TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

Large-Scale Sediment Retention Device Testing (ASTM D 7351)

of

FLEXSTORM Inlet Filter

February 2009

Submitted to:
Inlet & Pipe Protection, Inc.
24137 W. 111th St., Unit A
Naperville, IL 60564

Attn: Mr. Jamie Ringenbach

Submitted by:
TRI/Environmental, Inc.
9063 Bee Caves Road
Austin, TX 78733

C. Joel Sprague
Project Manager

February 24, 2009

Mr. Jamie Ringenbach
Inlet & Pipe Protection, Inc.
24137 W. 111th St., Unit A
Naperville, IL 60564
E-mail: jr@inletfilters.net

Subject: Sediment Retention Device Testing of the FLEXSTORM Inlet Filter (# 2278-01-36)

Dear Mr. Ringenbach:

This letter report presents the results for large-scale sediment retention device tests performed on the FLEXSTORM Inlet Filter. Included are data developed for simulated sediment-laden runoff from a 100-ft long, 3:1 slope exposed to a 4 inch storm event. All testing work was performed in general accordance with the ASTM D 7351, *Standard Test Method For Determination Of Sediment Retention Device Effectiveness In Sheet Flow Application*, though the protocol was modified to present the flow toan inlet and to stop the test upon the inlet bag ceasing to continue passing flow. Generated results were used to develop the following effectiveness percentages for the tested material:

Property	Woven 200
Retention Effectiveness (Filtration Efficiency)	82%
Soil Captured During Rain Event (@ 80 lf/ft^3)	1.24 ft^3
Tested Bag Capacity	2.14 ft^3
Capacity Utilization Rate	58%
% of Storm Event Handled	40%
Bag Volume Req'd for Storm Event	5.4 ft^3

TRI is pleased to present this final report. The data presented herein appears to be consistent with commonly reported values. Please feel free to call if we can answer any questions or provide any additional information.

Sincerely,

C. Joel Sprague

C. Joel Sprague, P.E.
Senior Engineer
Geosynthetics Services Division

Cc: Sam Allen, Jarrett Nelson - TRI

SEDIMENT RETENTION DEVICE (SRD) TESTING REPORT

Inlet Filter Bags

TESTING EQUIPMENT AND PROCEDURES

Overview of Test and Apparatus

TRI/Environmental, Inc.'s (TRI's) large-scale sediment retention device testing facility is located at the Denver Downs Research Farm in Anderson, SC. Testing oversight is provided by C. Joel Sprague, P.E. The large-scale testing is performed in accordance with ASTM D 7351 *modified to present the flow to an inlet and to stop the test upon the inlet bag ceasing to continue passing flow*. At a minimum, the amount (via water and soil weight) of sediment-laden flow is measured both upstream and downstream of the SRD. The measurement of sediment that passes through, the SRD compared to the amount in the upstream flow is used to quantify the effectiveness of the SRD in retaining sediments.

This test method is full-scale and therefore, appropriate as an indication of product performance, for general comparison of product capabilities, and for assessment of product installation techniques. For this testing, a simulated area inlet comprised of a wooden "box" section and inlet opening was used to position the Inlet Filter Bag in a representative condition.

The test apparatus is shown in Figure 1 and the bag setup is shown in Figure 2.

Sediment Retention Device (SRD)

The following table describes the tested SRDs.

Table 1. Tested SRD Descriptions

Fabric Component	Woven 200
Description	Woven, monofilament
AOS, mm	0.85
Water Flow Rate, gpm	200
Tested Bag Capacity, ft^3	2.14

Test Soil

The test soil used as sediment had the following characteristics.

Table 2. TRI-Loam Characteristics

Soil Characteristic	Test Method	Value
% Gravel	ASTM D 422	2
% Sand		60
% Silt		24
% Clay		14
Liquid Limit, %	ASTM D 4318	34
Plasticity Index, %		9
Soil Classification	USDA	Sandy Loam
Soil Classification	USCS	Silty Sand (SM)

Test Setup

SRD Installation – The Sediment Retention Device (SRD) installation used a simulated area inlet comprised of a wooden “box” section and inlet opening to position the Inlet Filter Bag in a representative condition.

Mixing Sediment-Laden Runoff - Sediment-laden runoff was created by combining water and soil in the mixing tank and agitated during the test. 4000 lb of water and 240 lb of soil were combined to create the sediment-laden runoff. This amount of water and sediment simulates sheet flow from a slope measuring 16 ft (4.8 m) wide by 100 ft (30 m) long during the peak 30 minutes of a 4 in (100 mm) per hour rainfall hydrograph as outlined in the following calculation (which is outlined in the standard). . .

“For this testing, a standard 10-year, 6-hour storm event (mid-Atlantic region of US) was selected. This return frequency is commonly used for sizing sediment control ponds and, thus, was deemed appropriate for the testing of other SRDs. Using this criterion, a 100 mm (4 in) rainfall was selected. It was also assumed that approximately 25% of the storm would occur during the peak 30 minutes, and that 50% of the rainfall would infiltrate into the ground. A theoretical contributory area of 30 m (100 ft) slope length by 6 m (20 ft) wide was selected to limit runoff to sheet flow conditions. Runoff and associated sediment were calculated using the Modified Universal Soil Loss Equation (MUSLE) which allows for calculating a storm-specific quantity of sediment. Following is the MUSLE (SI formula):

$$T = 89.6\ (V \times Q_p)^{0.56}\ K\ LS\ C\ P$$

Where: T = sediment yield (tonnes); V = runoff (m^3) = (Rainfall – Infiltration) x Area; Q_p = peak flow (m^3/s); and K, LS, C, P are from RUSLE charts

The following calculations provided the runoff and sediment load used in the testing:

$V = (0.5)^* \times (0.1\ m) \times (180\ m^2) = 9\ m^3$

$Q_p = (0.1m) \times (0.25)^* \times (0.5)^{**} \times (180m^2) = 2.25\ m^3/ 30min = 0.00125\ m^3/s$

(= 25% of storm during 30-min peak; ** = 50% infiltration)*

K, sandy-silt = 0.041; LS, 2-10%/30m = 0.46 (approx); C, P = 1.0

T = 89.6 (9 x 0.00125)$^{0.56}$ (0.041) (0.46) (1.0) (1.0) = 0.136 Tonnes = 136 kg of soil
(assume most sediment is generated during the peak flow period)

Std. Test Quantities: 30-Minute Runoff: 2.25 m^3 x 1000 kg/m^3 = 2250 kg (approx. 5000 lb)
Sediment Load: 136 kg (approx. 300 lb)"

Actual Test Quantities adjusted for 16 ft wide slope:
30-Minute Runoff: 5000 lb x (16 ft / 20 ft) = 4000 lb
Sediment Load: 300 lb x (16 ft / 20 ft) = 240 lb

Installation of Sediment Retention Device

As noted, the submitted SRD installation used a simulated area inlet comprised of a wooden "box" section and inlet opening to position the Inlet Filter Bags in a representative condition. This facilitated multiple test repetitions. Sediment laden flow was introduced through a pipe from the mixing tank as shown in Figure 1.

Figure 1. Test set-up, including mixing tank and wooden box with simulated area inlet inside collection tank. (typical grab sampling shown)

Test Procedure

Releasing, and Collecting Sediment-Laden Runoff - The sediment-laden water was discharged evenly for a maximum of 30 minutes. The flow was stopped when seepage through the inlet bag ceased. The quantity of released runoff was measured at 1-minute intervals by noting the reduction in weight in the mixing tank, adjusting the valve on the tank outlet to increase/decrease flow to stay as close as possible to the target (4240 lb / 30 min = 140 lb / min). The discharge flow introduced to the inlet area through a 6-inch diameter pipe. Retention observations and associated times, are recorded during the test.

As runoff passing the SRD enters the collection tank, the weight of the collection tank is recorded and grab samples are taken, at intervals. Cutoff time is when there is minimal discharge.

Collecting and Measuring Sediments - Grab samples are evaluated in a lab to determine turbidity using a Hach 2100 AN Turbidimeter and to determine percent dry solids content. Drying of collected sediments is accomplished in a forced air oven at 110°C for a minimum of 24 hours or until all moisture is driven off, whichever is greater. All weighing of sediments is done with laboratory scales accurate to ± 0.01 lbs.

Figure 2. Woven 200 Bag Test

TEST RESULTS

Total sediment and associated runoff measured during the testing are the principle data used to determine the performance of the product tested. This data is entered into a spreadsheet (see appendix) that transforms the sediment concentration and collected runoff into the retention effectiveness and percent of storm event values shown in Table 3. Additionally, turbidity samples were taken to determine if any change in turbidity resulted from the measured short-term Inlet Filter Bags performance. No significant difference in upstream (runoff) and downstream (short-term seepage) turbidity was found. This is likely the result of the inadequate time afforded for settlement of fine-grained suspended soil particles during the test.

Table 3. Measures of Effectiveness

Property	Woven 200
Retention Effectiveness (Filtration Efficiency)	82%
Soil Captured During Rain Event (@ 80 lf/ft^3)	1.24 ft^3
Tested Bag Capacity	2.14 ft^3
Capacity Utilization Rate	58%
% of Storm Event Handled	40%
Bag Volume Req'd for Storm Event	5.4 ft^3

APPENDIX A – RECORDED DATA

Test Record Sheets

ASTM D 7351 (Modified) - SEDIMENT RETENTION DEVICE (SRD) TESTING

TEST I.D.: FlexStorm Inlet Protection Bag A DATE: 01/13/09

SRD Device & Installation Details, including Product Description:

Inlet Protection Bag A is comprised of Propex 117F Geotextile on a 22” x 22” frame.

Bag Volume:

Bag Surface Area:

Soil Subgrade Type: Loam **Sediment Type:** Loam

Sediment Weight: 240 lbs **Runoff Weight**: 4000 lbs

Runoff Discharge- Start Time: 9:25 am **Finish Time**: 9:37 am

Upstream Runoff			Downstream Runoff				SRD		
Time	Sample #	Reservior Weight (lbs)	Time	Sample #	Collected Weight (lbs)	Collected Height (in)	Time	Ponding Height (in)	Observation #
0		4240	0			0			
5	A1	3500	5	A1L	724		5		
10	A2	2800	10	A2L	1488		10		
12		2560	12		1680		12		1
Time	Sample #	Turbidity	Time	Sample #	Turbidity				
0			0						
5	A1	7257	5	A1L	7825				
10	A2	7433	10	A2L	7683				
12			12						

OBSERVATIONS:

1. Bag completely filled and minimally draining at 12 minutes, so test stopped.

2.

3.

APPENDIX B – CALCULATIONS

Effectiveness Calculation Spreadsheets

Retention Effectiveness Calculations
Run A: FlexStorm Inlet Protection Bag A
1/13/2009

Sample Number	Test Time, minutes	Turbidity	Total Weight, g	Decanted Weight, g	Dry Weight, g	Bottle Weight, g	Dry Sediment Weight, mg	Total Collected Water Wt., g	Total Collected Volume of Water, l	Sediment Conc., mg/l	% Solids	Reservoir Weight, lb	Assoc. Discharge, gal	Cumm Discharge, gal	Coll. Tank Depth, in	plot time	% Soil Retained	Cumm Soil Loss, lbs	Assoc. Solids Loss, lbs	Soil Retention Effectiveness, %
Upstream													0			0		0		
	0									77626	7.76%	4240	40	0		2.5		26.1	26.1	
A1	5	7257	286.3	62.5	45.4	26.7	18700	240.90	0.24	77626	7.76%	3516	83	81		7.5		79.5	53.4	
A2	10	7433	279.1	61.5	44.6	26.7	17900	234.50	0.23	76333	7.63%	2752	53	166		11.0		113.5	34.0	
	12									76333	7.63%	2560	11	187		12.0		120.3	6.8	
Water Added To Mixer (lbs): 4000					Soil Added To Mixer (lbs): 240				AVGS:	76979	7.70%	TOTALS:	187					120	120.3	
Downstream													0			0		0		
	0									13420	1.34%	0	43	0		2.5	81.6%	4.8	4.8	
A1L	5	7825	291	41.9	30.2	26.7	3500	260.80	0.26	13420	1.34%	724	88	86		7.5	81.6%	14.7	9.9	
A2L	10	7683	288.6	42.9	29.5	26.7	2800	259.10	0.26	10807	1.08%	1488	57	176		11.0	82.0%	20.4	5.7	**82.21%**
	12									10807	1.08%	1680	11	199		12.0	82.2%	21.4	1.0	
										12113	1.21%	1680	199						21.4	
Soil Collected from Bag (lbs):				**98.9**						(avg)	(avg)	(total)	(total)						(approx.)	**98.91**

APPENDIX C – TEST SOIL

Test Soil Grain Size Distribution Curve

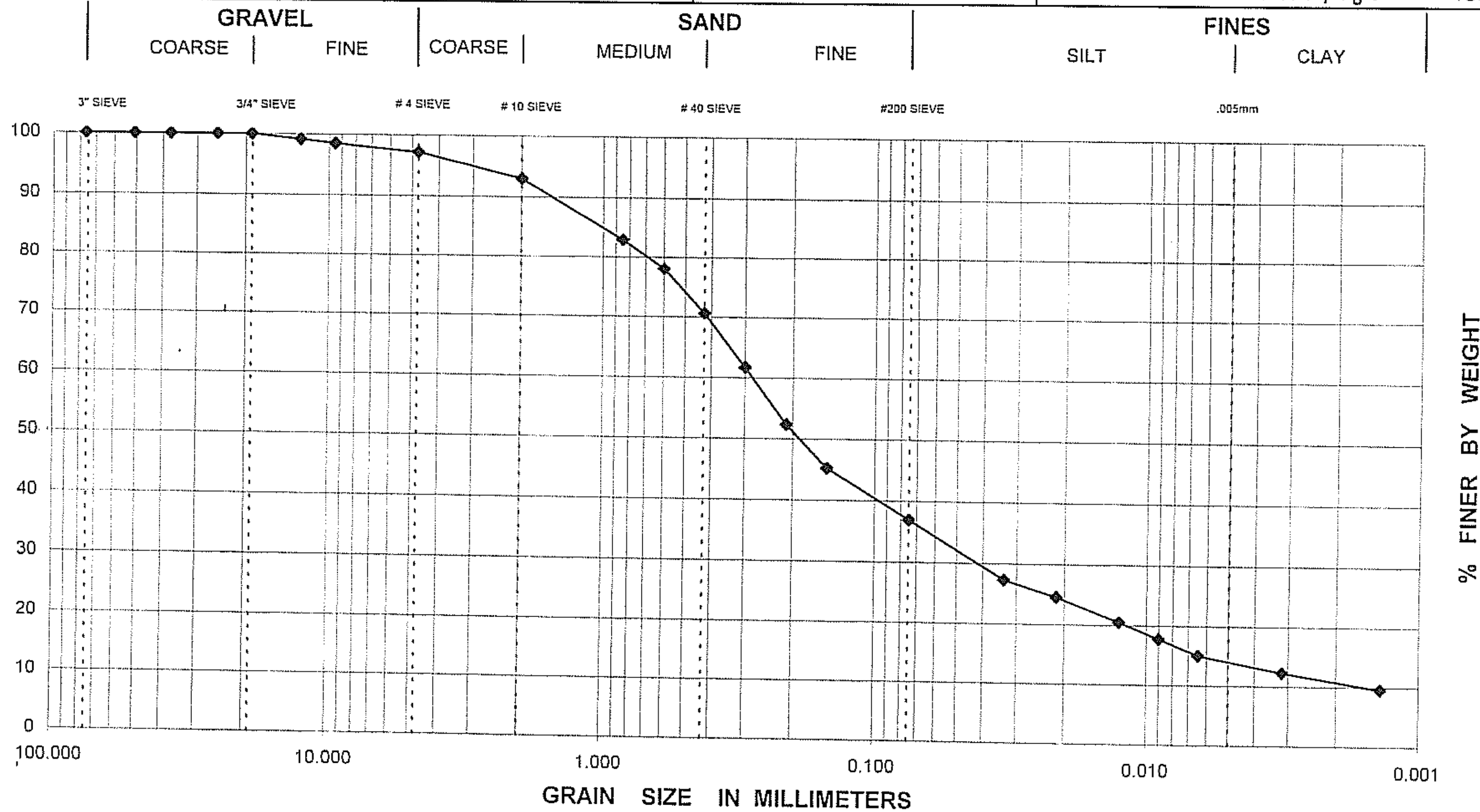
QORE PROPERTY SCIENCES

PARTICLE- SIZE DISTRIBUTION TEST REPORT
SIEVE AND HYDROMETER ASTM D422

REV1,9/17/03

AASHTO R18

JOB NAME :	Sprague & Sprague - General Laboratory Testing						
JOB NO. :	7752	REPORT NO. :	118471	DATE :	8/6/07	REVIEWED BY :	EWW
BORING / PIT NO. :	-	DEPTH / ELEV. :	-	SAMPLE NO. :	1	SAMPLE TYPE :	Bulk
SAMPLE LOCATION :							
SOIL DESCRIPTION :	Brown Silty Fine to Medium Sand					SP. GRAVITY, Gs :	2.63
LIQUID LIMIT, % :	34	PLASTICITY INDEX , % :	9	MOISTURE , % :	-	FINES , % :	36.9
D10 , MM :	0.0015	D30 , MM :	0.042	D60 , MM :	0.28	COEFF. OF CURVATURE , C_C :	4.2
CLASSIFICATION		UNIFIED :	SM	AASHTO :	-	COEFF. OF UNIFORMITY , C_U :	186.7



APPENDIX D – LABORATORY QUALIFICATIONS

Testing Expertise

TRI/Environmental (TRI) is a leading, accredited geosynthetic, plastic pipe, and erosion and sediment control product testing laboratory. TRI's large-scale erosion and sediment control testing facility in the upstate of South Carolina at the Denver Downs Research Farm (DDRF) is initially focused on the following full-scale erosion and sediment control performance tests:

- ASTM D 6459: Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Hillslopes from Rainfall-Induced Erosion;
- ASTM D 6460: Determination of Rolled Erosion Control Product (RECP) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion;
- ASTM D 7208: Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion.
- ASTM D 7351: Determination of Sediment Retention Device Effectiveness In Sheet Flow Applications.

Technical Oversight

Joel Sprague, P.E., TRI's Senior Engineer provides technical oversight of all of TRI's erosion and sediment control testing and can be contacted at:

Mr. C. Joel Sprague, Senior Engineer
PO Box 9192, Greenville, SC 29604
Ph: 864/242-2220; Fax 864/242-3107; jsprague@tri-env.com

Mr. Sprague has been involved with the design of erosion and sediment control systems and the research, development, and application of erosion and sediment control products/materials for many years. He was the lead consultant in the development of bench-scale testing procedures for the Erosion Control Technology Council. Mr. Sprague has authored numerous technical papers on his research and is readily available to assist clients with their research and testing needs.

Operations Management

Sam Allen, TRI's Division Vice President provides operational management of all TRI laboratories and can be contacted at:

Mr. Sam Allen, Vice President & Program Manager
9063 Bee Caves Road
Austin, TX 78733
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Mr. Allen pioneered the laboratory index testing of rolled erosion control products (RECPs) and has been actively involved in the development and standardization of testing protocol and apparatus for more than 10 years. He set up and oversees TRI's erosion and sediment control testing laboratories. His oversight responsibilities include test coordination, reporting, and failure resolution associated with the National Transportation Product Evaluation Program (NTPEP) for RECPs.