, the test with a joint still performed better than the silt fence.
- Downstream water quality: ERTEC ProWattle was able to improve downstream water quality. However, it was not as efficient in retaining sediment upstream, but it still had 57.67% relative TSC reduction. It still performed at the same level as the silt fence, despite the sleeve joint.
- Ease of installation/removal: ERTEC ProWattle was easy to install and remove. ERTEC ProWattle was lightweight and required minimal trenching and staking. Backfilling was tricky because the horizontal flap tended to flip up, weakening the soil compaction.
- Ponding: Ponding depth decreased to roughly 1 in. within an hour of the test completion, but the final inch would not drain under gravity. A subsequent storm event caused a risk of

overtopping. ERTEC ProWattle took the least time to ponding subsidence upstream. A sleeve joint helped to drain water upstream.

- Product failure: The main concern with this product was the risk of overtopping. Despite good filtration, ponding still occurred to the point that back-to-back events may lead to overtopping. According to the results, there is no need to worry about joint failure.

Triangular Silt Dike

- Sediment retention: The triangular silt dike was the most effective at preventing sediment from flowing downstream.
- Downstream water quality: The triangular silt dike had the highest relative TSC reduction (78.94%).
- Ease of installation/removal: This product was somewhat easy to install and remove. There was no need to hammer stakes into the soil, which is energy saving.
- Ponding: Ponding was very severe. The triangular silt dike took the longest to drain water upstream of the product. After the test, water drained quickly during the first hour, but the rate was slow afterward. A subsequent storm event could cause overtopping.
- Product failure: The only concern with this product was the risk of overtopping.

Sediment Log

- Sediment retention: The sediment log was fairly effective, as it performed as well as some damming devices. It had a sediment trapping efficiency of 68.17% when 45° angle staking was applied, which was the highest among all filtering devices. It performed best among all filtering devices when trenched and good ground contact was ensured.
- Downstream water quality: The sediment log with 45° angle staking performed well to reduce sediment concentration downstream with nearly 60% relative TSC reduction, even slightly higher than ERTEC ProWattle.
- Ease of installation/removal: This product was fairly difficult to install because of the trenching required and the difficulty of getting the stakes through the material. In general, the product was slightly less difficult to install than the silt fence. However, it was easier to remove than the silt fence because the material was degradable.
- Ponding: This product produced minimal to no observed ponding. Minimal ponding occurred right before the product.
- Product failure: Undercutting was the biggest issue with this product, which was primarily associated with improper trenching and staking. Therefore, proper installation and maintenance were strongly recommended for this product. Moreover, overlap and butt ends joints caused a sharp decrease of sediment retention.

Coconut Coir Log

- Sediment retention: The coconut coir log was effective at trapping sediment upstream. Its performance was only worse than the sediment log with 45° angle staking among all filtering devices and was better than the silt fence. Despite having less retained sediment than the ERTEC ProWattle with a sleeve joint and GeoRidge, the coconut coir log still had a higher sediment retention efficiency considering the high sediment loading applied to the ERTEC ProWattle (joint) and GeoRidge tests.
- Downstream water quality: Compared with sediment retention performance, the coconut coir log did not perform as well at reducing sediment concentration downstream. The relative TSC reduction was similar to that of the silt fence.
- Ease of installation/removal: The coconut coir log was not as difficult as the sediment log to install because stakes were placed right behind the product rather than penetrating the product. It is difficult to penetrate the product to insert a stake. There is no need to remove this product because it is biodegradable. In general, the product was less difficult to install than the silt fence.
- Ponding: Ponding was not as severe as the silt fence but was slightly more than other filtering products.
- Product failure: Undercutting was the biggest concern. It was primarily associated with improper trenching and poor ground contact.

Siltworm

- Sediment retention: Siltworm was not as effective as the silt fence at retaining sediment upstream. Its sediment retention efficiency was less than 50%, which was in the lower tier and only better than straw wattles and Terra-Tube.
- Downstream water quality: Siltworm was among the least effective products tested to improve water quality downstream. It only had 33.1% relative TSC reduction, which is much less than that of the silt fence (51.84%).
- Ease of installation/removal: This product was heavier than other rolled materials and needed more effort to maneuver. It normally needs two people to handle a 12 in. product. There was no call for trenching in this study. In general, Siltworm is as difficult as the silt fence to install and remove.
- Ponding: This product produced minimal to no ponding during the testing.
- Product failure: Undercutting was the biggest issue with this product. The irregular shape of the product along with no trenching led to substantial undercutting. Once undercutting occurred, the product no longer worked as intended to retain sediment.

Straw Wattles

- Sediment retention: Straw wattles was among the least effective of the products tested. It filtered less sediment than the silt fence no matter what angle staking was applied.

- Downstream water quality: Straw wattles was among the least effective of the products tested. Its relative TSC reduction was only about 40%, which was only better than siltworm and some sediment log joint tests.
- Ease of installation/removal: This product was somewhat easy to install. It was easier to hammer stakes through the product into the soil compared with other rolled products because straw wattles had larger permeability. There is no need to remove the product because straw was a good amendment to improve soil fertility.
- Ponding: This product did not create ponding.
- Product failure: The main concern with this product was the risk of undercutting due to poor contact with the ground. Proper trenching was vital to perform well for this product. It was not helpful to use 45° angle staking to pin the product on the ground.

Terra-Tube

- Sediment retention: Terra-Tube was among the least effective of the products tested. This product had the lightest weight among all rolled products, which caused poor contact with the ground. Staking at a 45° angle really helped to retain more sediment upstream. Trenching and staking could be very helpful to trap sediment but still needs to be verified by more tests.
- Downstream water quality: Terra-Tube was slightly better than the silt fence at reducing sediment concentration downstream. This effectiveness did not reflect in the way of enough sediment retained upstream because most of the sediment was trapped under the product in the trench. Staking at a 45° angle did not perform as expected because severe undercutting occurred in that test, which caused soil detachment downstream due to a high flow velocity.
- Ease of installation/removal: This product was very hard to penetrate by a stake. A knife was necessary to dig a small hole in the product before installation in terms of the convenience of hammering stakes. Trenching and staking were applied.
- Ponding: This product did not create ponding.
- Product failure: Undercutting was the primary concern of failure. Proper trenching was vital to perform well for this product. Reducing the installation angle of stakes is another approach to improve ground contact and avoid failure. However, the function of staking still needs more tests to verify this.

GeoRidge

- Sediment retention: Although the sediment retention efficiency of this product was lower than some filtering devices, such as sediment and coconut coir logs, GeoRidge was still nearly 60%, which was 10% higher than that of the silt fence.

- Downstream water quality: This product had the best performance among all filtering devices. Its relative TSC reduction was nearly 60%, which was almost 10% higher than that of the silt fence.
- Ease of installation/removal: This product was easy to install. GeoRidge dams are very light and can be reused in future projects. An erosion control blanket can be left on site in terms of biodegradable materials. However, the netting normally is nonbiodegradable and easily gets tangled with mowing equipment and wildlife. Therefore, it is recommended to remove the erosion control blanket unless it is net-free.
- Ponding: As a filtering device, this product did not create ponding.
- Product failure: There is no obvious concern of failure with this product. In addition, GeoRidge dams were connected to each other to take the function, so the joint was inherent with the installation of this product. Therefore, there was no need to worry about joint failure.

Rolled Products Summary

- In this study, the rolled products tested include Filtrexx Siltsoxx, sediment log, coconut coir log, siltworm, straw wattles, and Terra-Tube. Among these six products, only Filtrexx Siltsoxx is a damming device. All logs used in this study were 12 in. diameter products.
- Technical performance: Filtrexx Siltsoxx and sediment log (45° angle staking) were two effective products whether in the performance of sediment retention or water quality improvement downstream. Siltworm and straw wattles were the least effective and were not recommended unless more proper installation methods were applied. The coconut coir log and Terra-Tube were in the medium level with effective performance in just one aspect, either sediment retention or downstream water quality.
- Installation: All the logs are toed-in with a 6 in. deep trench, except Filtrexx Siltsoxx and siltworm. The Filtrexx Siltsoxx tested in this study was heavy enough (12–30 lb/ft) to maintain good ground contact, so there was no trenching. There was no trenching for Siltworm, per the instructions by Siltworm Inc. However, according to the test results, it is recommended to trench Siltworm. In general, trenching and staking are helpful to improve performance. Staking at a 45° angle fortified the function of the sediment log, but it did not bring obvious benefits to others. Sleeve was the most preferred way to make a joint. In addition, compared with the current stake spacing (4 ft), 2 ft spacing could be better to avoid frequent undercutting between stakes.
- Ponding: Most logs did not create large-scale ponding upstream. Only Filtrexx Siltsoxx had obvious ponding. Sediment and coconut coir logs had minimal ponding upstream of the product.
- Product failure: The primary concern of failure for rolled products was undercutting. Proper trenching, backfilling, and staking was fundamental to take the function for logs. Filtrexx Siltsoxx with an 8 in. product had an overtopping concern.

- Despite the similar shape of these rolled products, they still have different physical characteristics (such as tightness and rigidness of the product) due to the filling intricacy of interior material, so it is hard to have a universal way to stake and join them. It is case by case, generally. For example, 45° staking improves sediment log performance but may be challenging to implement for Terra-Tube.
- Trenching and backfilling are recommended for rolled products due to inherent poor ground contact, especially when the product is not heavy enough. However, trenching and backfilling still cannot eliminate undercutting issues completely. Considering the good performance of the erosion control blanket used in the GeoRidge test, the erosion control blanket could be used in junction with the rolled products as an alternative to trenching and backfilling.

VEGETATED BUFFER STRIPS TEST

There are many previous studies on the effectiveness of vegetated buffer strips (VBSs). Yuan (2009) conducted a review study on sediment trapping effectiveness of VBSs in the agricultural field. The test protocol in this study was developed according to Natural Resources Conservation Service (NRCS) conservation practices training guide (NRCS, 1999). Abu-Zreig (2004) had a similar test protocol with a study on runoff reduction and sediment removal by VBSs. Overall, this protocol was almost the same as the previous product test. However, there were still some adjustments in this case. Figure 51 shows the test apparatus. First, there was no need for scanning by 3D DISTO because sediment was trapped in the buffer. Secondly, turbidity and TSC determination were not necessary for the buffer test because there was almost no downstream sample for most of the cases. The only evaluation criteria was sediment trapping efficiency (Figure 52).

Figure 51. Photo. Buffer test apparatus.

$$\textit{sediment trapping efficiency} = 1 - \frac{\textit{sediment amount downstream}}{\textit{sediment amount upstream}} \times 100\%$$

Figure 52. Equation. Equation for sediment trapping efficiency.

Figure 53. Photo. Downstream runoff collection.

Buckets were used to collect runoff downstream (Figure 53). Runoff volume downstream can be measured according to the dimension of the bucket, and sediment concentration downstream can be obtained by analyzing grab samples in the lab. Before grabbing the sample from the bucket, stirring was needed to make sure sediment-laden water was homogeneous. In this study, tests were conducted in terms of different buffer widths (5 ft, 10 ft, and 15 ft). Table 4 lists the results of the vegetated buffer strip tests.

Table 4. Vegetated Buffer Strip Test Results

Buffer width (ft)	5	10	15
Soil moisture (vol)	24.8	38.8	29.2
Runoff (L)	325	26.2	22.4
Sediment amount downstream (g)	8333	854	587
Efficiency (%)	83.99	98.36	98.87

Overall, the vegetated buffer strips performed better than any other perimeter barrier product, except for the triangular silt dike and ERTEC ProWattle, in terms of high sediment trapping efficiency. The efficiency of VBSs in trapping sediment increased as the buffer width increased. However, it was noted that there was not a significant increase in efficiency when the buffer width was over 10 ft under the flow pattern in this study. This appeared to be verified by the findings of Dillaha et al. (1989) and Parsons et al. (1991). They found that the filter length controls sediment trapping up to an effective maximum length value; thereafter, additional length does not improve filter performance. This maximum effective length depends on the source area, topography, and the hydraulic characteristics of the strip. It should also be noted that the soil moisture was slightly high for the 10 ft buffer test compared to the 5 ft or 15 ft tests. Therefore, the 10 ft (or higher) wide VBSs can be an effective sediment perimeter barrier, but the width needs to be adjusted considering storm event, slope, etc.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

CONCLUSION

Based on the observations and data analysis, the damming products performed better than the filtering products for sediment retention. However, the damming products easily have overtopping or undercutting issues to cause failure. To avoid overtopping, the design height of products needs to be considered. Undercutting is hard to avoid because backfilling soil is normally not compact enough and upstream hydrostatic pressure is increasing as ponding water level increases. The following product recommendations were made based on observations and data analysis, along with ease of installation and removal, cost, and sustainability:

1. The triangular silt dike performed the best, given it had the highest relative TSC reduction and the highest sediment retention efficiency (visual observation). Overtopping risk is a limitation for the application of this product; however, a 10 in. high triangular silt dike is not going to have overtopping under the storm event in this study.

2. ERTEC ProWattle, GeoRidge, Filtrexx Siltsoxx (compost log), woven monofilament geotextile, and sediment log also performed better or similar to the silt fence. Among these five products, ERTEC ProWattle has the best technical performance. ERTEC ProWattle can be considered a better alternative because it is reusable, easy to install, and less affected by wind (due to its height). However, a 10 in. height has to be ensured to avoid overtopping under the storm event in this study. Moreover, the performance of ERTEC ProWattle is still better than the silt fence even with a sleeve joint.

3. Filtrexx Siltsoxx is also considered a better alternative because its technical performance is just slightly lower than ERTEC ProWattle's and is much better than the silt fence. The size (product diameter) and weight of Filtrexx Siltsoxx affects performance directly. In this study, ponding depth upstream was almost 8 in., so it is likely to have an overtopping issue if an 8 in. product was applied. A 12 in. product does not need to worry about overtopping. Light Filtrexx Siltsoxx is likely to have undercutting. Under the storm event in this study, 12–30 lb/ft of unit weight is enough to ensure no undercutting.

4. GeoRidge and the sediment log can be considered good alternatives because their technical performances were better than those of the silt fence. They both provide an additional benefit of no overtopping. Moreover, these two products are not difficult to install. They could be preferred to the silt fence in a situation where upstream ponding would be unfavorable or impractical.

5. Stakes with a 45° angle are preferred for the sediment log to have better ground contact. Moreover, a sleeve joint should be recommended for use instead of overlap and butt ends joints in light of more sediment retention upstream and less TSC downstream.

6. The woven monofilament geotextile could be considered a potential alternative because of its similar technical performance with the silt fence. However, it is not as desired as

ERTECT ProWattle, GeoRidge, and sediment log because of its worse technical performance as well as its difficulty to install.

7. The woven monofilament geotextile performed better than the silt fence with IDOT-approved fabric because of the higher material permeability. Less-permeable fabrics create more ponding, a factor that led to failure of the IDOT-approved fabric. The silt fence with IDOT-approved fabric is less recommended due to excessive ponding upstream of the product, leading to significant undercutting. Additionally, the product is prone to failure due to high wind, which is a prevalent condition in Illinois.

8. The performances of Siltworm, coconut coir log, straw wattles, and Terra-Tube were not desired, despite coconut coir log and Terra-Tube having somewhat decent performance in sediment retention and downstream water quality. None of the products were able to reduce TSC downstream to that of the silt fence. The common drawback of these four products is lack of weight or irregular shape in order to make good contact with the ground. Alternative methods to increase ground contact and further testing are required to determine if these products can be alternatives to the silt fence.

9. Trenching and soil backfilling helped to improve the performance of the rolled products. Staking with a 45° angle is recommended for the logs (perhaps not for Terra-Tube), but 4 ft spacing was not enough to avoid undercutting. However, backfilling and staking still were not able to eliminate undercutting entirely. In light of the previous ditch check study, an erosion control blanket can be used in conjunction with log products to avoid undercutting. In this study, the GeoRidge test also reflected the beneficial aspect of erosion control blankets on sediment retention.

10. A buffer width of 10 ft (or higher) can be considered for vegetated buffer strip application, considering a 10 ft buffer is capable of trapping more than 98% of sediment.

PRODUCT SELECTION ASSISTANCE

A weighted decision matrix, which helps to rank the products and choose which one to use in a certain condition, was developed and provided to IDOT. The decision-maker can set a predetermined weight for each factor to show factor priority. The technical scores were determined from the results in this study. Ponding scores were based on product category. Filtering products had a score of 2, and damming products had a score of 1. In particular, the silt fence and triangular silt dike had a score of 0 because of severe ponding. Cost scores were obtained by incorporating material and labor costs, which is related to easement of installation. Cost scores are subject to change according to the actual prices in practice. Sustainability scores were based on product material. Products that can be reused or biodegradable were given a score of 1. Otherwise, the score was 0. Weights for criteria depend on the decision-maker’s judgement on a real situation, which can change. Specifically, weight should be determined by the decision-maker according to priority preference. Once the decision-maker sets the weight for each criteria, the total score for each product will show up because the sub-scores for each criteria of each product have been determined according to the findings in this study.

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APPENDIX A: SEDIMENT RETENTION VISUALIZATION—PRE-SCAN (LEFT) VS. POST-SCAN (RIGHT)

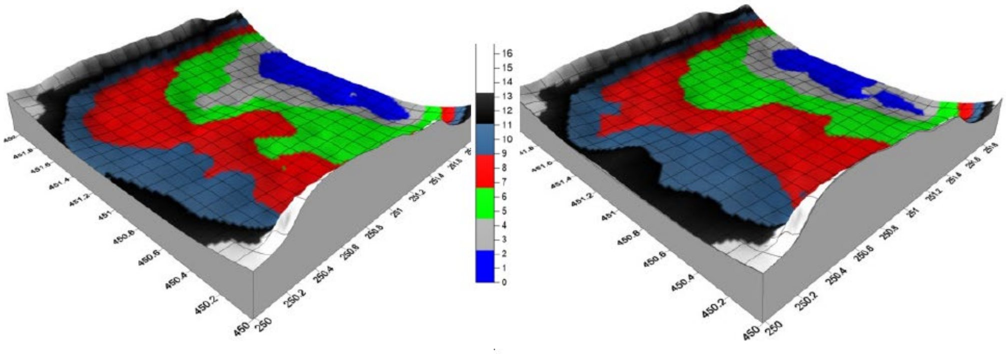

Figure 54. Graph. Silt fence.

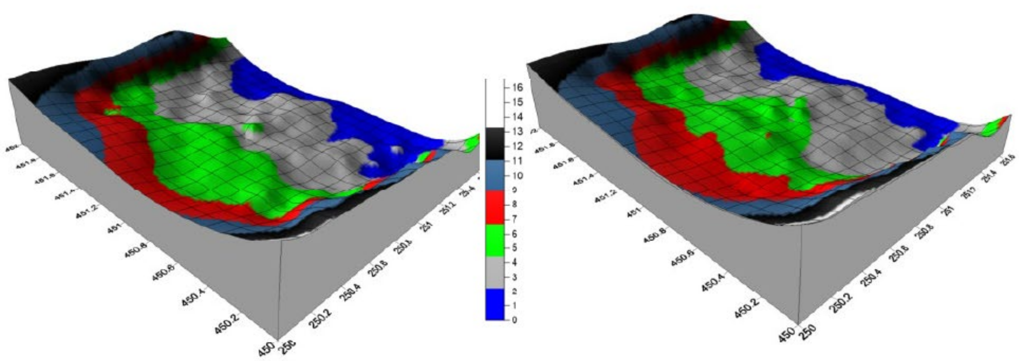

Figure 55. Graph. Woven monofilament geotextile.

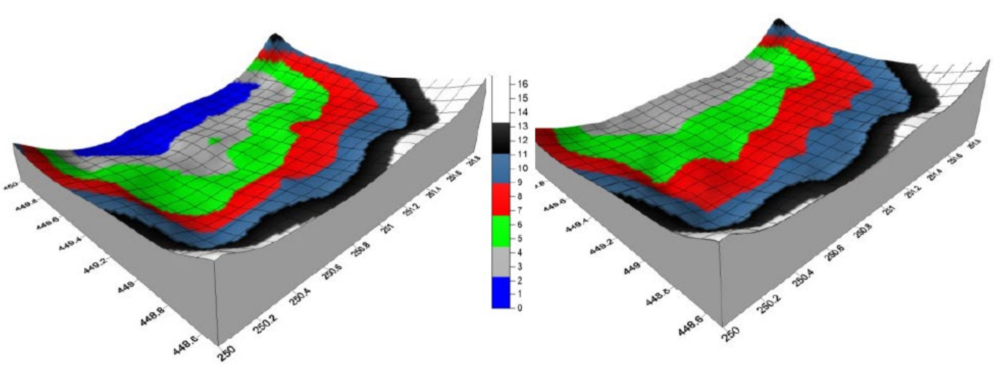

Figure 56. Graph. Compost Log.

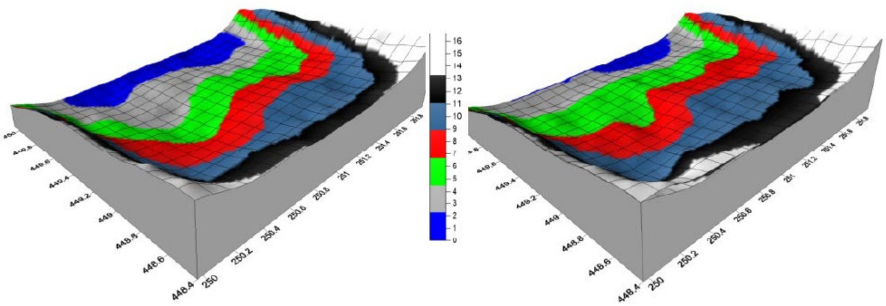

Figure 57. Graph. ERTEC ProWattle.

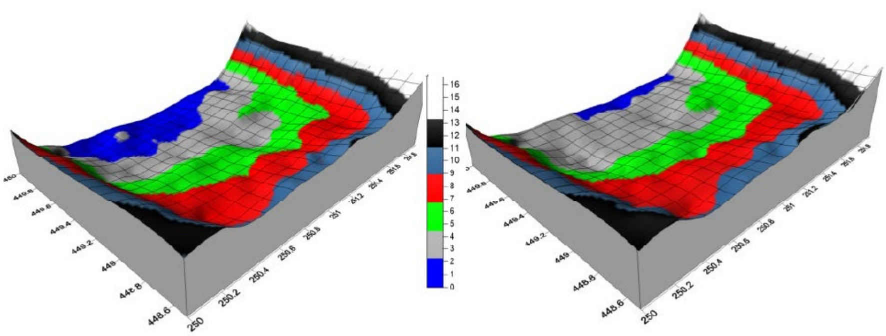

Figure 58. Graph. Sediment log 90°.

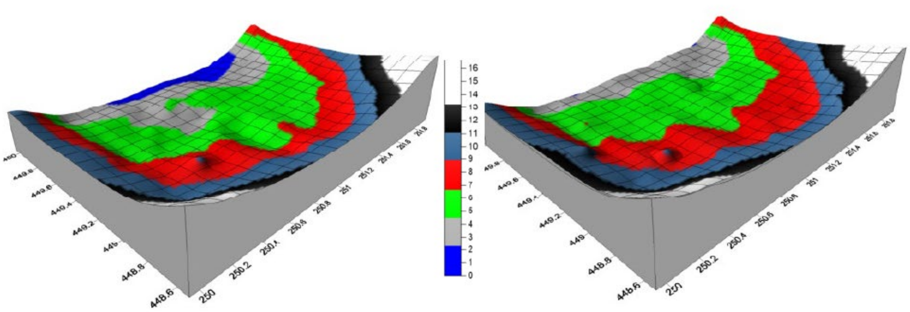

Figure 59. Graph. Coconut coir log.

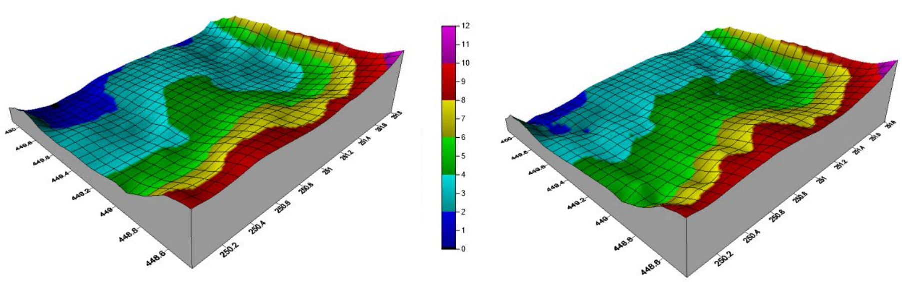

Figure 60. Graph. Siltworm.

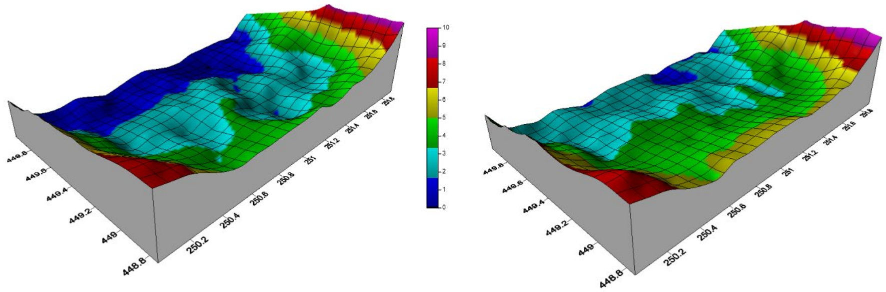

Figure 61. Graph. GeoRidge.

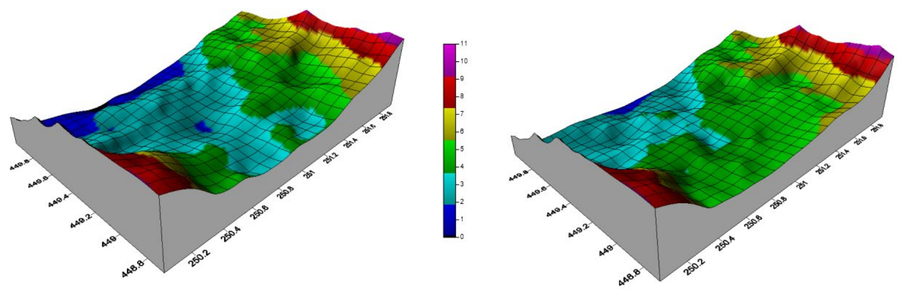

Figure 62. Graph. Straw wattles 90°.

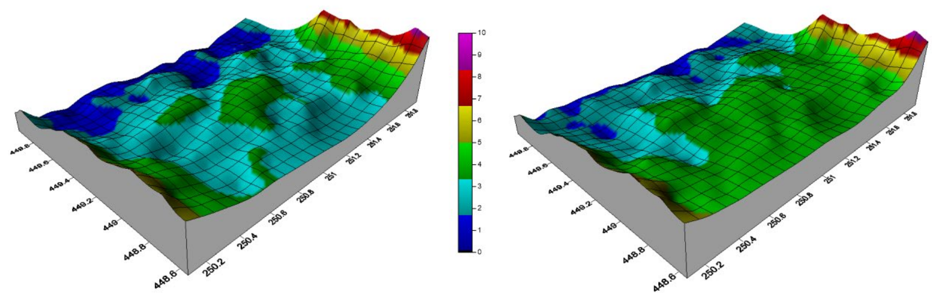

Figure 63. Graph. Terra-Tube 90°.

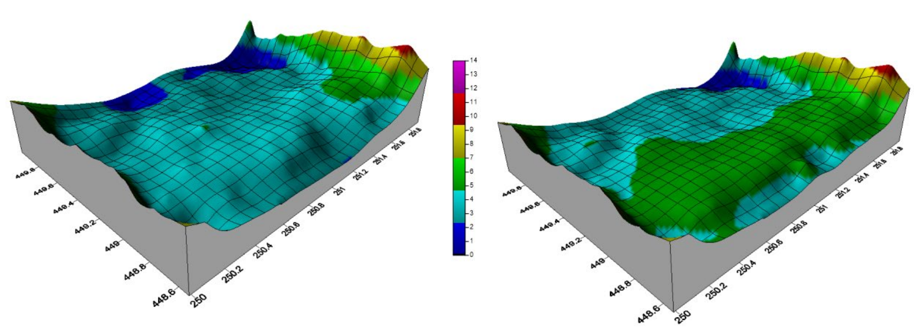

Figure 64. Graph. Sediment log 45°.

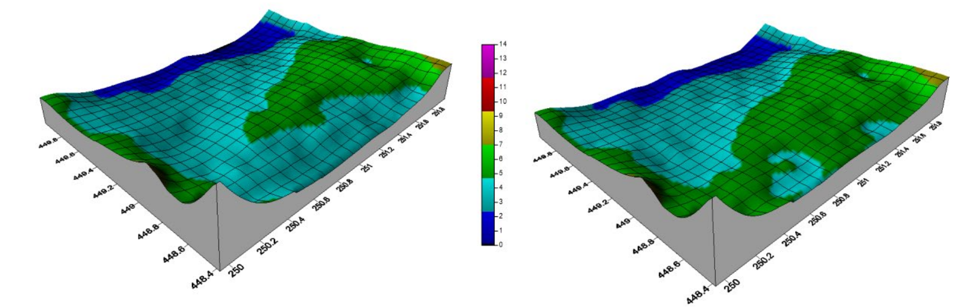

Figure 65. Graph. Straw wattles 45°.

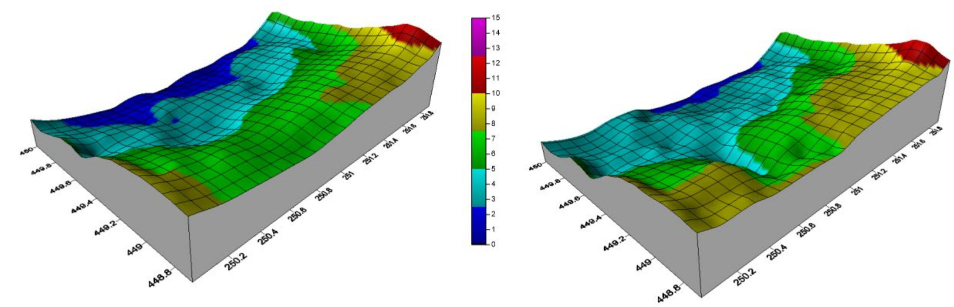

Figure 66. Graph. Terra-Tube 45°.

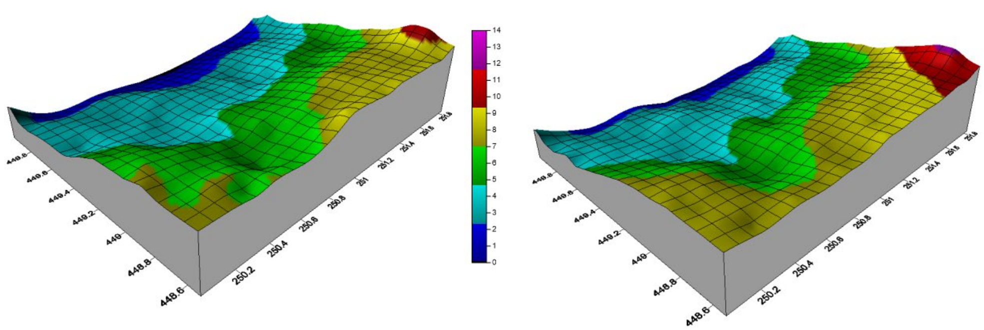

Figure 67. Graph. ERTEC ProWattle Joint.

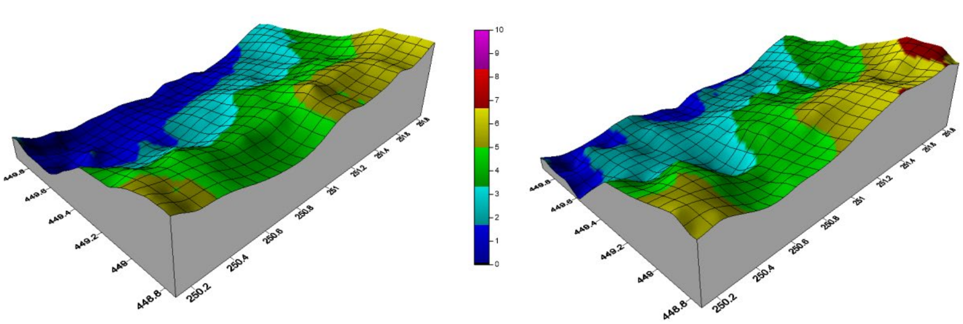

Figure 68. Graph. Sediment log Overlap Joint.

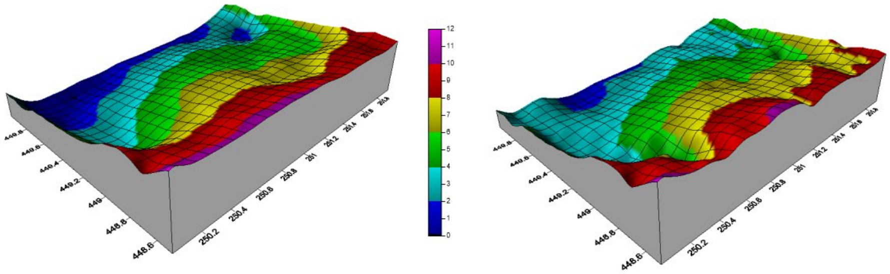

Figure 69. Graph. Sediment log butt ends joint.

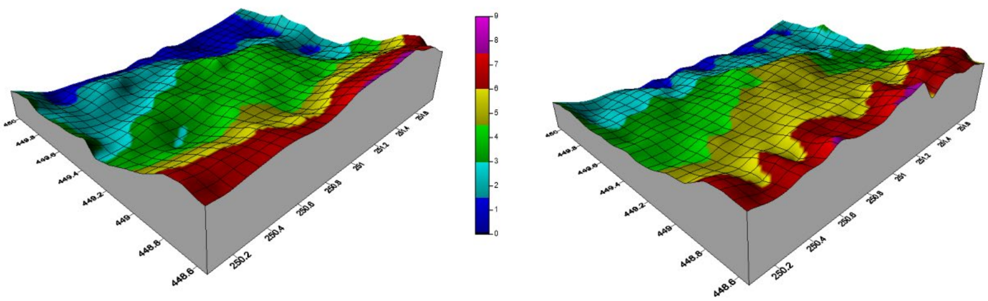

Figure 70. Graph. Sediment log sleeve joint.

APPENDIX B: SPECIFICATION FOR SEDIMENT PERIMETER BARRIER

This specification is intended to describe how to apply products in the construction site as sediment perimeter barriers under the typical weather pattern in Illinois. This specification is based on the findings for the ICT Project R27-190: Evaluation of Various Perimeter Barrier Products.

A. Silt Fence & Woven Monofilament Geotextile

I. Component & Material

Silt fence takes the function by impounding stormwater and promoting the removal of solids by means of sedimentation and to a lesser degree, filtration. Silt fence shall include three structural components: monofilament, reinforcement, and vertical support structures. Monofilament shall be made of polypropylene. These filaments shall be woven by reinforcement to form a stable and durable network such that the filaments retain their relative position. It is nonbiodegradable and resistant to most soil chemicals. Silt fence shall have a water flow rate of 8gpm/ft^2. Woven Monofilament Geotextile has a similar configuration to silt fence. Woven Monofilament Geotextile shall have a minimum water flow rate of 18gpm/ft^2. It has fewer clogging issues compared to silt fence in terms of permeability.

II. Installation

Vertical support structures shall be stuck with filter fabric with 4′ spacing by staples. Vertical support structures shall be on the downstream side of the fabric and strong enough to hold the standing of the fabric. A 6″ deep by 6″ wide trench shall be created to fold the bottom of the fabric. The depth of vertical support structure into the ground shall guarantee the bottom 6″ of the fabric completely sealed into the trench. The trench shall be backfilled and compacted. The function and installation approach of Woven Monofilament Geotextile is exactly the same as silt fence.

III. Maintenance

Silt fence shall be inspected routinely and after runoff events. Sediment shall be removed from behind the fence when it has accumulated to half the original height of the structure and install a new fence. However, there are several problems associated with cleaning. The soil is normally very wet behind a silt fence, inhibiting the use of equipment needed to move the sediment. Another solution is to leave the sediment in place where it is stable and build a new silt fence above or below it to collect additional sediment. The proper maintenance may be site specific.

IV. Removal

When the land-disturbing activities are sufficiently completed to allow permanent soil stabilization on the site, the silt fences and sediment basins are removed. The fabric and damaged posts shall go to the landfill. Steel posts and some of the wooden posts can be reused. Then the sediment shall be spread over the site to provide fertile soil, and the area can be seeded and mulched to support revegetation.

B. Filtrexx Siltsoxx (Compost Filter Sock)

I. Component & Material

Filtrexx Siltsoxx is a 3D tubular device comprised of 100% recycled filter media encased in polypropylene or biodegradable Filtrexx mesh used for sediment control and slope interruption. Filter media shall be a locally/regionally sourced composted organic product. The products come in a variety of diameters, including 5″, 8″, 12″, 18″, and 24″. 12″ Filtrexx Siltsoxx shall be recommended in the light of typical rainfall patterns in Illinois. However, if anticipated rainfall/runoff amounts are low, 8″ SiltSoxx may be used. The Filtrexx mesh shall be made of knitted polypropylene or natural biodegradable fibers and have a 1/16–3/8″ opening. The compost material shall consist of coarse grade compost with particle sizes 50% > 3/8″. The unit weight of Filtrexx Siltsoxx shall be 12–30 lb/ft to maintain decent ground contact.

II. Installation

Filtrexx Siltsoxx shall be placed on the ground directly after large rocks and debris are removed from the installation area. A shallow trench is optional. Stakes with a maximum 5′ spacing shall penetrate the filter media to make sure the product is secured in place. The upstream edge of the product shall be pressed to fortify ground contact. If staking is not possible due to surface conditions, it is acceptable to place gravel bags or sand bags downstream as required.

III. Maintenance

Filtrexx Siltsoxx shall be inspected after each runoff event to make sure that overtopping has not occurred. Sediment shall be removed from behind the product when it has accumulated to half the original height of the structure. Ground contact shall be fortified after sediment removal.

IV. Removal

Filtrexx Siltsoxx shall be removed after stabilization is complete. This may be accomplished by cutting the mesh open and spreading the interior material on the site, helping vegetation growth and minimizing removal and disposal costs. All nonbiodegradable materials shall be removed. If the biodegradable mesh is used, no removal or disposal is necessary.

C. Siltworm

I. Component & Material

Siltworm is a 3D tubular device including netting tube and fill material. It comes with diameters of 8″, 12″, and 18″ Siltworm will become oval when in place. Thus the actual installation height will be less than the nominal diameter. The netting tube is made of high-density polypropylene. The fill material consists of kiln-dried wood chips and bark-free softwood, which are 100% recycled.

II. Installation

A shallow 2″ trench is recommended to be created to place the Siltworm with good ground contact to reduce undercutting issue. Staking shall be placed downstream at 45° angles toward the flow into the ground 12–24″ with 4′ spacing to pin the Siltworm on the ground.

III. Maintenance

Siltworm shall be inspected after each runoff event and shall be removed and replaced if signs of undercutting or downstream rills are observed. Sediment shall be removed from behind the product when it has accumulated to half the original height of the structure.

IV. Removal

Siltworm shall be removed after stabilization is complete. The product removal may be accomplished by cutting the sock open and spreading the interior material on the site. All nonbiodegradable materials shall be removed.

D. ERTEC ProWattle

I. Component & Material

ERTEC ProWattle is intended to spread and reduce water velocity while providing particle filtration. ProWattle is a freestanding L-shaped high-density polyethylene (HDPE) polymer matrix shell with a 350 micron HDPE particle filter on the inside. ProWattle comes in a 7′ length segment of either 6″ or 10″ height. The product is made from 90% recycled materials and can be reused multiple times for a functional life of over four years. To avoid overtopping issues, 10″ high ERTEC ProWattle shall be recommended in the light of a typical rainfall pattern in Illinois. However, if anticipated rainfall/runoff amounts are low, 6″ height ERTEC ProWattle may be used.

II. Installation

A 1″ deep by 4″ wide trench shall be created to fold the base flap of the product pointing upstream in the trench. The base flap shall be secured by two 6″ nails with the same interval in the trench for each segment. Do not position nails where segments overlap. The product shall be reinforced by three wooden stakes behind the vertical section with the same interval (maximum is 5′). If staking is not possible due to surface conditions, it is acceptable to place gravel bags downstream of the vertical section as required. The trench shall be backfilled and compacted. 1′ joint shall be made in practice. A joint shall be achieved by sliding the end of one product into the end of another one.

III. Maintenance

ERTEC ProWattle shall be inspected after each runoff event to avoid overtopping issues. Sediment shall be removed from behind the product when it has accumulated to half the original height of the structure.

IV. Removal

ERTEC ProWattle shall be completely removed after the site has been stabilized. They can be reused for future projects.

E. Triangular Silt Dike

I. Component & Material

The triangular silt dike shall contain triangular urethane foam wrapped in geotextile fabric. The product shall be designed with protective aprons on both sides of the barrier to prevent erosion and product failure. The product shall come in a 7′ length segment with multiple heights (5″, 8″, and 10″). For sediment perimeter barrier, 8″ product is enough in the light of sheet flow compared to the concentrated flow. If anticipated rainfall/runoff amounts are low, 5″ product may be considered. However, the 5″ product only has a protective apron on the upstream side of the barrier where overtopping will not cause erosion on the backside.

II. Installation

Triangular silt dike shall be laid perpendicular to the flow to provide an interception to sediment-laden water. A 4″ deep trench shall be created to fold the apron upstream. Five staples shall be used to secure the apron in the trench. Six staples shall be used to secure the apron downstream with two rows and three columns configuration. The trench shall be backfilled and compacted. A joint shall be achieved by adjoining end to end directly.

III. Maintenance

Sediment shall be removed from behind the product when it has accumulated to half the original height of the structure. If the fabric becomes clogged, it should be cleaned or, if necessary, replaced. The product shall be replaced when structural deficiencies are found.

IV. Removal

The triangular Silt Dike shall be completely removed after the site has been stabilized. They may be reused for future projects.

F. Lightweight Rolled Products

I. Component & Material

A lightweight rolled product is a 3D tubular device with lightweight and easily handled by one person. This kind of product is not designed to create an impoundment on the upstream side of the product but to provide sediment-laden water filtration. Sediment log, coconut coir log, straw wattles, and Terra-Tube belong to this category. These rolled products shall include two main components: the interior material and the netting tube. The interior materials of these rolled products shall be biodegradable, for example, wood fiber, mattress coconut coir, and straw fiber. Some netting tubes are biodegradable or photodegradable.

II. Installation

These products shall be laid perpendicular to the flow to provide temporary flow interruption. A 6″ deep by 12″ wide trench shall be created to place the product. 12″ diameter product shall be used to provide enough filtration and decent ground contact, with wooden stakes at 45° angles toward the flow. If the wooden stakes can not penetrate the product, staking shall be placed downstream into the ground 12–24″ with 4′ spacing. If possible, 2′ spacing shall be recommended to avoid the frequent undercutting issue. The trench shall be backfilled and compacted. The upstream edge of the product shall be pressed to fortify ground contact. 1′ joint shall be made in practice. To make the joint for these rolled products, one end of the product shall be open, and interior material shall be removed. Then the netting tube shall be slid to the other product. A wooden stake shall be placed at the joint. Erosion control blanket shall be considered as an alternative to trenching and backfilling to reduce undercutting and improve the performance of these light-rolled products.

III. Maintenance

These products shall be inspected after each runoff event and removed and replaced if signs of undercutting or downstream rills are observed.

IV. Removal

These products shall be removed after stabilization is complete. Most of the components from these products are environment-friendly, which can be left on site. All nonbiodegradable materials shall be removed.

G. GeoRidge

I. Component & Material

GeoRidge dam shall be intended as a permeable berm to reduce water velocity, spread water over a wider area, trap sediment, and aid in vegetation establishment. Standard GeoRidge plastic dam shall be made of durable, UV-stabilized high-density polyethylene (HDPE). GeoRidge Bio is biodegradable, which is an alternative to the standard GeoRidge dam. It shall be used with an erosion control blanket.

II. Installation

GeoRidge dams shall be used in conjunction with an erosion control blanket. A trench shall be created upstream to fold the blanket by staples and to backfill. The erosion control blanket with 3–4′ length shall be stretched out to cover the installation area. Then GeoRidge dams shall be laid perpendicular to the flow and placed on the top of the blanket in the center by nails. GeoRidge dams shall be connected to each other by aligning holes and anchoring nails.

III. Maintenance

These products shall be inspected after each runoff event. GeoRidge dam and erosion control blanket shall be replaced if they are damaged.

IV. Removal

Standard GeoRidge dams shall be removed after the site has been stabilized and can be reused in future projects. GeoRidge Bio check dams will degrade on-site over 18 to 24 months. Erosion control blanket can be left on-site in terms of biodegradable materials. However, the netting is typically nonbiodegradable and easily got tangled with mowing equipment and wildlife. Therefore, an erosion control blanket is recommended to remove unless it is net-free.

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