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EVALUATION OF DITCH CHECKS FOR SEDIMENT RETENTION

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16. Abstract

Construction activities generally involve significant land disturbances, leaving the soil unprotected and more susceptible to erosion, which may in turn adversely affect the surrounding environment. The lack of quantitative and qualitative data on erosion and sediment control product performance using standardized evaluation methodologies under locally relevant climate and soil conditions makes it difficult to appropriately select the most suitable erosion and sediment control best management practices (BMPs).

During roadside construction, ditches are often impacted and may be left bare of vegetation throughout the duration of the construction project. As rain hits this bare soil, it tends to heavily erode the ditch, carrying large quantities of sediment in runoff. This sediment is then free to enter larger water systems, which is a detriment environmentally and economically, and could be harmful to human health. At the Erosion Control Research and Training Center (ECRTC) at the University of Illinois at Urbana-Champaign, a series of tests were conducted to analyze the effectiveness of various ditch checks to ensure they could be used in real-life construction sites to mitigate soil transport. The tests were conducted to determine their practicality in field use. The goal of these tests were to examine how well they reduce sediment leaving the ditch and how much ponding occurs, as well as other criteria of interest to the Illinois Department of Transportation (IDOT).

The test was performed following protocols designed by the University of Illinois in consultation with IDOT. Because there is currently a lack of products available for contractors to use on IDOT construction jobs, the importance of this test cannot be overstated. The tests were performed to determine whether a new product could be feasibly used.

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EXECUTIVE SUMMARY

Construction activities generally involve significant land disturbances, leaving the soil unprotected and more susceptible to erosion, which may in turn adversely affect the surrounding environment. The lack of quantitative and qualitative data on erosion and sediment control product performance using standardized evaluation methodologies under locally relevant climate and soil conditions makes it difficult to appropriately select the most suitable erosion and sediment control best management practices (BMPs).

During roadside construction, ditches are often impacted and may be left bare of vegetation throughout the duration of the construction project. As rain hits this bare soil, it tends to heavily erode the ditch, carrying large quantities of sediment in runoff. This sediment is then free to enter larger water systems, which is a detriment environmentally and economically, and could be harmful to human health. At the Erosion Control Research and Training Center (ECRTC) at the University of Illinois at Urbana-Champaign, a series of tests were conducted to analyze the effectiveness of various ditch checks to ensure they could be used in real-life construction sites to mitigate soil transport. The tests were conducted to determine their practicality in field use. The goal of these tests were to examine how well they reduce sediment leaving the ditch and how much ponding occurs, as well as other criteria of interest to the Illinois Department of Transportation (IDOT).

These tests were performed following protocols designed by the University of Illinois in consultation with IDOT. Because there is currently a lack of products available for contractors to use on IDOT construction jobs, the importance of these tests cannot be overstated. The tests were performed to determine whether a new product could be feasibly used.

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SECTION 1: INTRODUCTION

Construction activities generally entail earthmoving operations that involve substantial disturbance of topsoil and vegetative cover. As a result, stormwater runoff and erosion rates are significantly increased. The sediment runoff rates from construction sites are typically 10 to 20 times greater than those from agricultural lands (EPA 2000). Hence, various practices have been devised to improve effluent quality by adopting the necessary best management practices (BMPs), implementing proper stormwater management, and using available technology to reduce pollution of water bodies.

To prevent undesired costs and effects of sediment in runoff, ditch checks are often used. The lack of information on ditch check product performance under standardized testing and evaluation protocols creates difficulties for engineers, designers, and installers in choosing appropriate technologies to mitigate the possibility of pollution from construction areas. Performance data are often difficult to compare and interpret due to differences in testing conditions and evaluation procedures. Additionally, data available for sediment retention performance and effluent quality are frequently incomplete or partial.

Most ditch checks aim to reduce sediment in water flow by lowering the velocity of the water, which allows for sediment to settle out. Ditch checks can also act as filters that allow water to pass through them but enhance the settlement of sediment upstream of the structure. Determining how effective a ditch check at performing these functions is a key to determining its overall effectiveness. Furthermore, other factors such as ponding amounts, product failure under high flow rates, and ease of installation must be examined to determine practicality of the product.

This study was intended to compare the performance of five types of sediment control products under Illinois weather and soil conditions, based on prior studies. This study also provides guidance to the Illinois Department of Transportation (IDOT) in the installation and maintenance of sediment control devices, as well as providing quantitative data as a resource for assessing whether specific products should be permitted for use in IDOT projects.

SECTION 2: OBJECTIVES

The purpose of this study was to examine the performance of a series of ditch check products. This testing was undertaken to provide the Illinois Department of Transportation (IDOT) with recommendations on the effectiveness of such products and whether they should be used in the field. The specific goals of the project were as follows:

- Install the product according to the manufacturer's instructions.
- Conduct the field tests and collect samples to analyze the effectiveness of various ditch check products.
- Examine the samples, specifically for turbidity and sediment concentration, to determine how well the product removed sediment from the water flow.

SECTION 3: METHODOLOGY

3.1 FIELD SITE DESCRIPTION

The erosion and sediment control studies for ditch check products and erosion control blankets were conducted at the Erosion Control Research and Training Center (ECRTC) at the Agricultural and Biological Engineering South Farm, which belongs to the University of Illinois at Urbana-Champaign. The total area of the demonstration and research site was 3.95 acres (1.6 ha). The site contained an elbow-shaped berm, a detention pond, and three channels. An aerial view of the ECRTC testing facility is presented in Figure 3.1.

Figure 3.1 Aerial view of the ECRTC research and demonstration site.

The elbow-shaped berm measured approximately 300 feet (91.4 meters) in length and 12.5 feet (3.8 meters) in height. The southwestern face of the berm had an approximate slope of 3:1; the northeastern face had an average slope of approximately 2:1.

The detention pond had an approximate surface area of 13681 ft^2 (1271 m^2) and a maximum storage volume of 64485 ft^3 (1826 m^3). The detention pond provides the water supply for the testing and evaluation performed at the site. The three channels were constructed with target lengths of 200 feet (61 meters) and bed slopes of 2%, 3%, and 4%. The 1% and 4% slopes had straight configurations, while the 3% slope channel had an elbow configuration with a bend approximately near the center (Monical 2011). The soil type in the site was found to be a relatively equal mix of silt loam and silty clay loam soils. Specific soil series included Brenton (38%), Drummer (47%), and Flanagan (15%), as indicated by the Soil Survey Geographic (SSURGO) Database (Soil Survey 2013).

The testing was performed in a straight ditch at the ECRTC with a slope of approximately 4%. The testing channel had a parabolic shape that simulated the typical channel profile found in construction sites and roadside ditches. The channel had a top width of 9.85 feet (3 meters) at the upstream end and 26 feet (7.9 meters) at the downstream end. The channel side slope was 2(H):1(V) throughout the channel profile. The ditch was approximately 200 feet (61 meters) long but only the first half was used in this test.

The testing channel was divided into two zones: the discharge zone and the testing zone. The discharge zone received the water from the pumping station. The discharge zone was stabilized with a turf reinforcement mat (TRM) and vegetation to minimize erosion in the discharge zone and the sediment concentration of the flow before reaching the testing zone.

To measure the channel flow rate, a polymethyl methacrylate (Plexiglas) 90 degree V-notch weir was installed across the width of the channel between the discharge and testing zone. The V-notch weir was installed on a 3.28 feet (1 meter) deep trench with an initial layer of cement approximately 11.81 inches (30 centimeters) thick, and then covered by compacted soil.

3.2 PRODUCTS EVALUATED

3.2.1 Sediment Log

Curlex sediment logs are manufactured by American Excelsior and contain curled excelsior wood fiber in rolls of various diameters (Figure 3.2). The fibers are curled with soft interlocking barbs, of which 80% are 6 inches in length or longer. Sediment logs provide temporary, biodegradable channel interruption by slowing water velocity to reduce shear stress over the channel, thereby minimizing soil degradation in the channel and enhancing vegetation establishment (American Excelsior 2015).

The sediment logs evaluated were Type II (diameter of 11.81 inches, or 30 centimeters) and designed to be used in mild to medium concentrated flow areas. The product was installed in accordance with manufacturer's guidelines and IDOT recommendations for staking pattern. The installation guidelines are available at www.americanexcelsior.com.

Figure 3.2 Sediment logs installed at field study site.

3.2.2 GeoRidge Plastic Dam

GeoRidge ditch checks are permeable plastic berms manufactured by Nilex, Inc. and designed for erosion and sediment control (Figure 3.3). The GeoRidge plastic dams are made of a durable, UV-stabilized high-density polyethylene (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. This product can be reused in future projects. The product was installed according to the manufacturer's guidelines, which are available at www.nilex.com.

Figure 3.3 GeoRidge installed at field site.

3.2.3 Triangular Silt Dike

Triangular silt dikes are manufactured by the Triangular Silt Dike Company, Inc. and contain triangular urethane foam wrapped in geotextile fabric (Figure 3.4). The product is available in multiple heights, but the 9.85 inch (25 centimeter) model was used in this study. The product was designed with protective aprons on both sides of the barrier to prevent erosion and product failure. The product was installed following the manufacturer's guidelines available at www.tri-siltdike.com.

Figure 3.4 Triangular silt dike installed at field study site.

3.2.4 Straw Wattle

The straw wattle is made of a mesh casing with straw fibers inside, in the shape of a log (Figure 3.5). This product is meant to lie across a ditch 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 out. It can also act as a filter to remove sediment that passes through from the water. The product is installed by digging a shallow trench for the product to lie in. It is then staked in with a stakes at 2 foot intervals along the log. Stakes are staked in 45 degrees against the flow of water. This is done to make sure the log does not rise as water hits it. The stakes hold the product against the ground at that angle. The product should span the entire width of the ditch to ensure water does not flow around it when the ditch is at full capacity. Two straw wattles were installed about 10 feet away from each other in the test ditch (Figure 3.6).

Figure 3.5 Straw wattle installed in test ditch.

Figure 3.6 Both straw wattles in a series.

3.2.5 Siltworm

The Siltworm is a polypropylene geotextile tube filled with a proprietary blend of recycled wood products (Figure 3.7). The Siltworm ditch check product was evaluated at ECRTC according to the testing methodology for ditch check products using both the manufacturer's installation guide and revised method (see Section 4.5).

Figure 3.7 Siltworm ditch check product installed according to manufacturer´s guidelines.

3.3 TESTING PROTOCOL FOR SEDIMENT CONTROL (DITCH CHECK) PRODUCTS

This section outlines a full-scale testing and evaluation protocol for ditch check products conducted at ECRTC. The proposed testing protocol is based on ASTM D7208-06 (ASTM 2007). It was used to test the performance of ditch check products and perform training and demonstration activities. The protocol will also help in updating the list of accepted ditch check products for protecting earthen channels from stormwater-induced erosion, as well as to evaluate new products. The testing protocol reflects the conditions typically found on construction sites around Illinois.

3.3.1 Apparatus

The proposed design for the testing and evaluation protocol required the following components: water source and delivery system, testing channel, soil stockpile, earthmoving and compacting equipment, total station, monitoring system, and miscellaneous other equipment.

3.3.1.1 Water Supply and Delivery System

The retention pond, located at the ECRTC facility, served as the water supply source. The water delivery system included the necessary pumps and piping to meet the required hydraulic conditions for testing. The water was discharged onto a stabilized surface to avoid soil erosion before the discharge was measured and the water reached the head of the testing channel. The recommended discharge measurement equipment is a 90 degree V-notch weir (Figure 3.8), which is most accurate when measuring discharges of less than 4993 gallons/minute or 0.315 m^3/s (Smajstrla 1981). Other optional equipment, such as flow meters, may also be used to measure flow discharge.

Figure 3.8 90 degree V-notch weir for flow rate measurement, and discharge zone stabilized with a turf reinforcement mat (TRM).

3.3.1.2 Soil Stockpile

A stockpile of soil of adequate quantity was required to replace eroded soil in the testing channel.

3.3.1.3 Earthmoving and Compacting Equipment

This equipment included a front-end loader to move soil from the stockpile into the testing channel when needed, a self-propelled tiller to obliterate any rills, rakes to repair and smooth the surface, and a soil compactor.

3.3.1.4 Scanning Equipment

A laser distance-meter was used to measure relative elevations of points with an accuracy of ±2 mm, along with a data logger and related software for calculations (see Section 3.3.2.4 for further details).

3.3.1.5 Monitoring System

A 90° V-notch weir was used to measure the flow rate into the system. It was installed at the head of the channel. The other equipment in the monitoring system consisted of a turbidity meter, a penetrometer, and a soil moisture meter. Periodic calibration of the equipment was performed as required.

3.3.1.6 Miscellaneous

Other miscellaneous equipment included a weather station (capable of measuring wind speed, temperature, and precipitation) and audiovisual equipment such as a camera and video recorder (Figure 3.9).

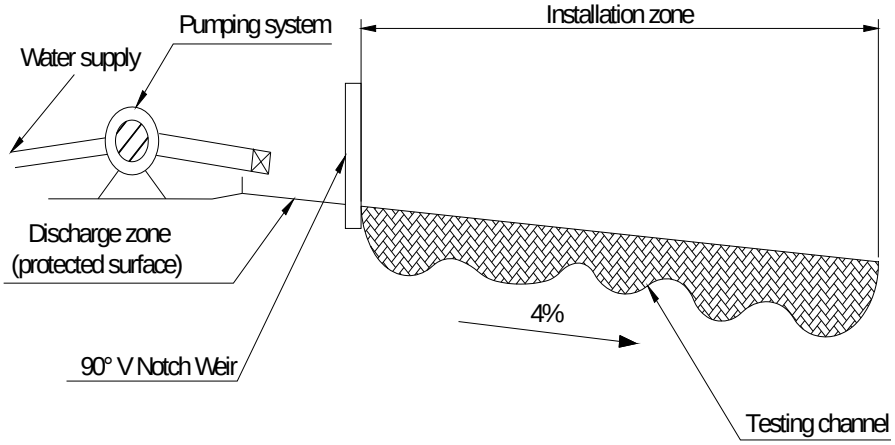

Figure 3.9 Diagram of evaluation procedure (not to scale).

3.3.2 Test Preparation

3.3.2.1 Channel Preparation

Channel preparation was begun by loosening the channel surface to a depth of approximately 3.94 inches (10 centimeters) using a self-propelled tiller. If testing had previously been performed, eroded soil was discarded and replaced with soil of the same kind from the stockpile. Any foreign material (vegetation, roots, or stones) that could have interfered in the product's evaluation was removed from the testing channel. Finally, the channel surface was smoothened with a hand rake and compacted using an 881.85 pound (400 kilogram) lawn roller (Figure 3.10).

Figure 3.10 Soil compaction operation during channel preparation.

3.3.2.2 Soil Moisture Measurement

The soil moisture content was measured at 10 to 15 random points along the channel length. If the soil moisture content was lower than 70% of saturation level, the channel was wetted using the rainfall simulator system until a minimum of 70% was achieved throughout the channel profile. The channel surface was smoothened again using the hand rake and compactor if necessary. Testing of other soil moisture conditions can be performed if required.

3.3.2.3 Ditch Check Installation

The ditch check was installed, following manufacturer's guidelines, after channel preparation was completed. Two ditch checks were installed in series.

For evaluating the performance of ditch checks in series, the spacing pattern followed the manufacturer's recommendations. If there were no recommendations available, spacing between ditch checks was computed as follows:

$$D = \left(\frac{H}{S}\right) \times 100 \qquad (1)$$

where D = spacing distance (m), H = distance between channel bed and top of installed temporary ditch check (m), and S = slope of channel bed (%).

This distance was calculated to position the bottom of the upstream ditch check and the top of the downstream ditch check at the same elevation.

3.3.2.4 Elevation Measurement

Elevation measurements were taken using a laser scanning distance-meter (Leica 3D Disto). The measurement pattern consisted of a rectangular grid with 4 by 4 inch (10 by 10 centimeter) spacing. The scanned area was on the upstream side of the ditch check. The scan was performed along a 3.28 foot (2 meter) section upstream from the ditch check and across the entire wetted width of the channel. Sequential channel profile scans were performed before and after product testing to generate successive surface profiles and provide an accurate estimate of the sediment deposition.

Figure 3.11 Elevation measurement pattern (not to scale).

3.3.2.4 Visual Documentation

Photographs were taken of the channel conditions and the ditch check installation before, during, and after the test was performed. It was recommended but not required to record video of the test operation as per ASTM D7208-06 (ASTM 2007).

3.3.2.5 Discharge Calibration

The discharge calibration was performed in one of the demonstration channels or in the testing channel prior to channel preparation. Once the desired steady-state flow rate was achieved, the ditch check evaluation commenced.

3.3.3 Test Operation and Data Collection

3.3.3.1 Channel Pre-Test Scan

Channel scanning was performed after channel preparation and prior to the test. Once scanning was completed, the product evaluation was performed under a particular flow condition.

3.3.3.2 Product Evaluation and Flow Conditions

The ditch was broken down into five sections for sample collection purposes:

- the V-notch weir
- immediately upstream of the first ditch check
- immediately downstream of the first ditch check
- immediately upstream of the second ditch check
- immediately downstream of the second ditch check

These location distinctions were utilized for sample collections and labeling on figures comparing sediment concentrations before and after each ditch check. The product evaluations were run for 30 minutes (or until product failure) for two different flow rates: (a) 79 gallons/minute (gpm) or 5 L/s and (b) 158 gallons/minute (gpm) or 10 L/s. Grab samples (0.09 gallon or 350 mL) were taken at 5 minute intervals from the upstream and downstream sides of every ditch check installed. At the same times

and locations, turbidity measurements were taken with the turbidity meter. The cutoff time for sample collection was 30 minutes.

Once the test was completed and any remaining water had drained out of the channel, scanning was performed. This second scan allowed computation of the total sediment deposition in front of the ditch check after the first test.

Figure 3.12 Collection of grab sample during test operation.

The second replication was performed after the post-test scanning was completed. This second replication was done under the same flow conditions and without product removal and channel preparation. This allowed computation of sediment accumulation after successive events and different soil moisture conditions. As in the first replication, post-test scanning was performed after any remaining water had drained out of the channel. Finally, a third replication was performed following the same methodology as for the second replication.

This procedure resulted in a total of four channel scans for each testing sequence: an initial scan after channel preparation and a post-test scan after every replication. The procedure was followed for each of the three flow conditions previously described.

3.3.3.3 Data Analysis

Total sediment concentration for each sample was measured based on the procedures in ASTM D3977-97 standard (ASTM 1999). The grab samples were taken to the laboratory for determination of total sediment concentration and placed in a drying oven at 219.2^{o}F (104°C) for 24 hours to evaporate most of the water.

Turbidity was measured in nephelometric turbidity units (NTUs) for all grab samples, and the relative reduction in NTU was computed between the upstream and downstream sides of each ditch check under evaluation. The total volume of sediment retained by each ditch check was computed using the scanned topographic data gathered before and after test operation with the laser distance-meter equipment. Total sediment volume was estimated using the commercial software SURFER.

3.3.3.4 Synthesis of Evaluation

All data and measurements (sediment volumes, total sediment concentration (TSC), and NTU) from testing a specific ditch check were compared to the results from other ditch checks tested under similar replicable conditions. The results were shared and discussed in detail with members of the project's Technical Review Panel. Ditch check recommendations were based on the test results and discussions.

SECTION 4: RESULTS AND DISCUSSION

The ditch check product evaluation was performed using two flow rates: a low flow of 79 gpm (5 L/s) and a high flow of 158 gpm (10 L/s). The products were tested under different flow conditions to evaluate how each might differently affect the ditch check product's performance. Higher total sediment concentration (TSC) was expected for higher flows. The TSC values calculated from the 5-minute grab samples appeared to show a trend of declining concentration with each test performed. The sediment concentration of grab samples seemed to consistently stabilize for all products after the first 15 minutes of each test.

4.1 TRIANGULAR SILT DIKE

The average TSC values computed from grab samples for the triangular silt dike under the high flow condition 158 gpm (10 L/s) are displayed in Figure 4.1. The results showed a declining trend in TSC during the first 10 minutes of the evaluation, after which the TSC stabilized until the test was completed. Samples were taken at the upstream and downstream sides of each of the two ditch checks installed in series. The TSC value after 5 minutes is not shown for the downstream side of the downstream ditch check, however, because the flow at this location did not reach steady state until approximately 10 minutes after the test began. This behavior was observed only for the triangular silt dike and was due to the specific characteristics of that product. In contrast to the sediment log and GeoRidge, permeability of the triangular silt dike was very low, which resulted in a significant flow barrier and created a series of cascades between the ditch checks installed along the channel. This diminished the energy slope and in turn the shear stress along the bottom of the channel, which prevented erosion in the channel bed and enhanced sediment settling. Steady-state flow occurred after approximately 15 minutes for the triangular silt dike for the low flow 79 gpm (5 L/s) condition (Figure 4.2). The average TSC values were similar for both high and low flows for triangular silt dike.

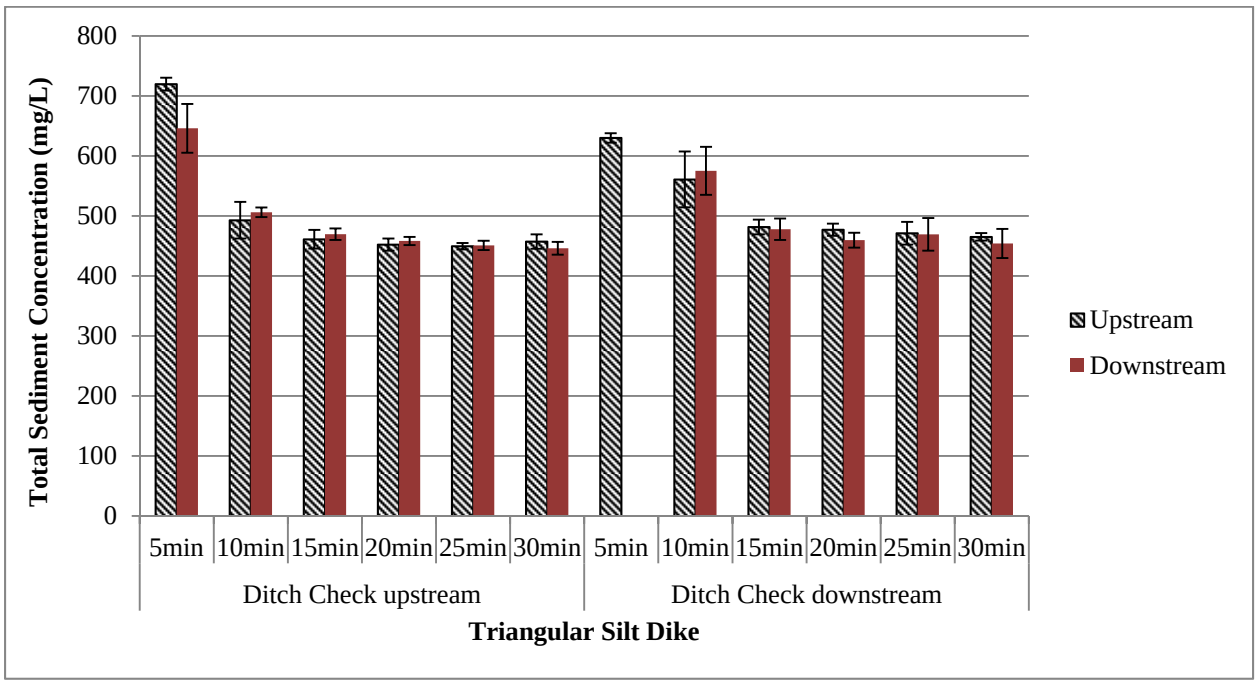

Figure 4.1 Average TSC values for triangular silt dike for the 158 gpm (10 L/s) flow rate.

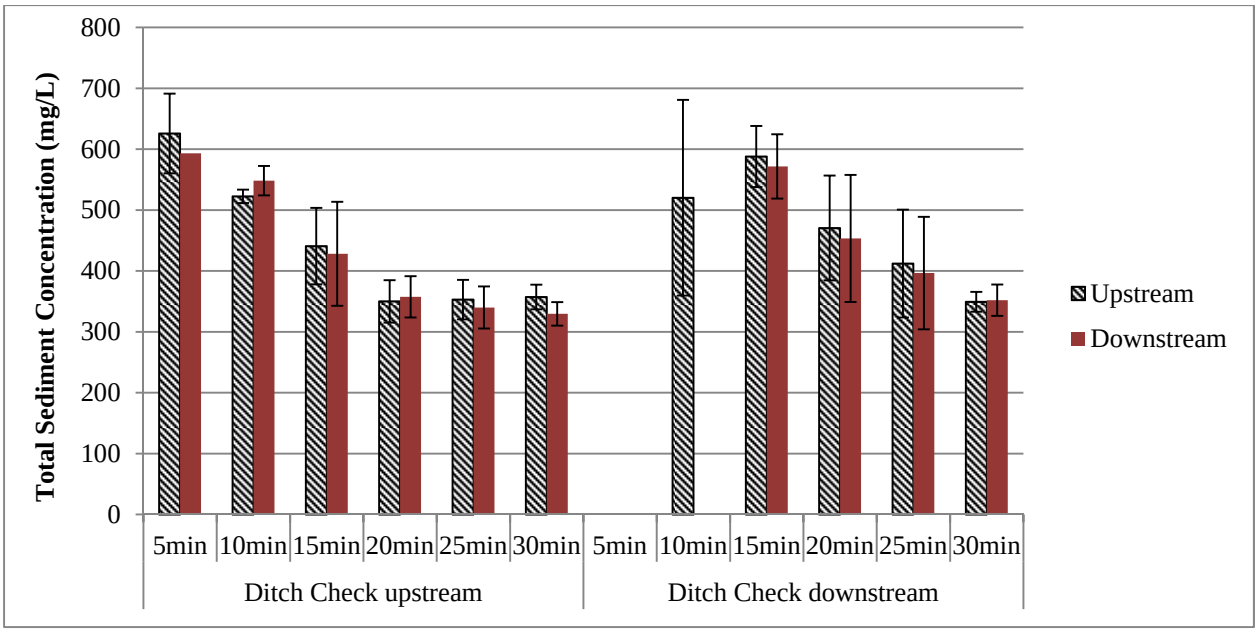

Figure 4.2 Average TSC values for triangular silt dike for the 79 gpm (5 L/s) flow rate.

Based on the before and after test scans, the amount of accumulated sediment in front of the triangular silt dike was measured to be 0.058 ft^3 (1651 cm^3) and 0.062 ft^3 (1762 cm^3) for low 79 gpm (5 L/s) and high flow 158 gpm (10 L/s), respectively.

4.2 GEORIDGE

The TSC values under the 158 gpm (10 L/s) flow rate for GeoRidge product evaluation showed a similar trend to the results of the triangular silt dike. In this case, steady-state flow occurred approximately 3 minutes after the test started; TSC values decreased during the first 10 minutes of evaluation, thereafter stabilizing to a constant value. The manner in which this product retained sediment and prevented erosion in the channel bed differed from the triangular silt dike. The GeoRidge ditch check primarily reduced flow velocities, causing sediment to settle upstream of the ditch check. Reduced water velocity also resulted in decreased downstream erosion. The average test results for GeoRidge ditch check product are presented in Figures 4.3 and 4.4 for high and low flow conditions. The average TSC values were similar for both high and low flows for GeoRidge.

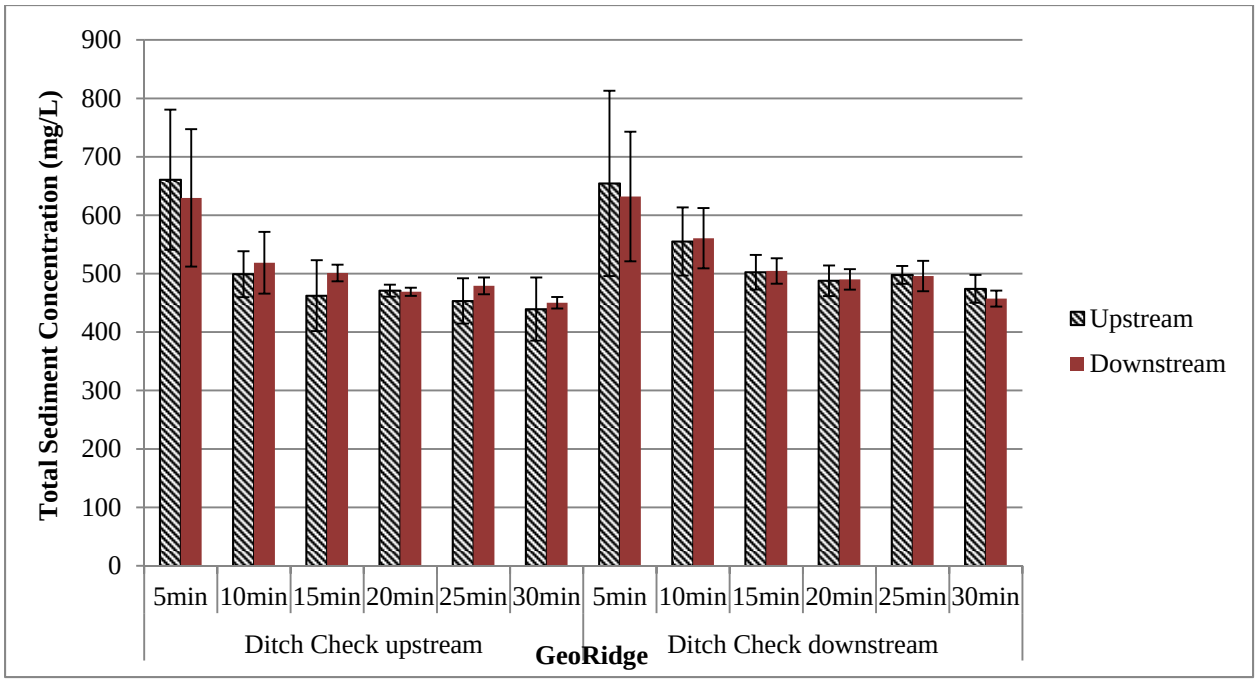

Figure 4.3 Average TSC values for GeoRidge for the 158 gpm (10 L/s) flow rate.

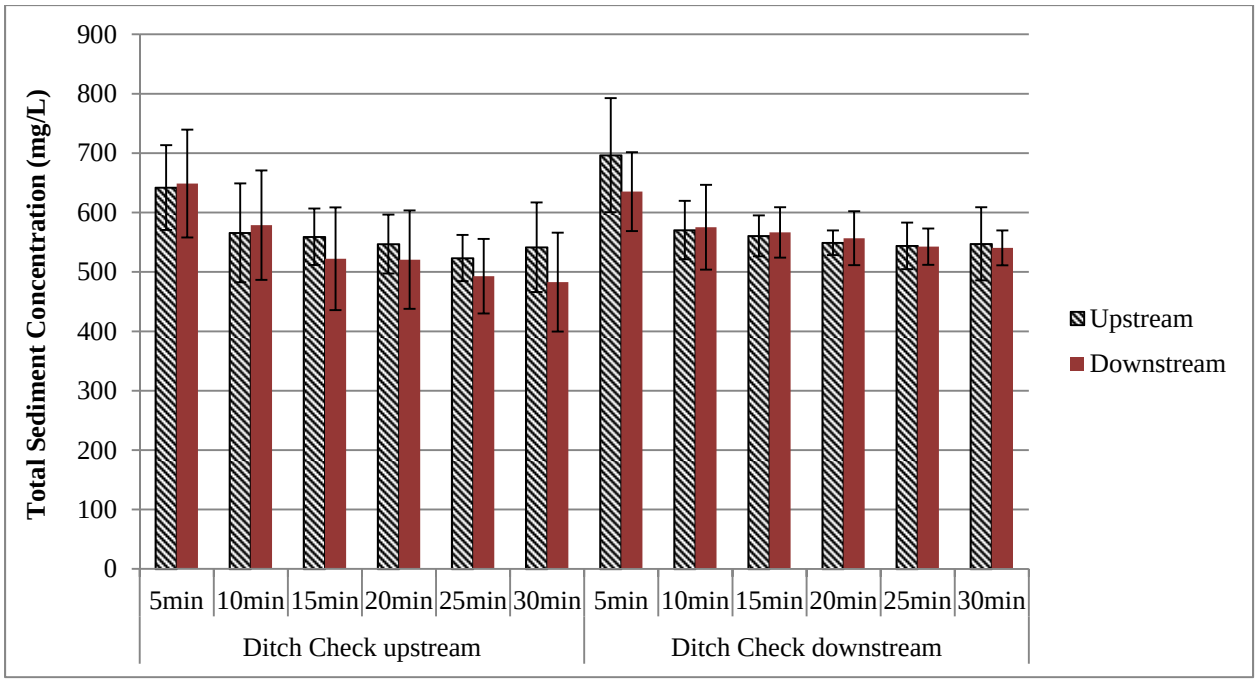

Figure 4.4 Average TSC values for GeoRidge for the 79 gpm (5 L/s) flow rate.

Based on the before and after test scans, the amount of accumulated sediment in front of GeoRidge was measured to be 0.156 ft^3 (4420 cm^3) and 0.193 ft^3 (5480 cm^3) for low 79 gpm (5 L/s) and high flow 158 gpm (10 L/s), respectively.

4.3 SEDIMENT LOG

The measured TSC concentration for the sediment log under the 158 gpm (10 L/s) flow rate is presented in Figure 4.5. The sediment log retained sediment and prevented channel bed erosion in a manner similar to the GeoRidge product. The sediment log exhibited a lower permeability than GeoRidge, which dissipated more flow energy, augmented sediment settling upstream of the ditch check, and minimized erosion downstream of the ditch check. Although the TSC concentration for the sediment log was expected to be below that of GeoRidge because of increased permeability of the material, a similar TSC was obtained; however, that finding was primarily the result of the flow undercutting that occurred during evaluation.

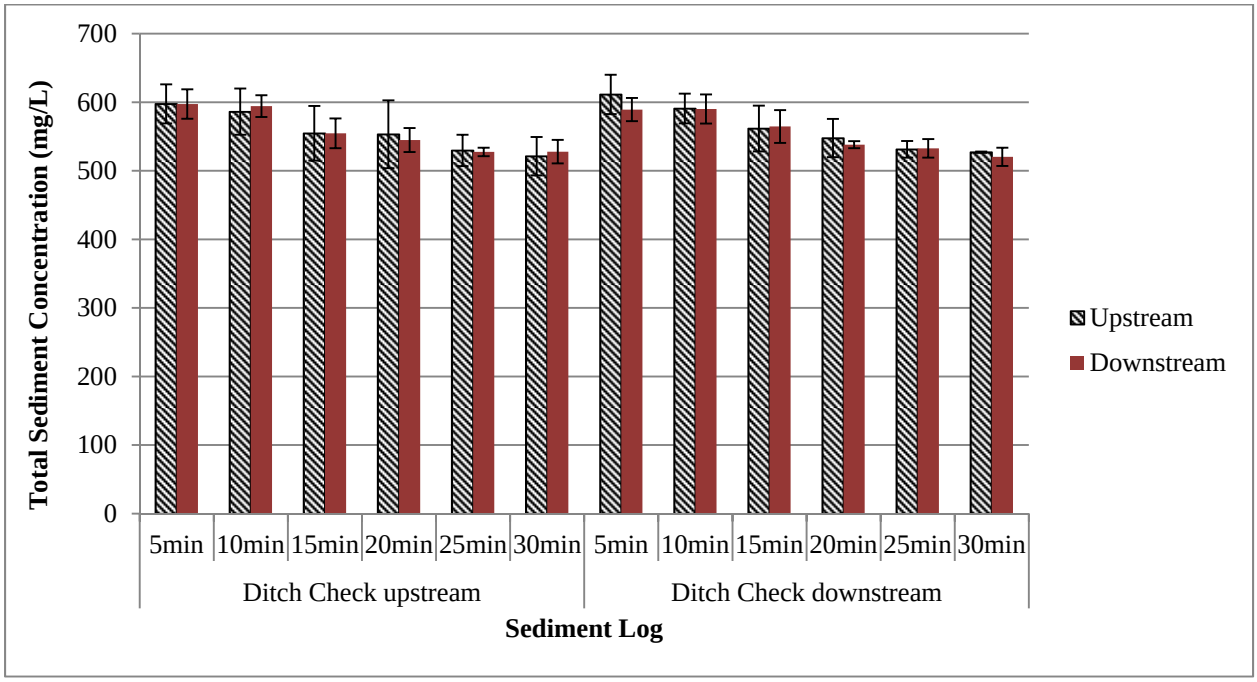

Figure 4.5 Average TSC values for sediment log for the 158 gpm (10 L/s) flow rate.

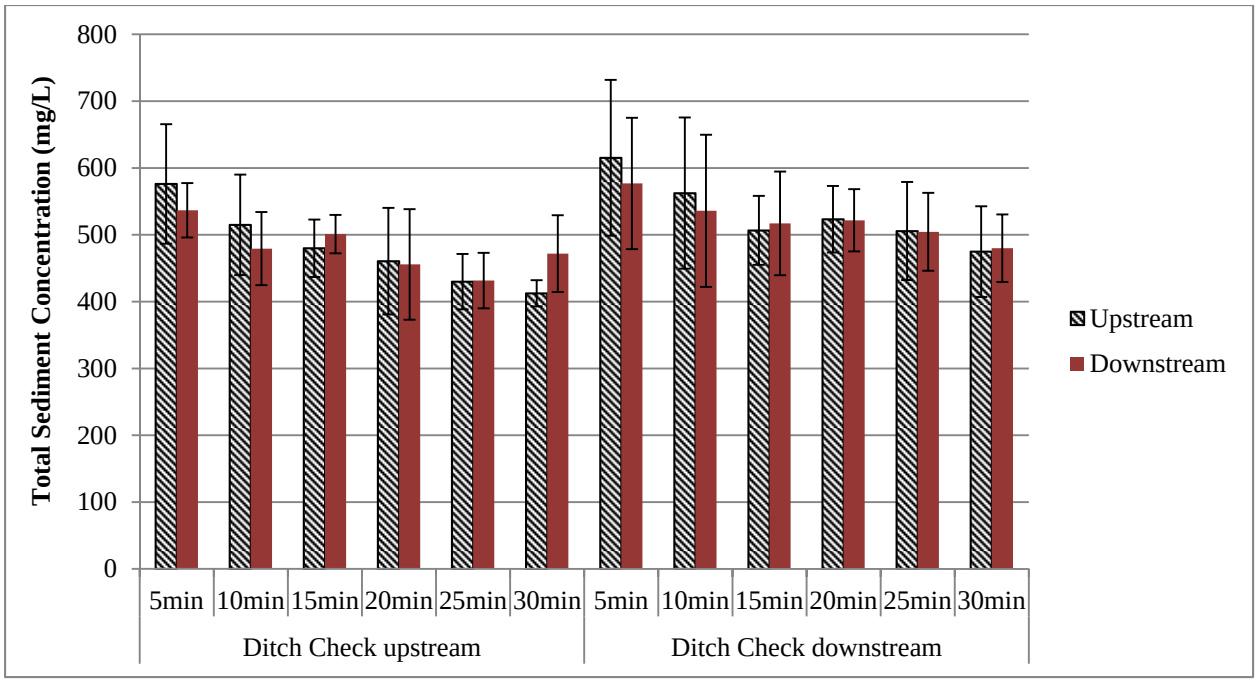

Figure 4.6 Average TSC values for sediment log for the 79 gpm (5 L/s) flow rate.

Based on the before and after test scans, the amount of accumulated sediment in front of the sediment log was measured to be 0.091 ft^3 (2572 cm^3) and 0.11 ft^3 (3108 cm^3) for low (79 gpm) and high flow (158 gpm), respectively.

4.4 STRAW WATTLE

Testing began at the designated starting flow rate of 79 gpm (5 L/s). Water immediately began to undercut both straw wattles, with undercutting being more severe at the first ditch check (Figures 4.7 and 4.8). This undercutting never led to large amounts of ponding at either ditch check. Ponding levels remained fairly constant throughout the test. Undercutting never stopped throughout the testing, either. At 30 minutes, the flow rate was increased to 158 gpm (10 L/s). Buildup of biological debris could be seen primarily at the first ditch check as it got caught on the ditch check. After testing was finished, it was observed that large chunks of soil had been removed from in front of the ditch check as a result of the undercutting. The ditch checks were fairly free of collected sediment.

Figure 4.7 Undercutting at the first ditch check.

Figure 4.8 Undercutting at the second ditch check.

The measured TSC concentration for straw wattle under the 79 and 158 gpm (5 and 10 L/s) flow rates is presented in Figures 4.9 and 4.10, respectively. It was observed that downstream sediment concentrations were consistently equal to or higher than upstream for both low and high flow conditions. This can be attributed to severe undercutting observed for this product. As the product endured undercutting throughout the entire experiment and downstream sediment concentration being higher than upstream end, we would further classify straw wattle as a product failure.

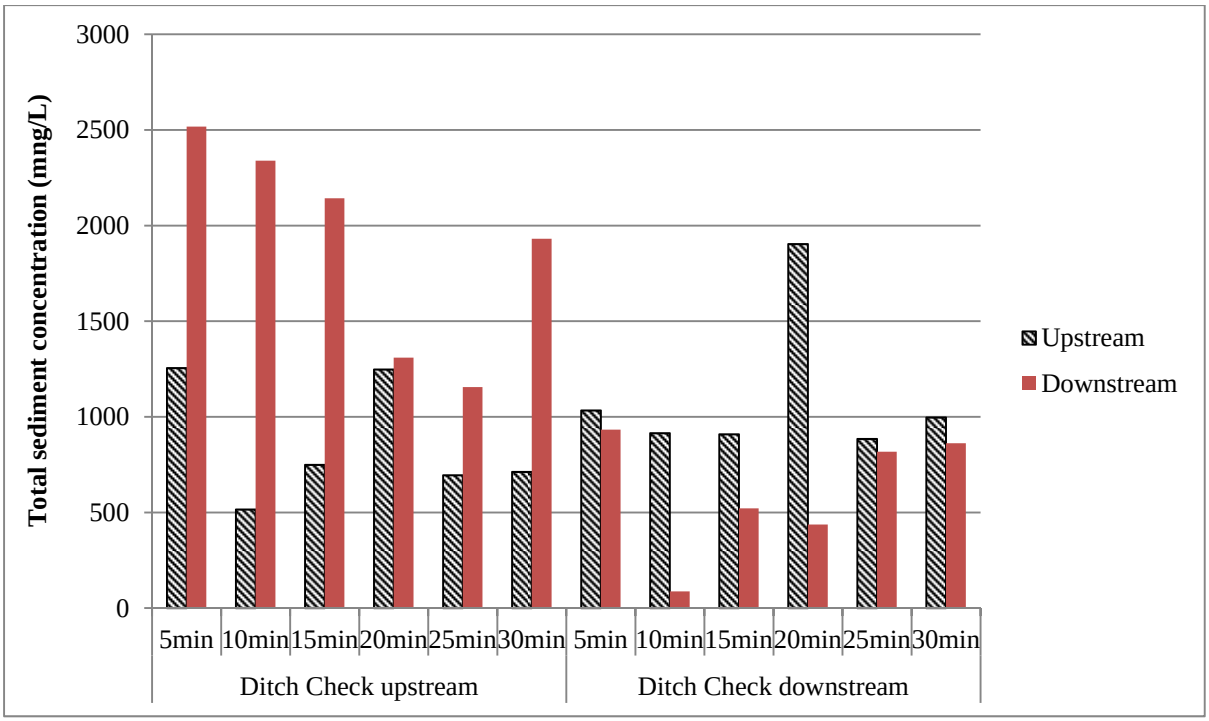

Figure 4.9 Measured sediment concentrations for the straw wattle for 79 gpm (5 L/s) flow rate.

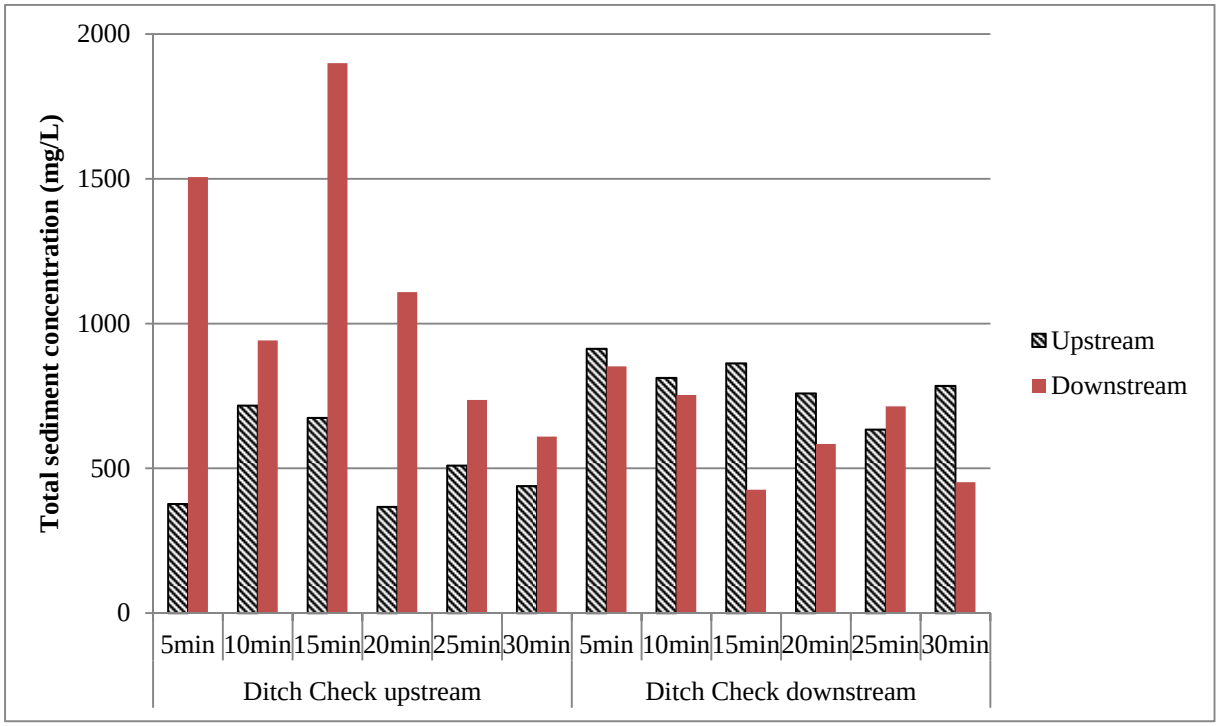

Figure 4.10 Average TSC values for the straw wattle for 158 gpm (10 L/s) flow rate.

Because of the severe undercutting observed for this product, the accumulated sediment in front of the product was not measured.

4.5 SILTWORM

The first field test was conducted on September 27, 2012. The product was installed by company representatives at the ESCTRC site, following the manufacturer's guidelines, as shown in Figures 4.11 and 4.12.

Figure 4.11 Siltworm ditch check product installed according to manufacturer´s guidelines.

Figure 4.12 Siltworm ditch check product installed according to manufacturer´s guidelines.

The trial was conducted using a high flow rate 158 gpm (10 L/s). The test was stopped in the middle of the experiment after severe undercutting was observed. During performance testing, one of the stakes was displaced from its original position, which resulted in product failure. Figures 4.13 and 4.14 show undercutting and stake displacement during this test.

Figure 4.13 Close-up view of severe undercutting during product evaluation.

Figure 4.14 Siltworm ditch check product during product evaluation.

The research team discussed options for evaluating the performance at a later date by altering the manufacturer guidelines. Accordingly, it was decided to re-evaluate the performance of the product in October 2012. The testing was conducted on October 16, 2012. At this test, the installation guidelines prescribed by the IDOT Erosion and Sediment Control Field Guide for Construction Inspection were followed (i.e., 45 degree staking for rolled erosion control/sediment control products), as shown in Figures 4.15 and 4.16. In the follow-up testing, severe undercutting was again observed in the middle of the test, resulting in product failure as shown in Figures 4.17 and 4.18, after which the testing was halted.

Figure 4.15 Siltworm installed in the testing channel according to IDOT installation guidelines.

Figure 4.16 Siltworm installed in the testing channel according to IDOT installation guidelines.

Figure 4.17 Close-up view of undercutting during product evaluation.

Figure 4.18 Close-up view of undercutting during product evaluation.

Because the product failed in both instances at the flow rate of 158 gpm (10 L/s), the product was not evaluated using lower flow rates. Likewise, the accumulated sediment in front of the product was not measured.

In consultation with Technical Review Panel members, an additional test was conducted to re-evaluate the performance of the product in May 2015. During the test, two measures were evaluated for reducing the product undercutting: adding an erosion control blanket underneath the product, and adding mulch in front of the product. The stakes were installed following the guidelines prescribed in the IDOT Erosion and Sediment Control Field Guide for Construction Inspection (45 degree staking for rolled erosion control/sediment control products), as shown in Figures 4.19 and 4.20. The experiment was conducted using the 158 gpm (10 L/s) flow rate for 30 minutes. With these improved installation methods, no apparent undercutting was observed.

Figure 4.19 Siltworm installed in the testing channel with blanket underneath (upstream) and mulch on the front side (downstream).

(a)

(b)

Figure 4.20 Siltworm installed in the testing channel with (a) blanket underneath (upstream) and (b) mulch on the front side.

SECTION 5: RECOMMENDATIONS

Sediment transport is a process that involves both suspended sediment and bed load transport. The process that yields the majority of soil displacement from its original position is bed load transport, which has a tremendous impact on long-term ditch stabilization. Ditch check products are intended to provide channel stabilization until vegetation can provide long-term channel soil protection. Prior to vegetation establishment, the soil in channels is highly erodible, and ditch check products are installed to prevent soil disturbance and reduce soil displacement.

Therefore, ditch check products should not only prevent sediment transport out of the construction site, but they should also ameliorate the negative effects that soil displacement has on long-term channel stabilization. After channel disturbance, ditch checks are installed and the channel bed is seeded to provide long-term stabilization; if the soil is displaced from its original position, however, it will carry the seeds along with it, and the areas where soil displacement occurred will not be able to generate a vegetative cover for long-term channel protection.

Test observations; photographs taken before, during, and after product evaluation; and total sediment retention analysis were used to determine the product effectiveness in terms of channel bed disturbance and potential product failure during performance testing.

5.1 PRODUCT COMPARISON

Figure 5.1 and the accompanying discussion provide a comprehensive performance overview of each product. The product recommendations are based on observations and results, along with ease of installation.

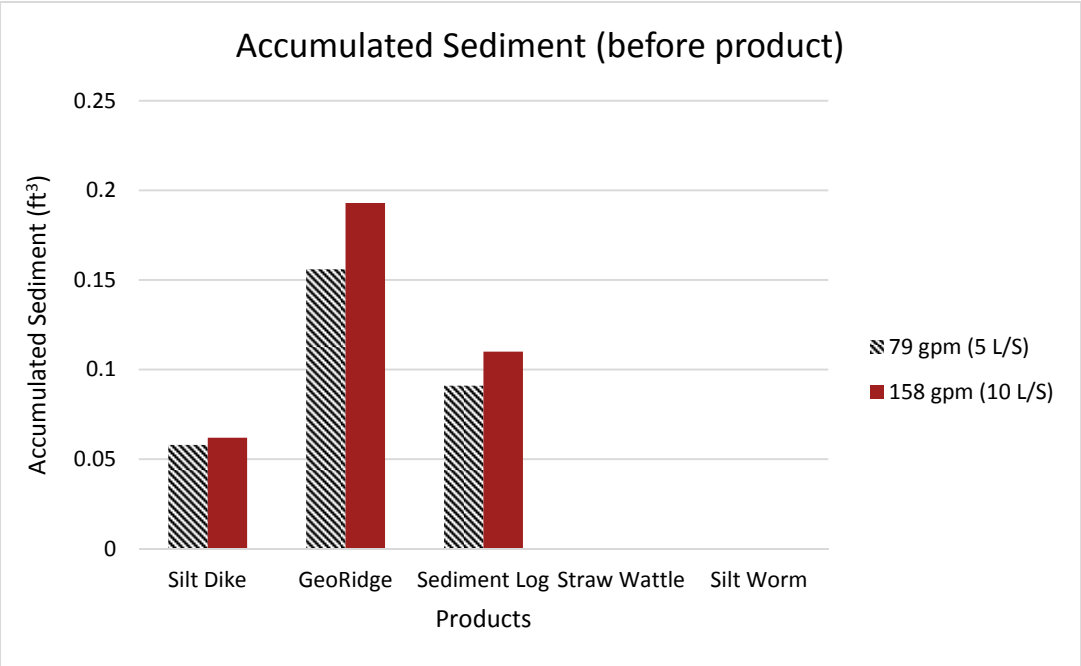

Figure 5.1 Comparison of accumulated sediment volume.

It was observed that the higher sediment accumulation occurred with high flow (158 gpm). The silt dike had the lowest downstream sediment concentration since the product created significant ponding and led to minimum channel erosion. The GeoRidge had the highest level of accumulated sediment, as sediment was easily captured by the product and erosion control blanket. The sediment log caused the water to slow down, which allowed sediment to settle in front of the product. The straw wattle is not recommended, as significant undercutting caused the product to be ineffective. Based on our observations, there is a negative correlation between ponding and accumulated sediment.

Figure 5.2 and the accompanying discussion provide a comprehensive performance overview of each product. The product recommendations are based on observations and results, along with ease of installation. For 158 gpm (10 L/s) flow, the percent sediment concentration reduction is as follows:

- Triangular silt dike: 1.85%
- GeoRidge: –2.09%
- Sediment log: –0.12%
- Straw wattle: –120.58%

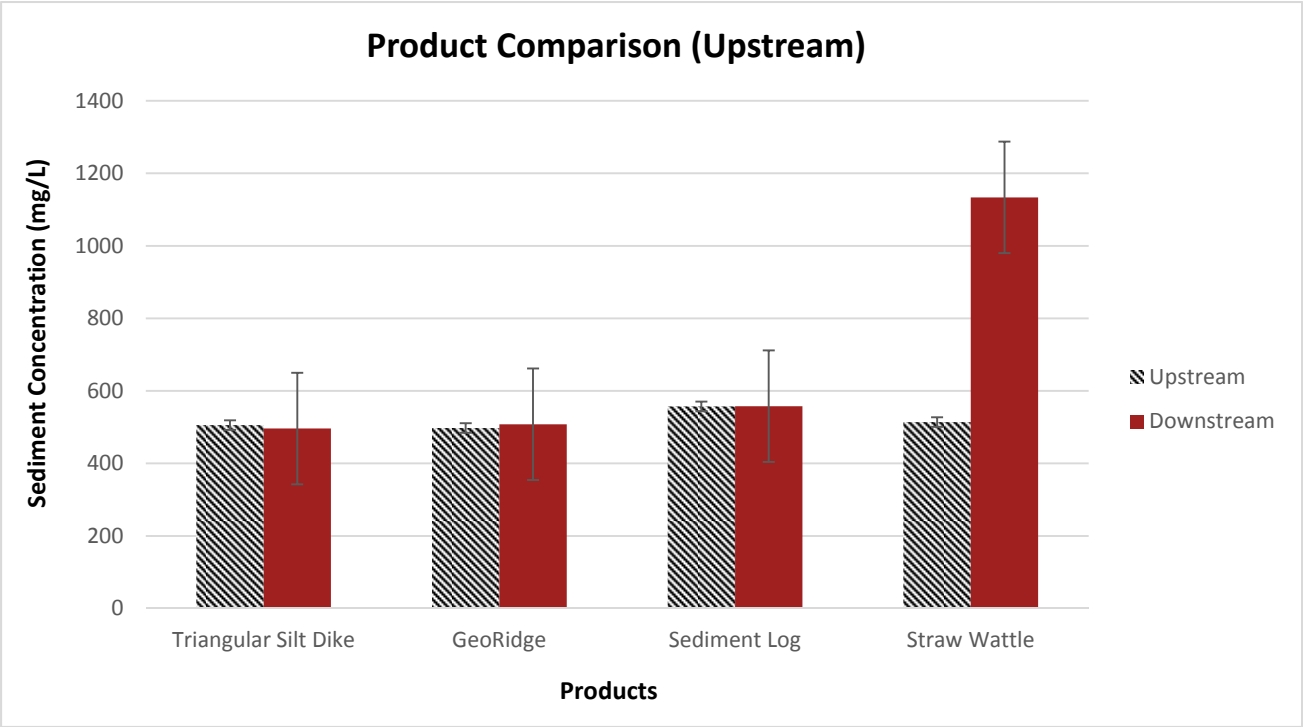

Figure 5.2 Product comparison for 158 gpm (10 L/s) flow.

Other than straw wattle, the performance of each product was similar to each other. Undercutting was the main cause for the poor performance for straw wattle.

Figure 5.3 and the accompanying discussion provide a comprehensive performance overview of each product. The product recommendations are based on observations and results, along with ease of installation. For 79 gpm (5 L/S), the percent sediment concentration reduction is as follows:

- Triangular silt dike: 1.99%
- GeoRidge: 3.92%
- Sediment log: –0.08%
- Straw wattle: –120.22%

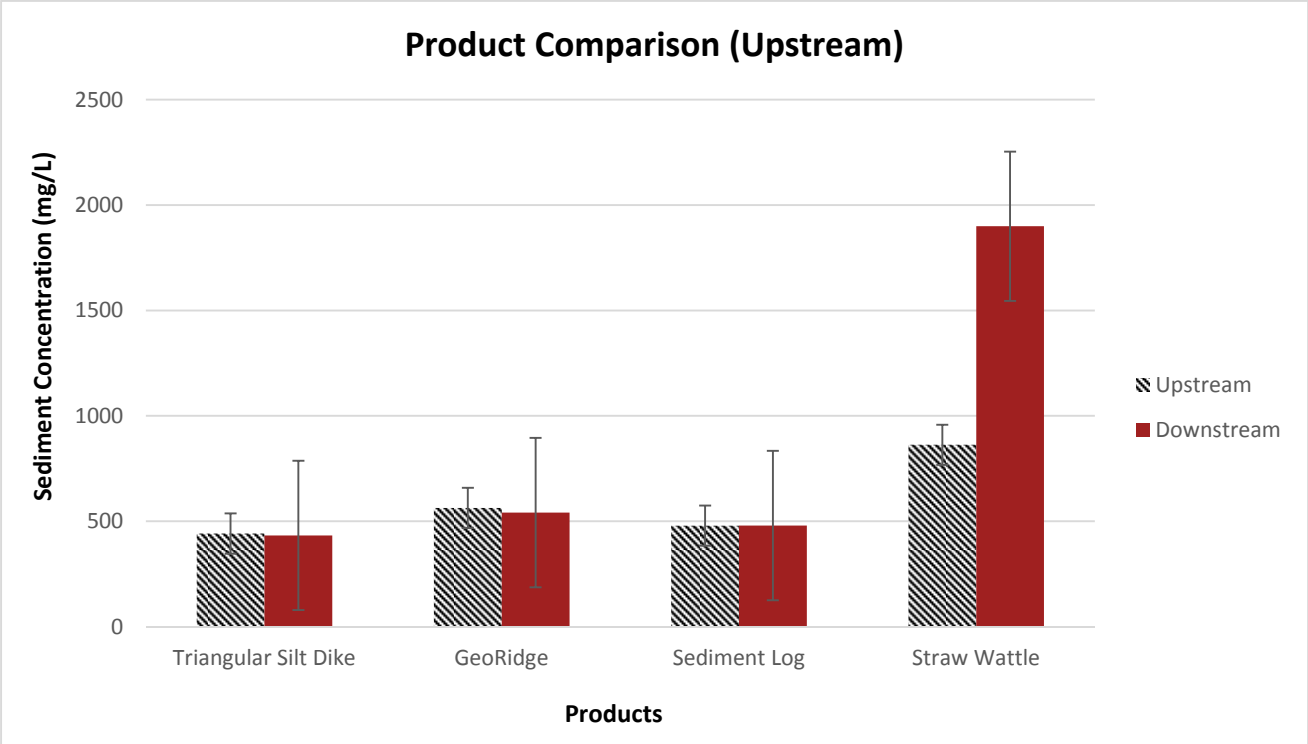

Figure 5.3 Product comparison for 79 gpm (5 L/s).

Other than straw wattle, the performance of each product was similar to each other. Undercutting was the main cause for the poor performance for straw wattle.

5.2 PRODUCT ANALYSIS

5.2.1 Triangular Silt Dike

- **Sediment removal**: Compared to sediment logs and GeoRidge, the triangular silt dike's permeability was very low, which resulted in a significant flow barrier and created a series of cascades between the ditch checks installed along the channel. Very little soil disturbance was observed for the triangular silt dike evaluation, and sediment accumulation in front of the triangular silt dike was barely noticeable. The amount of sediment deposited upstream of this product was less compared to those for GeoRidge and the sediment log. Due to good ground contact, undercutting was not an issue for this particular product.
- **Ease of installation:** Overall, this product was fairly easy to install.
- **Ponding:** This product created a large amount of ponding compared to other products.
- **Product failure:** The product appeared to hold up well at both high and low flow rates.

5.2.2 GeoRidge

- **Sediment removal**: Soil disturbance and sediment accumulation were visible for GeoRidge. Due to good ground contact, undercutting was not an issue for this particular product.
- **Ease of installation:** Overall, this product was fairly easy to install.
- **Ponding:** This product created very little ponding compared to other products.
- **Product failure:** The product appeared to hold up well at both high and low flow rates.

5.2.3 Sediment Log

- **Sediment removal**: Soil disturbance and sediment accumulation were visible with the sediment log. Because the product is not nailed into the ground (as with the triangular silt dike and GeoRidge, minor undercutting was observed for this product for the high flow condition. No significant undercutting was observed for the low flow condition.
- **Ease of installation:** Overall, this product was fairly easy to install.
- **Ponding:** This product created less ponding compared to the triangular silt dike, but it created more ponding than GeoRidge.
- **Product failure:** The product appeared to hold up well at both high and low flow rates.

5.2.4 Straw Wattle

- **Sediment removal:** This product had poor results regarding its ability to remove sediment from the water. The undercutting seemed to have lowered the product's ability to reduce sediment in the water. It would seem the second ditch check, where the undercutting was less severe, was able to retain more sediment than the first ditch check. During installation, measures should be taken to provide a good ground contact with this product. This product may probably perform better on rain events after the first one. Specifically, the product will probably sink into the mud after the first rain; therefore, less undercutting would be expected to occur as the product begins to make better contact with the soil.
- **Ease of installation:** Overall, this product was fairly easy to install. The installation protocol was nearly identical to that of sediment log. Therefore, straw wattles are highly practical

products. However, they are quite heavy, and they are much messier than the sediment log because the straw tends to fall out of its sleeve.

- **Ponding:** The straw wattle did not cause a large amount of ponding. If the prediction about the product's performance during rain events is true, more ponding could possibly occur as undercutting is reduced. Overall, this product caused very little flooding.
- **Product failure:** The straw wattle appeared to hold up well in higher flow rates. The product did not fall apart or get carried away in high flows. However, undercutting was a serious problem and happened almost instantly at low flow rates. Better trenching could possibly fix this issue, but the product might then sit too low in the dirt. Future rain events may have less undercutting for the reasons stated in the discussion about sediment removal, above.

5.2.5 Siltworm

- **Sediment removal:** Because the product was evaluated qualitatively, its efficiency in sediment removal could not be quantified.
- **Ease of installation:** Overall, this product was the most difficult to install among all the products evaluated. The product was heavier than the other tested products. Moreover, it was not easy to install wooden stakes through the product.
- **Ponding:** The Siltworm did not cause a large amount of ponding. Because of the nature of this product, it was difficult to achieve good ground contact. Hence, the product resulted in severe undercutting.
- **Product failure:** This was the only product that failed during evaluation due to severe undercutting. To prevent undercutting, an erosion control blanket should be placed underneath the product or mulch should be added in front of (upstream side) the product.

5.3 RECOMMENDATIONS FOR ROLLED PRODUCTS

It was observed that undercutting of the product was a common problem with rolled products such as the sediment log, straw wattle and Siltworm under high flow conditions. Unlike the triangular silt dike and GeoRidge, these products are not nailed into ground and therefore can't establish good ground contact. To improve the performance of such products, an erosion control blanket should be placed underneath the product or mulch/compost should be added in front of (upstream side) the product. It should also be noted that an erosion control blanket provides extra protection from scouring on the downstream side if the product is overtopped by flow.

5.4 SUMMARY OF PRODUCT COMPARISON

Product/Criteria	Sediment Removal	Ease of Installation	Ponding	Product Failure
Triangular silt dike	Good	Good	Bad	No
GeoRidge	Decent	Good	Good	No
Sediment log	Decent	Decent	Decent	No
Straw wattle	Bad	Decent	Bad	Yes
Siltworm	Bad	Bad	Bad	Yes

Note: Good: 8–10, Decent: 5–7, Bad: 0–4

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