EVALUATING SEDIMENT CONTROL BMPs

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The “BMP” Problem

- The broad use of the label “Best Management Practice, or BMP” has resulted in great uncertainty as to why a particular BMP might actually be the “best” in comparison to an alternative.
- We have lacked an objective means to specify performance. This is not in line with how other construction products are vetted, approved and purchased.

The Solution to the "BMP" Problem

- The implementation of standardized, repeatable large-scale performance tests is now well underway.
- These tests provide a long-needed means to perform "apples-to-apples" comparisons of the various technologies in different applications, and they offer data to show how the unique characteristics of these products translate into actual field performance.

Objective Evaluation Process

- **The influential <u>National Transportation Product Evaluation Program (NTPEP)</u> has incorporated large-scale performance testing into its objective process providing the DOTs with the quantitative evidence needed to determine which product or practice truly is “best” for a given application.**
- **The NTPEP evaluates rolled erosion control products (RECPs), hydraulically-applied erosion control products (HECPs) and, beginning October 1, 2015, sediment retention devices (SRDs).**

Supporting Organizations

- **The Erosion Control Technology Council (ECTC) – A consortium of erosion and sediment control product manufacturers/distributors.**
- **ASTM International - A globally recognized leader in the development and delivery of international voluntary consensus standards.**
- **The International Erosion Control Association (IECA) - The world's oldest and largest association devoted to helping members solve the problems caused by erosion and its byproduct-sediment.**

States that Currently Use NTPEP Testing of Erosion Control Products

Alabama
Arizona
Arkansas
Delaware
District of Columbia
Georgia
Idaho
Maine
Maryland
Minnesota
Mississippi
Montana
Nebraska
Nevada
New Hampshire
New York
Ohio
Pennsylvania
Rhode Island
South Carolina
Tennessee
Texas
West Virginia
Wisconsin

State Benefits

- The NTPEP program:
  - Relieves states of the economic burden relating to the construction, staffing and maintenance of a facility specifically to test and approve products.
  - Provides consistent testing practices across a wide range of materials.
  - Provides a single submission process for the manufacturer, thereby reducing the cost of doing business in each state while improving competition in each marketplace.

Available NTPEP Testing

Large-scale Erosion Control Testing:

- **ASTM D6459 for slope erosion control testing;**
- **ASTM D6460 for channel erosion control testing.**

Large-scale Sediment Control Testing:

- **ASTM's TM11340 for perimeter / toe-of-slope testing;**
- **ASTM D7351 modified for inlet testing;**
- **ASTM D7208 for channel check structure testing.**

GSWCC SEDIMENT CONTROL BMP PROGRAM

Sediment Retention Device Testing

- TM11340, Determination of Sediment Retention Device (SRD) Performance in Reducing Soil Loss from Rainfall-Induced Erosion in Perimeter Controls

- ASTM D 7208, Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion

- ASTM D 7351-modified, Test Method for Determination of Sediment Retention Device Effectiveness in Inlet Applications

- ASTM Proposed, Standard Practice for Measurement of Floating Pond Skimmer Flow Rate

EVALUATING SEDIMENT BARRIERS

Objective:
Full-scale Performance Evaluation of Sediment Barriers in Perimeter Control Applications

The most common sediment barriers, including silt fences and wattles, are used as so-called "perimeter devices" around building sites to intercept modest sheet flows when no obvious low point or ponding capacity exists on-site.

Testing Matrix

Sediment Barrier Type	# Tested	Installation
Silt Fence – GADOT Type A	3	36” fabric; 1.5” x 1.5” x 4ft oak posts @ 6ft spacing
Silt Fence – GADOT Type B	2	24” fabric; 1.0” x 1.0” x 3ft oak posts @ 6ft spacing
Silt Fence – GADOT Type C	3	36” fabric; wire backing; steel posts @ 4ft spacing
Silt Fence – GADOT C-System	2 Prefab Systems	Install according to manufacturer’s specifications
GSWCC Type B Silt Fence Alternative	Compost Sock	Install according to manufacturer’s specifications
GSWCC Type C Silt Fence Alternative	Scrim-Reinforced Silt Fence	Install according to manufacturer’s specifications
GSWCC-USDA “Traditional”	Straw Bales	Installed per the Manual / Installed per USDA

GSWCC Test Method 11340: **Full-scale Performance Testing of Sediment Barriers in Perimeter Control Applications**

- **3:1 slopes**
- **Sandy clay soil test plots**
- **27 ft long x 8 ft wide.**
- **ten "rain trees" around the perimeter of the test slope.**
- **Rain trees have four sprinkler heads atop a 15 ft riser pipe.**
- **The target rainfall intensities are 2, 4, and 6 in/hr and are applied in sequence for 20 minutes each.**
- **Three replicate test slopes.**
- **Sediment retention and flow efficiency obtained by comparing the protected slope results to control (unprotected) results.**

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Anderson, SC

Test Slopes

GSWCC Test Method 11340:
Test Preparations

- **Initially, the 12-inch thick (minimum) slope soil veneer is placed and compacted.**
- **Subsequently, the test slopes undergo a “standard” preparation procedure prior to each slope test:**
  - **Fill rills;**
  - **Re-till and rake smooth;**
  - **Compact with a steel drum roller.**
- **The submitted product is installed according to specification or ”Green Book” or manufacturer’s recommendations;**

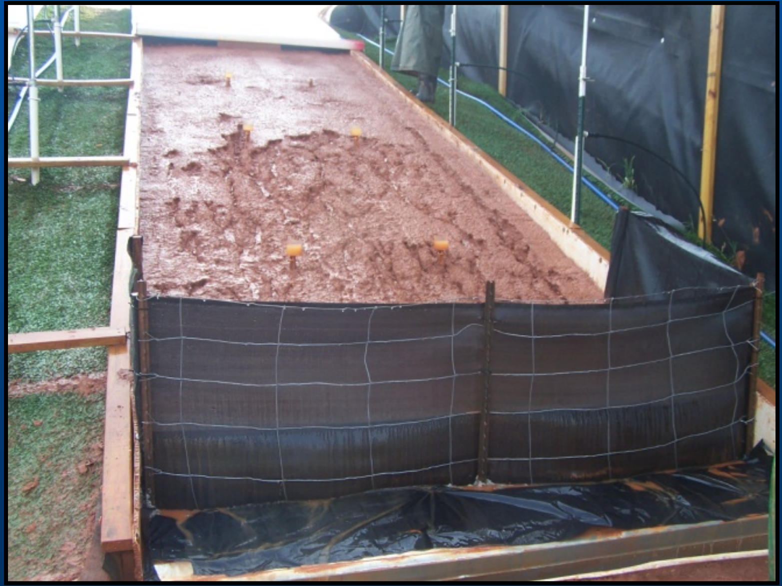
GSWCC Test Method 11340: **Test Procedures**

- Immediately prior to testing, place rain gauges;
- Soil moisture samples are sent to the lab;
- The slope is then exposed to three 20-minute rainfalls.
- All runoff is collected during the testing.
- Periodic runoff grab and flow rate samples are taken.
- Between rainfalls, intensity is reset and empty collection vessels are positioned;
- After at least 24 hrs, water is decanted from the collection vessels;
- The remaining sediments are collected and dried to determine total soil loss.

Silt Fence Tests

Prepared Slope &
Installed Product

Type A – End of Test



Type C – End of Test

Silt Fence and Other Tests

Type B – End of Test

Type C-System – End of Test

Compost Sock – End of Test

Comparison Tests: Controls & Tradition

Control Run – End of Test

Traditional Straw Bales – End of Test

Revised Universal Soil Loss Equation (RUSLE)

$$A = R \times K \times LS \times C \times P$$

where:

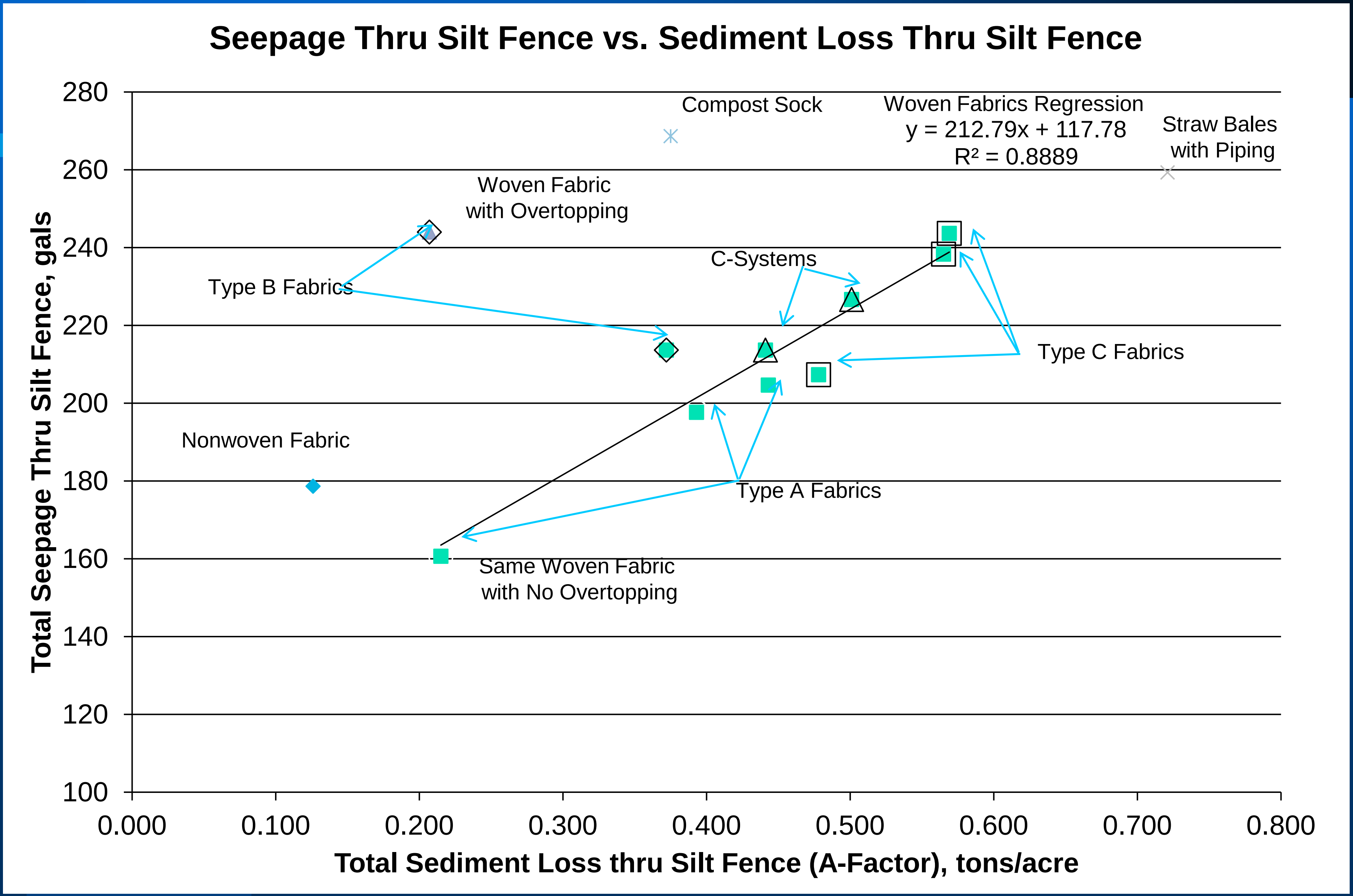
- A = the computed soil loss in tons per acre (measured/calculated from test);
- R = the rainfall erosion index (measured/calculated from test);
- K = the erodibility of the soil (calculated from control tests);
- LS = the topographic factor (2.02 for 8 x 27 ft slope);
- C = the cover factor = (1.0 for all test slopes); and
- P = . . .

The P-Factor

- P = the practice factor = ratio of protected slope sediment loss (via seepage through a sediment barrier) to control slope sediment loss (via runoff without sediment barrier).
  - Note: P = 1.0 for the control slope.

- Total sediment loss and the associated rainfall depth measured during the testing are the principle data used to determine the P-Factor.

Seepage vs. Sediment Loss



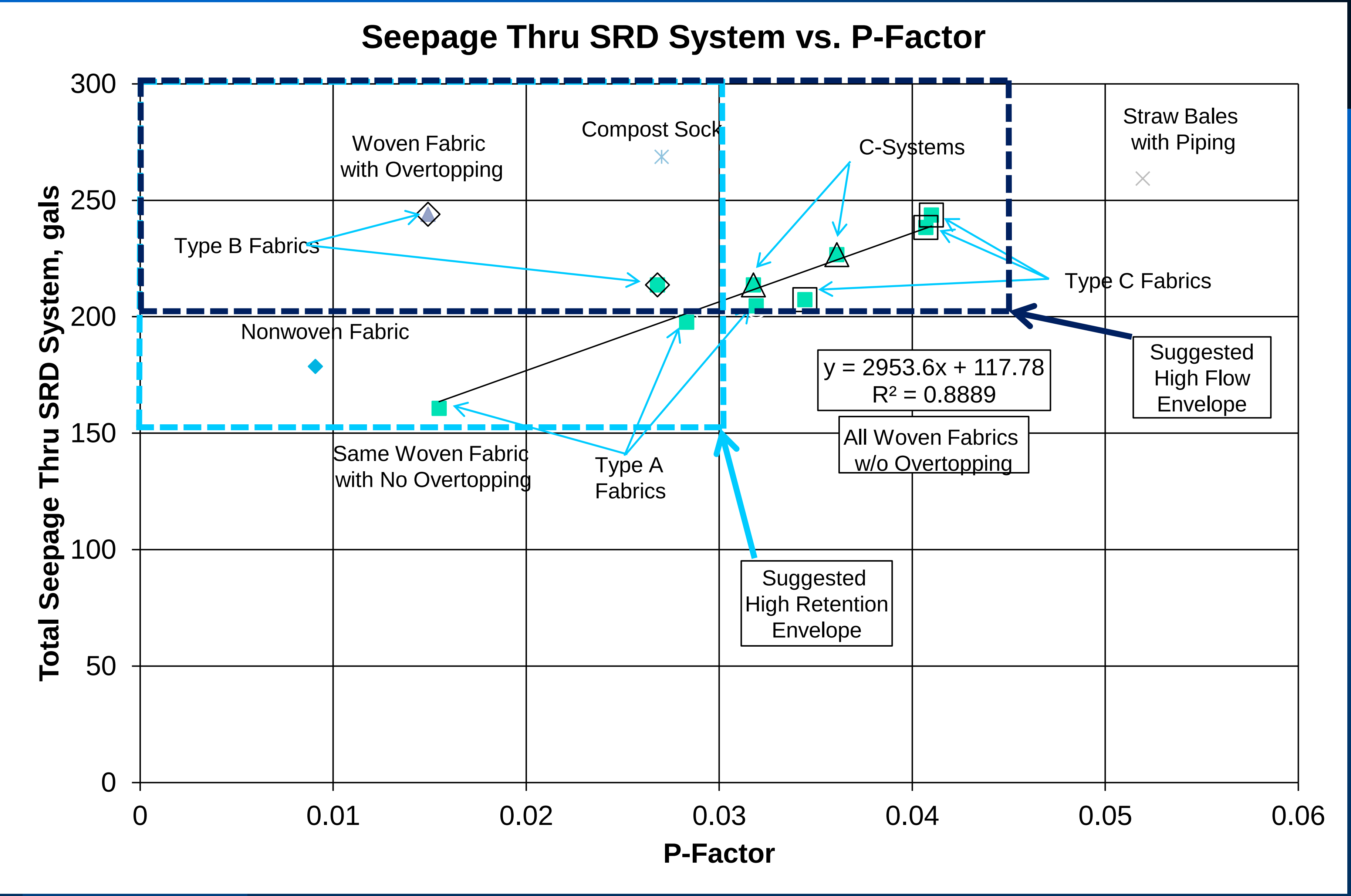
Conclusions

- Plotted data created performance envelopes for “High Retention” and “High Flow” systems, respectively.
- A lower P-Factor is generally associated with the High Retention systems, while High Flow systems typically have higher associated P-Factors.

Conclusions (continued)

- Generally, the test results suggest that it is possible to specify high retention systems for applications that can accommodate the associated ponding and high flow systems where ponding would create a hazard or exceed the available area.

Seepage vs. P-Factor



Recommended Material Specifications

Property	Units	Spec	Test	Type A & B	Type C	Alt. Systems
Tensile	lb	min	D4632	120 x 100	260 x 180	Properties and Installation Guidelines To Be Provided By Manufacturer
Elongation	%	max	D4632	40	40	
AOS	mm	max size	D4751	0.6	0.6	
Flow	gpm/ft^2	min	D4491	25	70	
POA	%	min	Light Projection	-	10	
Large-scale Performance	P-Factor	max	Method 11340	0.03	0.045	TBD
	gals	min		150	200	TBD

GSWCC Implementation in 6th Edition

Sd1 - PERFORMANCE EVALUATION

For a product or practice to be approved as a sediment barrier, that product or practice must have a documented P-factor no greater than 0.045 for non-sensitive areas or a P-factor no greater than 0.030 for sensitive areas, as specified by GSWCC.

EVALUATING CHANNEL CHECK DAMS

Objective:
Full-scale Performance Evaluation of Channel Check Dam Systems

- Performance of check dams is system or installation dependent. Therefore a large-scale test that can incorporate full-scale “as installed” conditions is desired.
- Check dams have been used to slow, or “check”, concentrated flows to make them less erosive until the associated channel can vegetate sufficiently to resist soil loss during concentrated flow events.
- Critical elements of this protection are the ability of the temporary check structure to: (a.) slow and/or pond runoff to encourage sedimentation, thereby reducing soil particle transport downstream, (b.) trap soil particles upstream of a structure, and (c.) decrease soil erosion.

Testing Matrix

Check Dam Description	Installation	Measured Properties
Compost Sock	Manufacturer's Recommendation	(~12-inch diameter, 25 lbs/ft; approx. 9" high x 16" wide installed
Straw Bales	GSWCC (1 row, std trench)	42"L x 18"H x 14"W @ 26.5 lbs = 4.3 lbs/ft^3
Straw Bales	NRCS (2 rows, deep trench)	42"L x 18"H x 14"W @ 26.5 lbs = 4.3 lbs/ft^3
Stone Check Dam	GSWCC (15-in High)	Graded size 2-10 inch stone
GADOT Type C Silt Fence	GADOT ("W" + wire backing)	Qualified Product List 36

ASTM D 7208, "*Determination of Temporary Ditch Check Performance in Protecting Earthen Channels from Stormwater-Induced Erosion*"

- Trapezoidal shaped flume with a 2 ft wide bottom and 2:1 side slope on a 5% overall bed slope
- 30 Minute test at a predetermined flow rate
- The test channel is 60 ft long and includes a 40 ft test section.
- Flow is metered into the channel via a calibrated sharp-crested weir
- Nine (9) evenly spaced cross-sections are delineated within the test section and nine (9) evenly spaced measurement points are located at each cross-section.
- These measurement points enable before and after measurements of the soil surface.
- Tables and graphs of cross-sectional soil loss (and gain) are generated from the accumulated data.

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Test Channel

Test Channel

Flume Setup
(typical control)

Flow into Channel at Weir

ASTM D7208: Test Preparations

- Initially, the 12-inch thick (minimum) slope soil veneer is placed and compacted;
- The test channels undergo a “standard” preparation procedure prior to each test:
  - Fill rills;
  - Replaced soil to a depth of 1 inch and groom to create a channel bottom that is level side-to-side with a smooth 5% bed slope and compacted 2:1 side slopes;
  - A trapezoidal form with a vibrating plate compactor is run over the renewed channel surface.
- The submitted product is installed according to Spec / ”Green Book” or manufacturer’s recommendations

ASTM D7208: Test Procedures

- Immediately prior to testing, the initial soil surface elevation readings are made at predetermined cross-sections.
- The channel is then exposed to the predetermined flow rate for 30 minutes.
- During the testing, flow depth and corresponding flow velocity measurements are taken at the predetermined cross-section locations.
- At the end of 30 minutes, the flow is stopped and soil surface elevation measurements are made to facilitate calculation of soil loss.

Channel Prep Pics

Compaction of Veneer

Channel Forming

Typical Flow Conditions

Compost Sock
Check Structure

Straw Bale
Check Structure

Typical Flow Conditions

Rock Check Structure

Silt Fence
Check Structure

Test Results

- Soil loss and the associated flow depth and velocity measurements made during the testing are the principle data used to determine the performance of the product tested.
- This data is entered into a spreadsheet that transforms the soil gain/loss measurements into related soil accretion and loss volumes using cut/fill calculations based on the Simpson Rule.
- From this data a Soil Accretion Index (SAI) and a Clopper Soil Loss Index (CSLI) are determined.

Data and Calculations for 0.5 cfs

Tested System (0.5 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Un-checked	Obser-vations	Approx. Install. Time, min.
Control (Unchecked Channel)	0.00	-2.53	95.22	0.00	-2.65	-2.65	100		0
Straw Bales (14" High / GSWCC)	2.99	-9.68	134.15	2.23	-7.22	-4.99	188	Blowout	30
Straw Bales (14" High / GSWCC)	3.74	-6.24	127.94	2.93	-4.88	-1.96	74	Blowout	30
Straw Bales (14" High / NRCS)	2.33	-2.34	152.30	1.53	-1.54	-0.01	0		60
Compost Sock (9" High)	0.28	-1.21	118.20	0.24	-1.02	-0.79	30		10
Rock + Geotextile (15" High)	0.97	-1.55	118.92	0.82	-1.31	-0.49	18		60
Type C Silt Fence (21" High / GSWCC)	0.77	-4.14	116.02	0.67	-3.57	-2.90	109	Blowout	240
Type C Silt Fence (21" High / Retest)	2.90	-4.78	128.42	2.26	-3.73	-1.46	55	Blowout	240

Values in box revised 8/21/14 to reflect correction of wetted area calculation.

Data and Calculations for 1.0 cfs

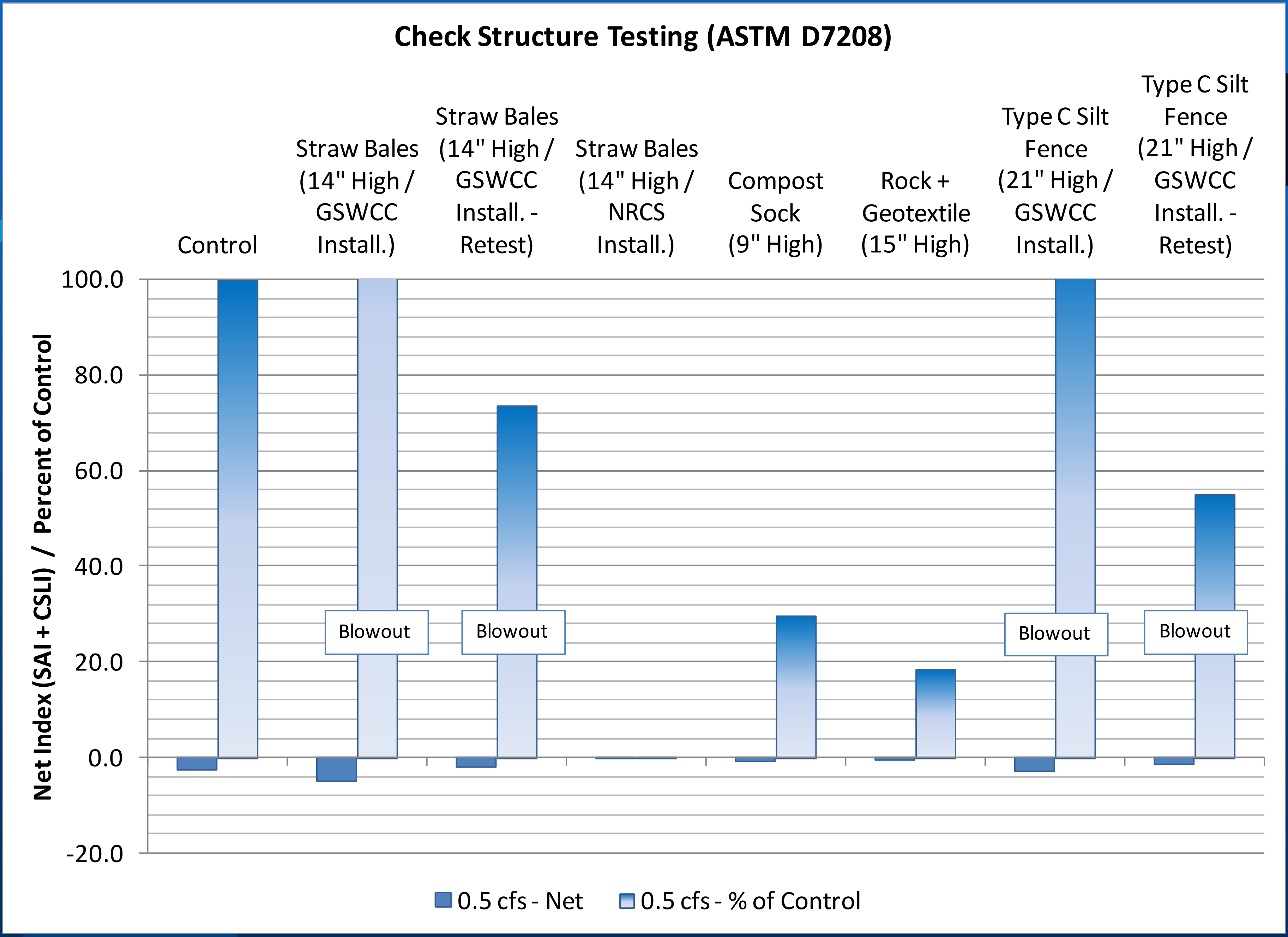
Tested System (1.0 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Un-checked	Obser-vations	Approx. Install. Time, min.
Control	0.00	-4.07	102.27	0.00	-3.98	-3.98	100		0
Straw Bales (14" High / NRCS)	2.93	-2.54	172.44	1.70	-1.47	0.22	-6		60
Compost Sock (9" High)	0.62	-1.55	121.93	0.51	-1.27	-0.76	19		10
Rock + Geotextile (15" High)	2.87	-2.94	134.62	2.13	-2.18	-0.05	1		60

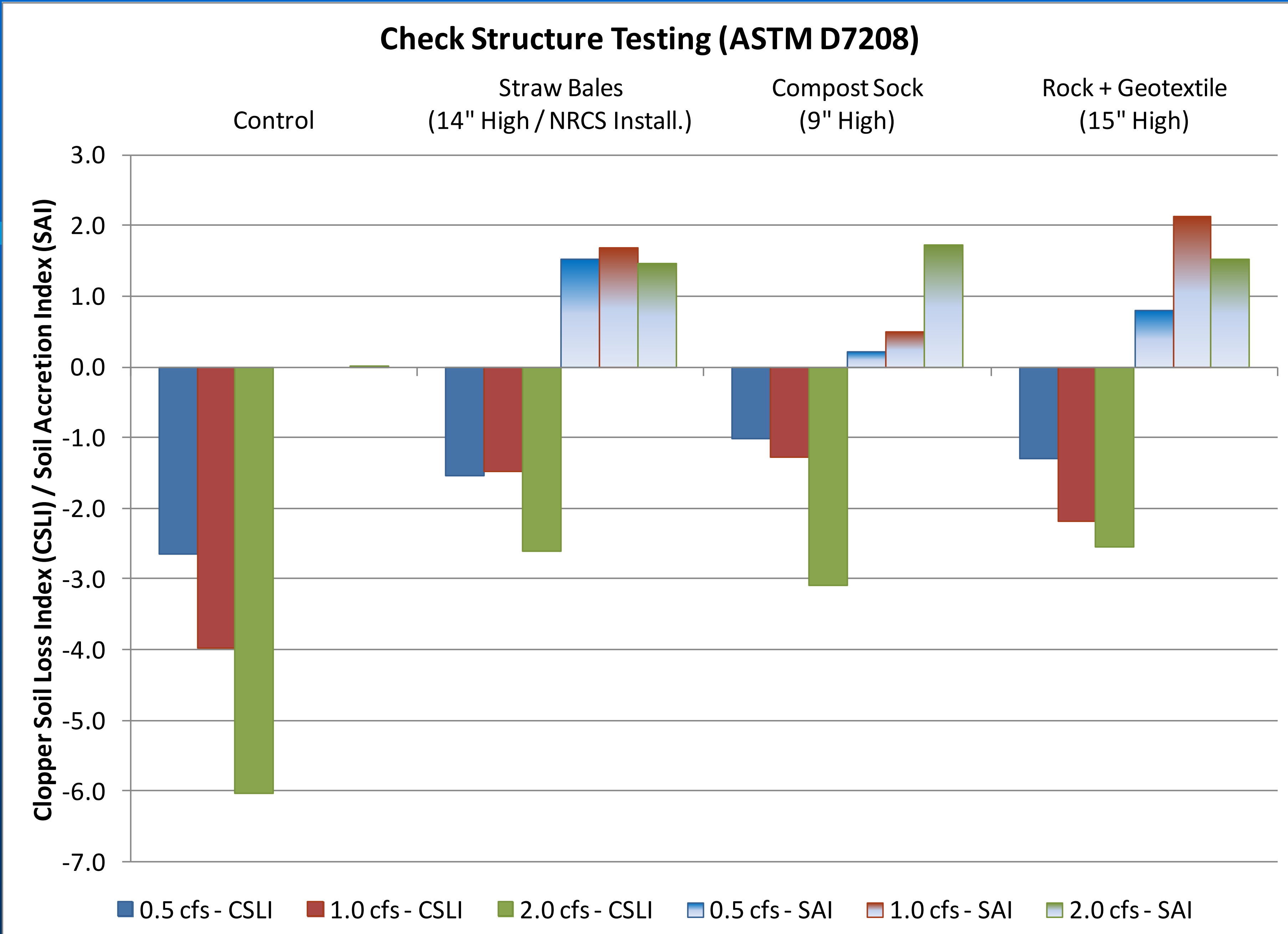
Values in box revised 8/21/14 to reflect correction of wetted area calculation.

Data and Calculations for 2.0 cfs

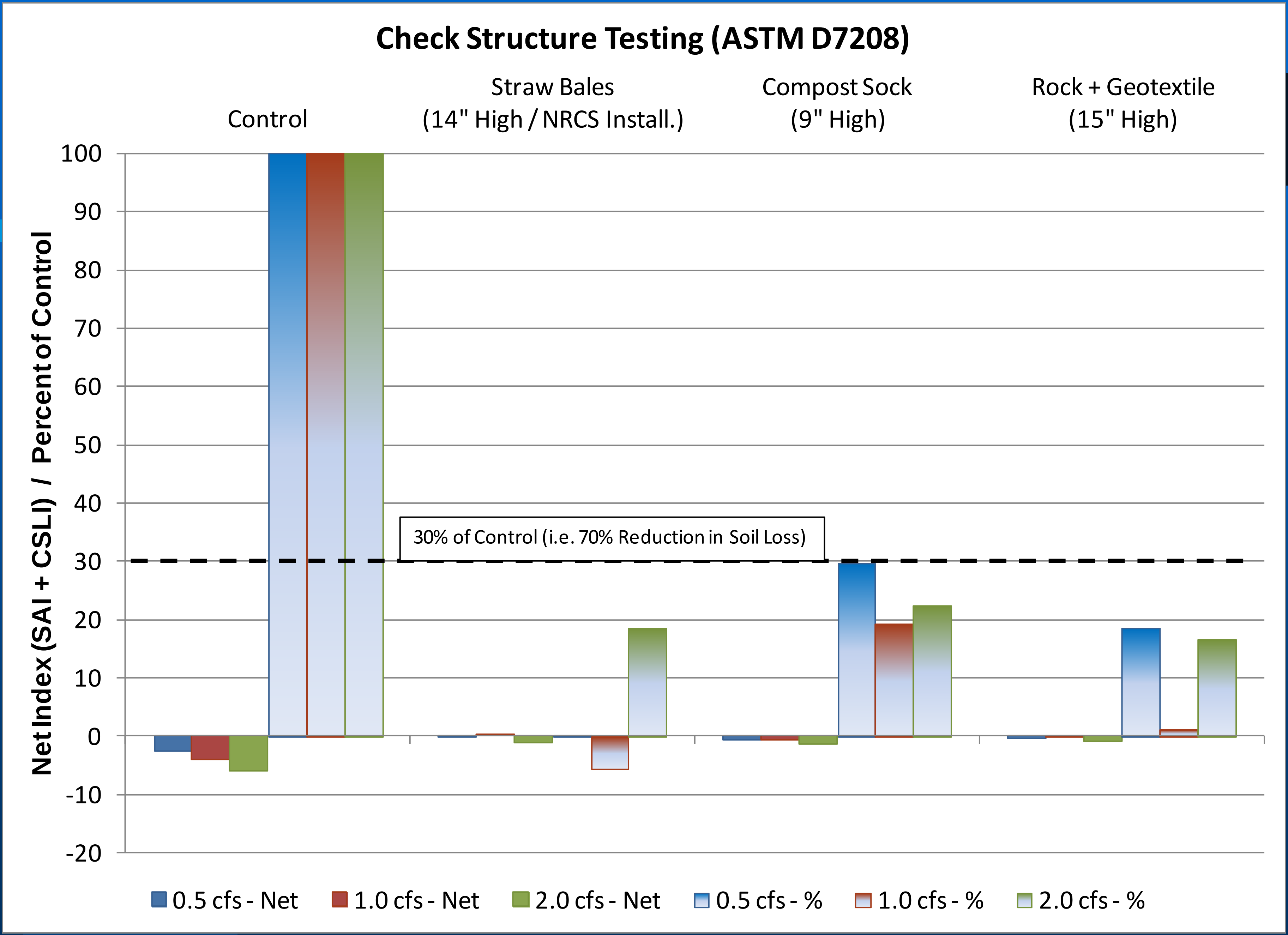
Tested System (2.0 cfs)	Total Soil Gain, ft^3	Total Soil Loss, ft^3	Total Wetted Area, ft^2	SAI	CSLI	Net	Net % of Un-checked	Obser-vations	Approx. Install. Time, min.
Control	0.00	-6.79	112.43	0.00	-6.04	-6.03	100		0
Straw Bales (14" High / NRCS)	2.91	-5.13	196.46	1.48	-2.61	-1.13	19		60
Compost Sock (9" High)	2.19	-3.90	126.12	1.73	-3.09	-1.36	23		10
Rock + Geotextile (15" High)	2.22	-3.66	143.53	1.54	-2.55	-1.01	17		60

Values in box revised 8/21/14 to reflect correction of wetted area calculation.


Check Structure Testing (ASTM D7208)
Control
Straw Bales (14" High / GSWCC Install.)
Straw Bales (14" High / GSWCC Install. - Retest)
Straw Bales (14" High / NRCS Install.)
Compost Sock (9" High)
Rock + Geotextile (15" High)
Type C Silt Fence (21" High / GSWCC Install.)
Type C Silt Fence (21" High / GSWCC Install. - Retest)
Blowout
Blowout
Blowout
Blowout
Net Index (SAI + CSLI) / Percent of Control
100.0
80.0
60.0
40.0
20.0
0.0
-20.0
0.5 cfs - Net
0.5 cfs - % of Control



Check Structure Testing (ASTM D7208)
Control
Straw Bales
(14" High / NRCS Install.)
Compost Sock
(9" High)
Rock + Geotextile
(15" High)
3.0
2.0
1.0
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
Clopper Soil Loss Index (CSLI) / Soil Accretion Index (SAI)
0.5 cfs - CSLI
1.0 cfs - CSLI
2.0 cfs - CSLI
0.5 cfs - SAI
1.0 cfs - SAI
2.0 cfs - SAI



Check Structure Testing (ASTM D7208)
Control
Straw Bales (14" High / NRCS Install.)
Compost Sock (9" High)
Rock + Geotextile (15" High)
Net Index (SAI + CSLI) / Percent of Control
100
90
80
70
60
50
40
30
20
10
0
-10
-20
30% of Control (i.e. 70% Reduction in Soil Loss)
0.5 cfs - Net
1.0 cfs - Net
2.0 cfs - Net
0.5 cfs - %
1.0 cfs - %
2.0 cfs - %

Conclusions

- Previous figure summarizes the results of systems that did not fail* during testing.

*Both single-row straw bale and “zig-zag” silt fence experienced significant undermining under the lowest flow events, and thus are considered undesirable alternatives.

- Figure presents the “net” of soil accretion and soil loss indices in the test section and the percent of the control soil loss that this represents.
- Superimposed on the figure is the suggested performance level (30% of control) for acceptable check dam systems. The following table shows how this performance limit could be incorporated into the existing GSWCC specifications for check dams.
- Generally, the test results agree with the GADOT and GSWCC goals of specifying check structure systems that provide the structural capacity to resist concentrated flows, ease of installation, and resistance to downstream scour.

Recommended Material Specifications

Property	Units	Spec	ASTM Test	Straw Bales (NRCS 2-row Installation)	Compost Socks	Rock over Geotextile
Material	-	-	-	Straw	Compost	2 – 10 inch
Density	pcf	min	-	4.3 lb/ft^3	25 lb/ft	1.4 tons/yd^3
Installed Height	in	max	-	14	9	15
Staking / Underlayment	-	min	-	2”x2” wood at 12” c-c	2”x2” wood at 12” c-c	8 oz/sy nonwoven geotextile
Large-scale Performance	%	max	D7208	~~20~~ 30*	~~20~~ 30*	~~20~~ 30*
				*Values revised 8/21/14		

GSWCC Implementation in 6th Edition

Cd - PERFORMANCE EVALUATION

For a product or practice to be approved for use in a check dam application, that product or practice must have a documented performance efficiency in channels with a flow rate of 2.0 cfs, as specified by GSWCC.

EVALUATING INLET SEDIMENT TRAPS

Objective:
Full-scale Performance Evaluation of Sediment Traps at Storm Water Manhole and Curb Inlets

Inlet sediment traps are commonly comprised of stone, open-cell concrete blocks, fence posts, and/or wire fabric, or they may be pre-manufactured products such as silt fence, sediment retention fiber rolls or proprietary 3-D structures.

Testing Matrix

Test	GSWCC Identification	BMP Type
Unpaved Surface Systems	Sd2-F	Filter Fabric on Support Frame
	Sd2-Bg	Block and Gravel Drop Inlet Protection
	SCDOT Type B	SCDOT Type B
Paved Surface Systems	Sd2-P	Fabric-Wrapped 8-inch Blocks
	Sd2-P	Plastic Mesh-Wrapped #57 Stone

ASTM D7351 Modified: Full-scale Performance Testing of Inlet Sediment Trap Performance

- ASTM D 7351 modified to present the flow to an inlet
- Simulates a manhole inlet.
- The BMP was installed adjacent to the opening.
- Sediment-laden water was discharged into the fully contained area around the inlet opening and allowed to run up to and seep through, over, and/or under an installed inlet sediment trap BMP protecting the inlet.
- The measurement of sediment and water that passes through, over, and/or under the BMP compared to the amount in the upstream flow is used to quantify the effectiveness of the BMP
- A complete test included 3 repeat flows, or events, separated by not less than 4 hours.

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Test Apparatus

Test Setup

ASTM D7351 Modified: Test Components

- The suggested system includes the following components:
  - A tank with an internal paddle mixer device mounted on scales capable of holding/weighing 10,000 lb of sediment-laden water.
  - A sufficient source of water and associated pumping equipment to repeatedly fill the mixing tank.
  - A simulated manhole/inlet that can accommodate an “real world” BMP installation and associated ponding of storm water runoff.
  - A tank mounted on scales of sufficient volume to collect all runoff passing the BMP.

ASTM D7351 Modified: Test Preparations

- The submitted erosion control product is then installed using the technique acceptable to / recommended by the client. For this testing, TRI technicians installed the product to be tested.
- For the tests reported herein, the sediment barrier installations were in accordance with the GSWCC’s Manual for Erosion and Sediment Control in Georgia (the “Green Book”) or manufacturer’s specifications.

ASTM D7351 Modified: Test Procedures

- Agitation water and sediment is maintained and discharge is released evenly for 30 minutes. The quantity of released runoff is measured at 5-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).
- As the discharged flow is allowed to flow up to and around the BMP. Retention observations, ponding depths, and associated times are recorded.

ASTM D7351 Modified:
Test Procedures (continued)

- As runoff passes the BMP system, it is collected in the collection tank and the weight and volume of the collection tank is recorded and grab samples are taken at 5 minute intervals.
- Cutoff time is the earlier of 90 minutes or when there is low-volume ponding and minimal discharge.
- 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 and weighing is done on scales accurate to ± 0.01 grams.

Test Preparation

Test Setup

Closeup of a Typical Installation (shown is GSWCC Sd2-F)

Simulated Unpaved Tests

Unpaved Test Setup – GSWCC Sd2-Bg

Unpaved Test Setup – SCDOT Type B

Simulated Paved Tests

Paved Test Setup – GSWCC Sd2-P

(Pigs-In-A-Blanket)

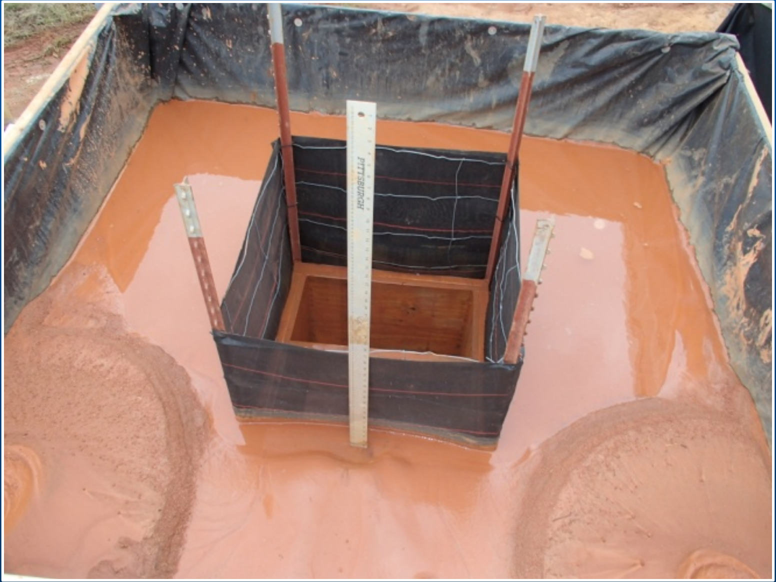
Paved Test Setup – GSWCC Sd2-P

(Wrapped Stone)

Typical Test

Introduction of Initial Runoff to the Sd2-F BMP

Start of Second "Event"



End of Test after Third "Event"

Comparison Tests: Controls & Tradition

Control Test

BMP Test

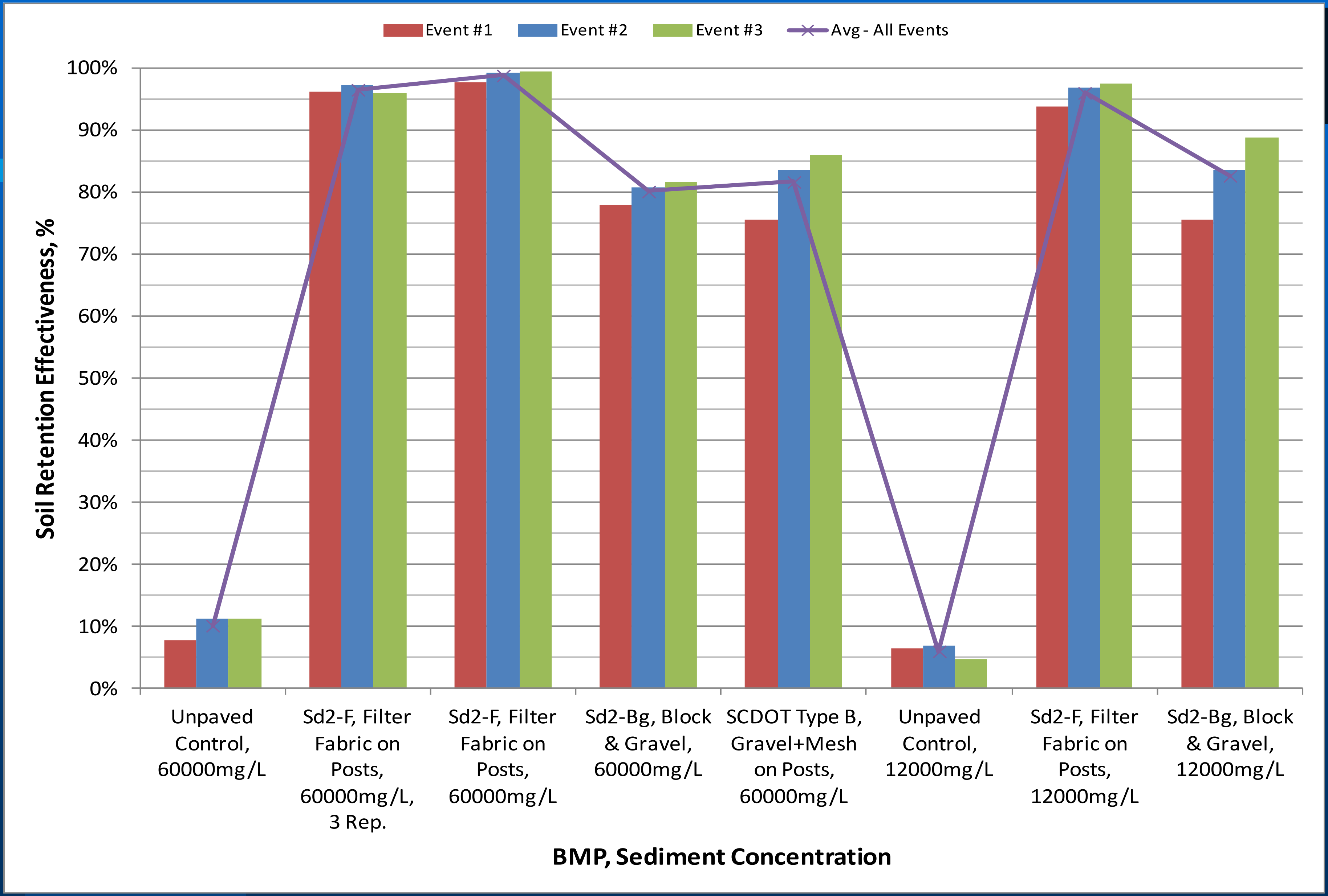
Test Results

- Sediment concentrations and associated runoff are measured over time.
- Soil Retention Effectiveness and Seepage Effectiveness are calculated.
- Additionally, turbidity samples were taken to determine if any change in turbidity resulted from the measured short-term system performance. In both tests, modest differences in upstream (runoff) and downstream (short-term seepage) turbidity were found.

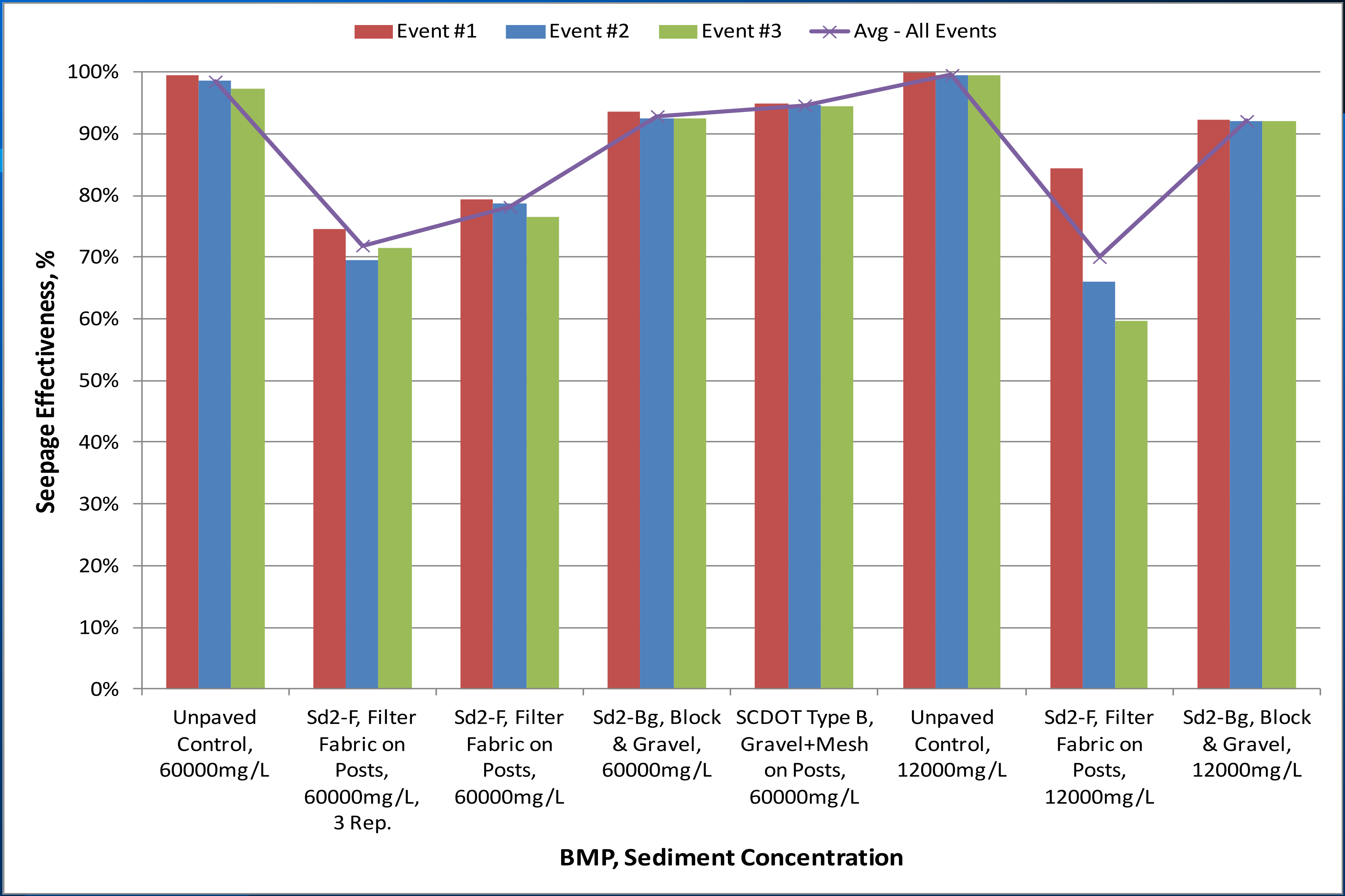
Test Series	Appli-cation	Setup	Performance Characteristic	%*	Time t Overtopp
1	Unpaved	Sd2-F, Filter Fabric on Posts, 60000mg/L (3 replicate)	Soil Retention Effectiveness:	96.54	No overtopp
			Seepage Effectiveness:	71.92	
2	Unpaved	Unpaved Control, 60000mg/L	Soil Retention Effectiveness:	10.13	No overtopp
			Seepage Effectiveness:	98.53	
3	Unpaved	Unpaved Control, 12000mg/L	Soil Retention Effectiveness:	6.01	No overtopp
			Seepage Effectiveness:	99.61	
4	Unpaved	Sd2-F, Filter Fabric on Posts, 60000mg/L	Soil Retention Effectiveness:	98.84	No overtopp
			Seepage Effectiveness:	78.21	
5	Unpaved	Sd2-F, Filter Fabric on Posts, 12000mg/L	Soil Retention Effectiveness:	96.03	No overtopp
			Seepage Effectiveness:	70.04	
6	Unpaved	Sd2-Bg, Block & Gravel, 60000mg/L	Soil Retention Effectiveness:	80.13	No overtopp
			Seepage Effectiveness:	92.92	
7	Unpaved	Sd2-Bg, Block & Gravel, 12000mg/L	Soil Retention Effectiveness:	82.66	No overtopp
			Seepage Effectiveness:	92.13	
8	Unpaved	SCDOT Type B, Gravel + Mesh on Posts, [illegible]	Soil Retention Effectiveness:	81.67	No overtopp
			Seepage Effectiveness:	94.68	

Test Series	Appli-cation	Setup	Performance Characteristic	%*	Time t Overtopp
9	Paved	Paved Control, 60000mg/L	Soil Retention Effectiveness:	2.50	No overtopp
			Seepage Effectiveness:	99.13	
10	Paved	Paved Control, 12000mg/L	Soil Retention Effectiveness:	3.43	No overtopp
			Seepage Effectiveness:	98.77	
11	Paved	Sd2-P, Fabric Wrapped Blocks, 60000mg/L	Soil Retention Effectiveness:	92.25	4:34
			Seepage Effectiveness:	90.35	
12	Paved	Sd2-P, Fabric Wrapped Blocks, 12000mg/L	Soil Retention Effectiveness:	91.42	14:33
			Seepage Effectiveness:	88.97	
13	Paved	Sd2-P, Fabric Wrapped Stone, 60000mg/L	Soil Retention Effectiveness:	77.04	2:45
			Seepage Effectiveness:	94.85	
14	Paved	Sd2-P, Fabric Wrapped Stone, 12000mg/L	Soil Retention Effectiveness:	90.32	10:48
			Seepage Effectiveness:	92.34	

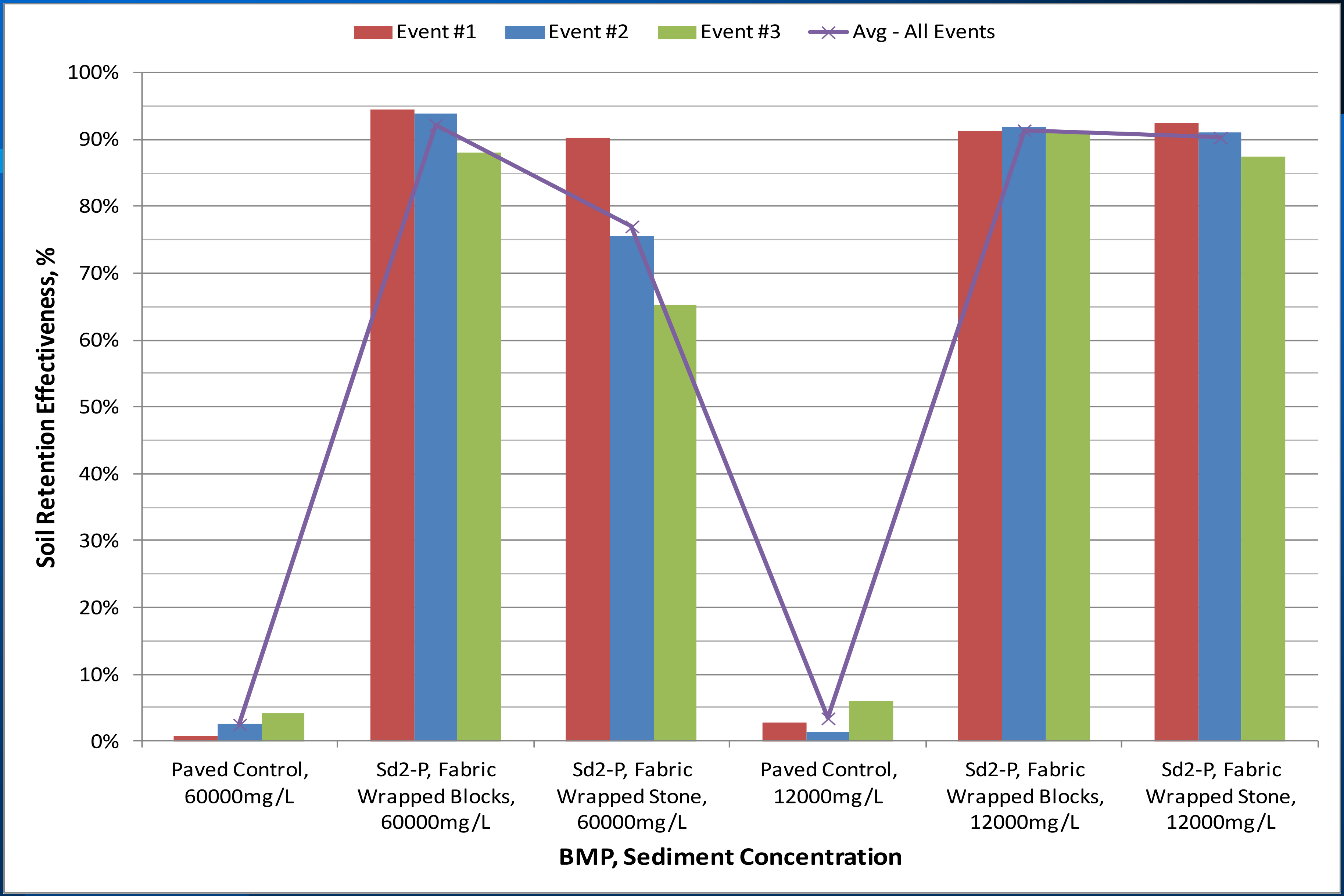
Unpaved Inlet Sediment Traps – Soil Retention Effectiveness



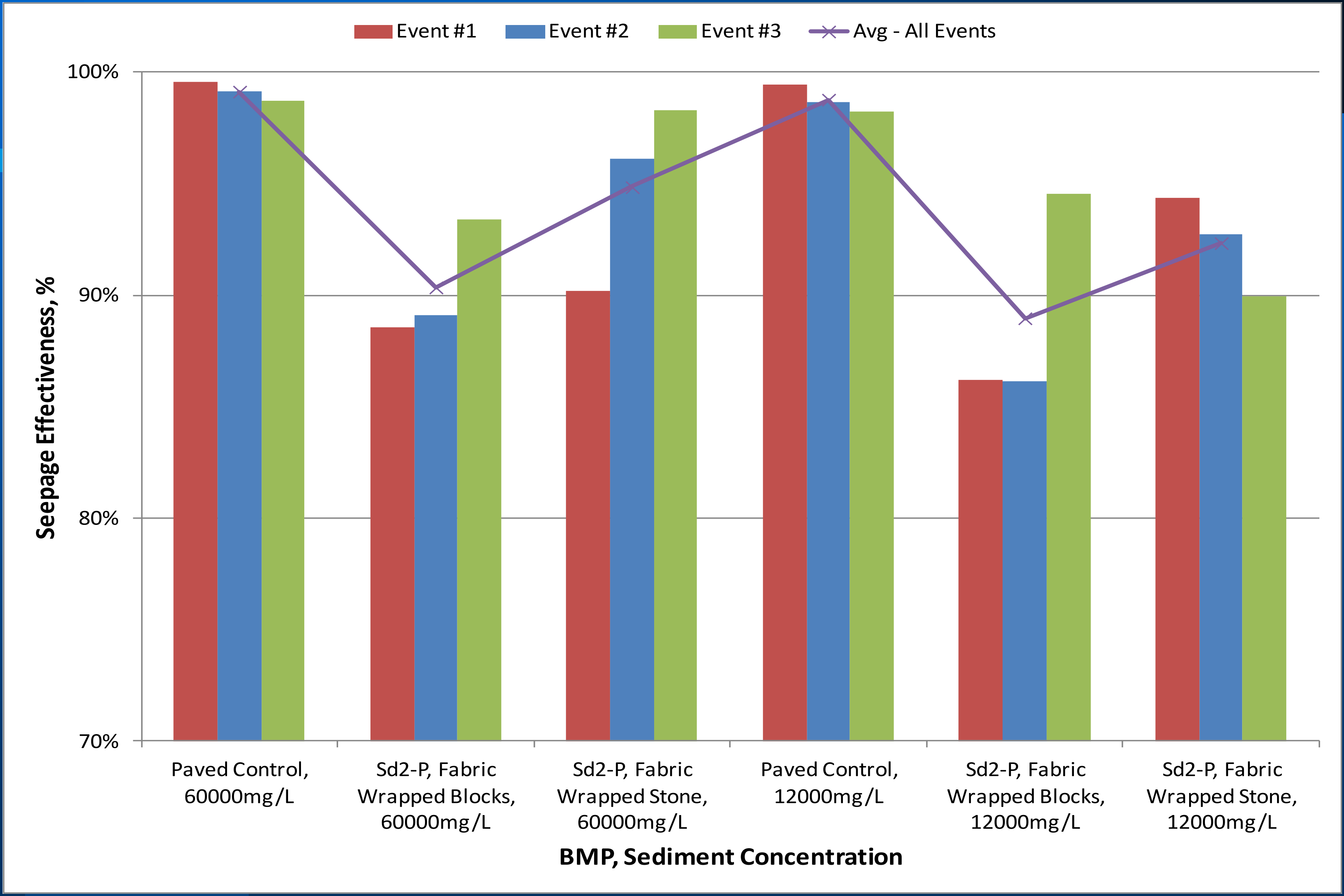
Unpaved Inlet Sediment Traps – Seepage Effectiveness



Paved Inlet Sediment Traps – Soil Retention Effectiveness



Paved Inlet Sediment Traps – Seepage Effectiveness



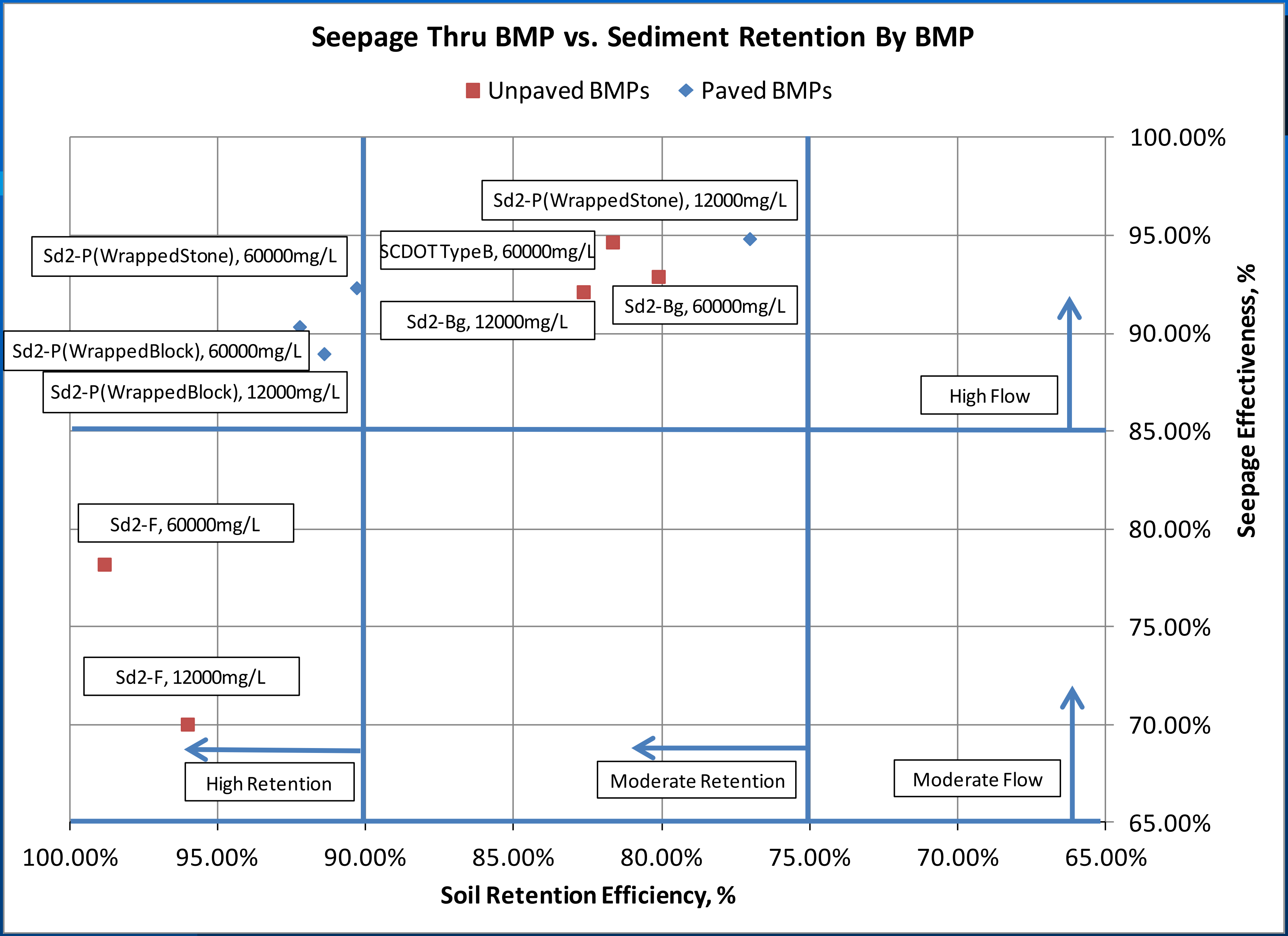
Discussion – Unpaved BMPs

- The figures clearly establish that the filter fabric based BMP (Sd2-F) had the highest retention effectiveness along with the lowest seepage effectiveness.
- Conversely, the stone based BMP (Sd2-Bg) had the lowest retention effectiveness but the highest seepage effectiveness.
- These relationships were consistent for both levels of sediment concentration tested.
- It should also be noted that both BMPs tested vastly outperformed the controls in retention effectiveness but only modestly underperformed the controls in seepage effectiveness.

Discussion – Paved BMPs

- The results are not so orderly for inlet sediment traps used in paved applications.
- This appears to be a result of the inevitability of overtopping that occurs as these low profile BMPs retain sediments and lose ponding volume.
- The stone wrapped system is susceptible to earlier overtopping occurring at low points which causes greater seepage and associated lower retention.
- As with the unpaved applications, both BMPs tested vastly outperformed the controls in retention effectiveness but only modestly underperformed the controls in seepage effectiveness.

Summary of BMP Test Results



Conclusions

- The test results presented herein appear to establish appropriate baseline performance characteristics for BMPs used in either unpaved or paved applications.
- For unpaved applications, the filter fabric based BMP (Sd2-F) provides maximum sediment retention while the stone based BMP (Sd2-Bg) provides maximum seepage. The Sd2-F system may be best used where sufficient ponding area is available, while the Sd2-Bg system should be preferred where ponding would cause a potential safety or property damage risk.

Conclusions

- For paved applications, it appears that the more determinant height of concrete block assures maximum ponding prior to eventual overtopping. Thus, the so-called "pigs-in-a-blanket" – filter fabric wrapped blocks - would appear to be a more dependable choice for curb inlet protection (Sd2-P) based solely on retention and seepage effectiveness.
- Comparatively, especially when considering the 12000 mg/L tests, the "pigs-in-a-blanket" appears to provide maximum sediment retention while the fabric-wrapped stone provides maximum seepage.   Still, consideration of cost and safety issues associated with the use of concrete blocks instead of stone is recommended.

Conclusions

- **Test results suggest that in both paved and unpaved applications, it is possible to differentiate between BMPs that provide maximum sediment retention and those providing maximum seepage. This may facilitate separate application-specific specifications for BMP systems.**
- **Results from testing with 60000 mg/L sediment concentration were very similar in most cases to testing with 12000 mg/L. Thus, as the lower concentration is more consistent with inlet flows downstream of toe-of-slope sediment barriers, testing only with 12000 mg/L sediment concentrations is recommended as sufficient to properly characterize inlet BMPs.**

GSWCC Implementation in 6th Edition

Sd2 - PERFORMANCE EVALUATION

Inlet sediment trap approval is based on efficiency of both soil retention and seep-age, as specified by the GSWCC.

- On unpaved areas inlet sediment traps shall meet 90% soil retention efficiency with a minimum seepage efficiency of 65%.
- On paved areas or areas where a safety hazard is a sediment traps shall meet 75% soil retention efficiency with a minimum seepage of 85%.

EVALUATING
FLOATING SURFACE SKIMMERS

Objective:
Full-scale Performance Evaluation of Floating Surface Skimmers

- **Each skimmer product (and each product size) has a unique performance, including the associated hydraulics, which is affected by the floatation, inlet, and drain design chosen.**
- **The discharge rate is dependent on the specific product design and can only be determined through product-specific testing.**

Intro to Floating Surface Skimmers

- A floating surface skimmer, or floating pond skimmer, is a buoyant device that releases/drains water from the surface of sediment ponds, traps or basins at a controlled rate of flow.
- It “skims”, or dewaters, from the water surface where sediment concentrations are at a minimum in the water column instead of draining from the bottom where sediment concentrations are their highest.
- Floating surface skimmers serve two primary functions:
  - facilitate drainage of a sediment pond, basin, or trap, and
  - reduce turbidity and sediment concentration of the effluent discharge.

The Traditional Alternative and Limitations

- Traditionally, the principal spillway of most sediment basins is a vertical riser pipe. The bottom half of the riser is typically perforated and covered with gravel, which filters the outflow as it passes through the perforations.
- Even with the gravel filter, the perforations in the lower elevations of the vertical riser allow discharge to pass which has a relatively high level of turbidity.
- Over time, the gravel filter surrounding the riser is coated with sediment that traps and detains water in the basin, reducing the storage capacity for incoming runoff.
- Sediment in the detained water is re-suspended with each new inflow.

Floating Surface Skimmer Advantages

- Floating surface skimmers draw water from the surface of the basin slowly at a relatively constant rate allowing particles to settle to the bottom of the sediment pond, thus:
  - reducing turbidity and sediment concentration of the discharged effluent, and
  - reducing the retention time to obtain similarly clear discharge using traditional outlets.

More Floating Surface Skimmer Advantages

- The inlet of the skimmer device is sized according to the basin volume and designed to drain the basin in a predetermined time.
- A well designed skimmer improves the performance of a sediment pond or basin by reducing retention time associated with meeting a desired water quality standard, discharging cleaner water, and providing consistent, predictable draw down times.

Floating Surface Skimmer Limitations

- A floating surface skimmer replaces the riser pipe as the principal spillway, but DOES NOT REPLACE THE EMERCENCY OVERFLOW SPILLWAY.
- The skimmer only drains the basin from the crest of the emergency overflow spillway.
- Skimmer flow capacity is too small for storm events that exceed pond storage capacity, so an emergency spillway is still required.

Floating Surface Skimmer Design Criteria

1. **The inlet of the floating surface skimmer must float at or near the surface of the impounded water.**
2. **The inlet of the floating surface skimmer must have an articulated connection to the pond outlet that insures that surface dewatering is maintained as the elevation of the pond rises and falls.**

Floating Surface Skimmer Design Criteria

3. The inlet must dewater through gravity forced flow, as opposed to siphoning, as siphoning will greatly increase the amount of soil particles that are “sucked” into the inlet.
4. The volume of the sediment pond, trap, or basin must be known, as well as the required number of hours/days to drain the basin.

Product Designs

A typical floating surface skimmer consists of three main components:

1. a flexible coupling,
2. a rigid tube that serves as the inlet, and
3. a floating headworks that serves to support the inlet at or near the surface of the impounded water.

Product Designs (continued)

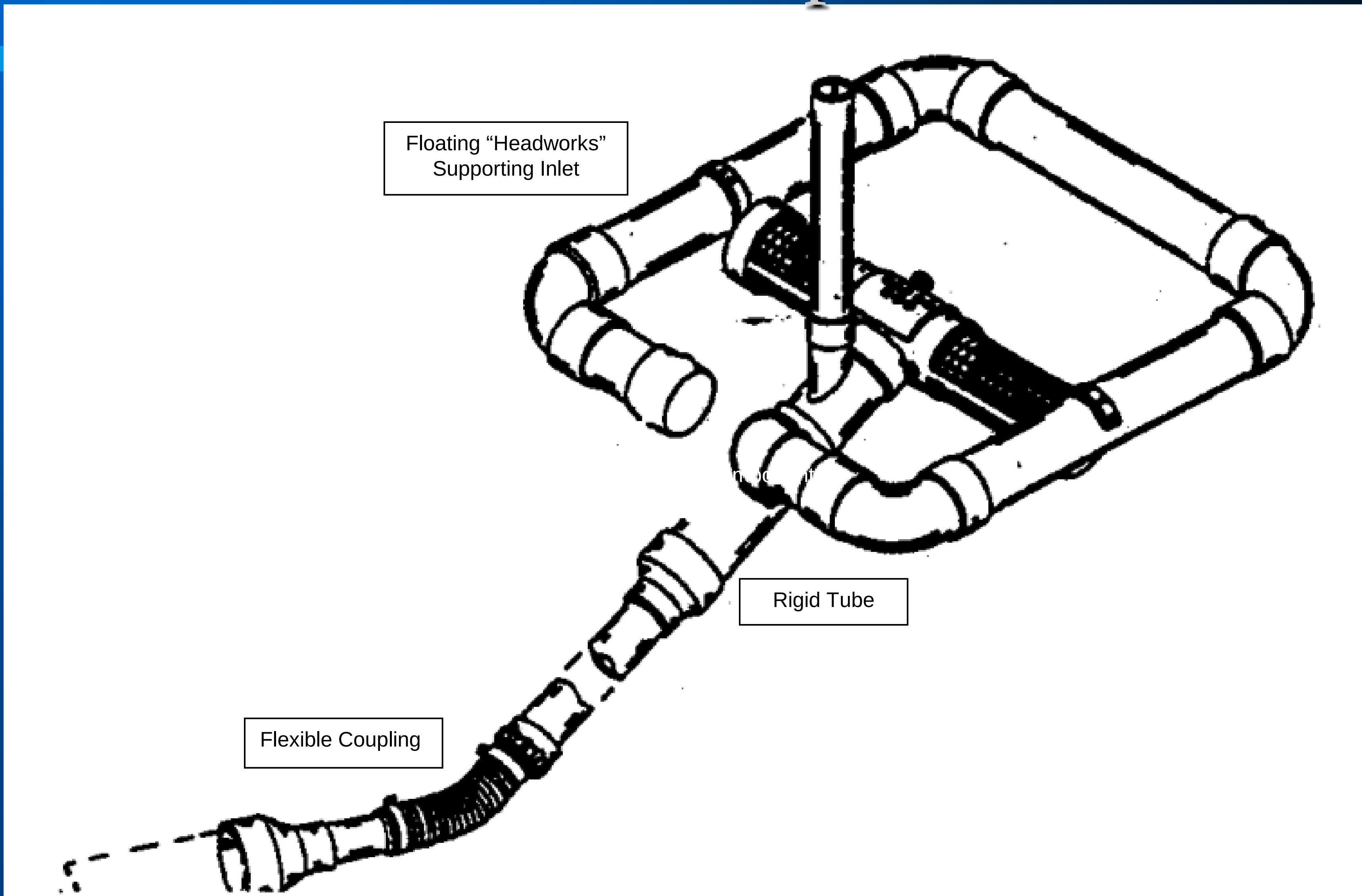
Additional components typically included:

4. **a trash guard to prevent floating debris from entering the inlet,**
5. **a maintenance rope tied to the floating headworks to allow for the floating surface skimmer to be accessed and maintained from the edge of a sediment pond,**
6. **a shallow pit filled that allows the skimmer to completely drain the basin.**

Product Designs – Discharge Rate

- Each product (and each product size) has a unique design, including the associated hydraulics that are affected by the floatation, inlet, and connecting tube/coupling designs chosen.
- <u>The discharge rate </u>is dependent on the specific product design and <u>can only be determined through product-specific, full scale, “as installed” testing</u>.

Skimmer Components



Product-Specific Test Data

B-Type

Product-Specific Test Data

E-Type

Product-Specific Test Data
F-Type

Product-Specific Test Data

I-Type

Product-Specific Test Data
S-Type

Testing Apparatus / Facility

- Calibrated basin: 40-ft long x 6-ft wide x 4-ft deep.
- The basin was outfitted with an 8” discharge pipe with a valve that could be controlled from the outside of the basin to initiate and stop flow through the skimmer.
- The basin was outfitted with a second valved discharge pipe to enable lowering of the water surface within the basin if desired to take flow rate measurements at various depths without waiting.
- A calibrated ruler was mounted to the side of the basin to allow depth to be read at pre-determined intervals.
- To facilitate quick re-filling of the basin, a high-capacity pump was used to draw water from an adjacent pond.

Denver Downs Research Facility
Anderson, SC

Test Basin

Dedicated Basin

Controlled Outlets + Bypass

Quick Fill

(ASTM Proposed) Standard Practice for Measurement of Floating Pond Skimmer Flow Rate

- **Test Setup**
- The skimmer to be tested was attached to the discharge pipe prior to pond filling using reducers/connectors depending on the size of the flexible coupling.
- The connection between the discharge pipe and the flexible coupling was watertight to ensure that the only outflow from the test basin was through the skimmer inlet.

(ASTM Proposed) Standard Practice for Measurement of Floating Pond Skimmer Flow Rate

- **Test Operation and Data Collection**
  - With the valve on the discharge pipe closed, and the skimmer to be tested in place, the test basin was filled with water to the maximum desired depth. Filling proceeded at a pace which allowed all of the air within the skimmer assembly to bleed completely during filling.
  - Once the basin was filled to the desired depth, the surface of the water was allowed to become still and the initial depth reading was recorded on the calibrated ruler mounted on the sidewall.
  - After the initial reading was taken, the skimmer discharge valve was opened and the clock on the test was simultaneously started. As the water discharged from the test basin through the floating skimmer, periodic depth and time readings were recorded.
  - Change in depth is equated to change in water volume, and an average flow rate at different water elevations was calculated for each skimmer.

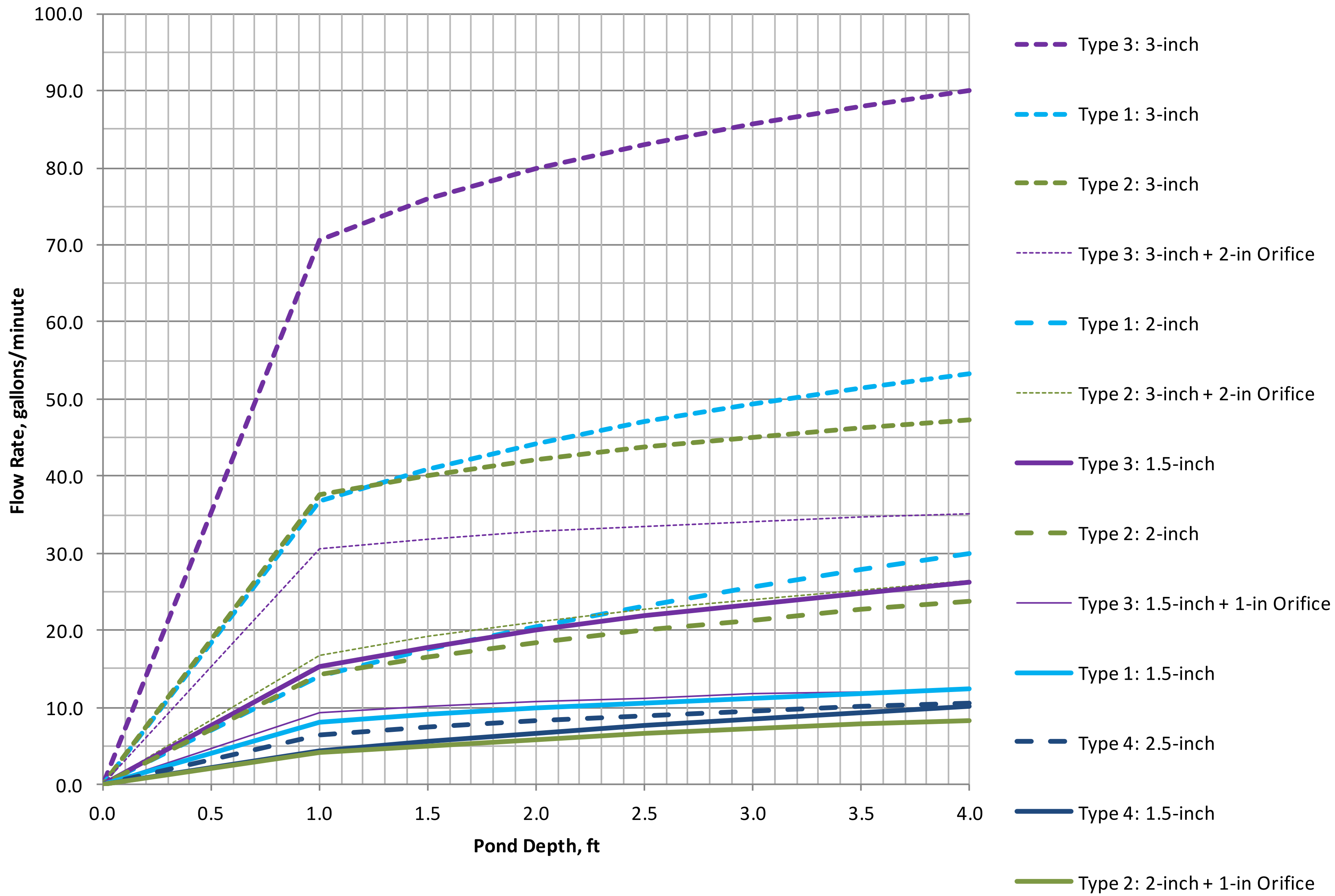
Test Results

- Measurements of water surface elevation over time were the principle data used to determine the performance of the product tested.
- This data is converted into a curve that fits average flow rate, in gallons per minute, to a given depth, in feet.
- The data shows that each skimmer type exhibits a unique flow rate at various depths.

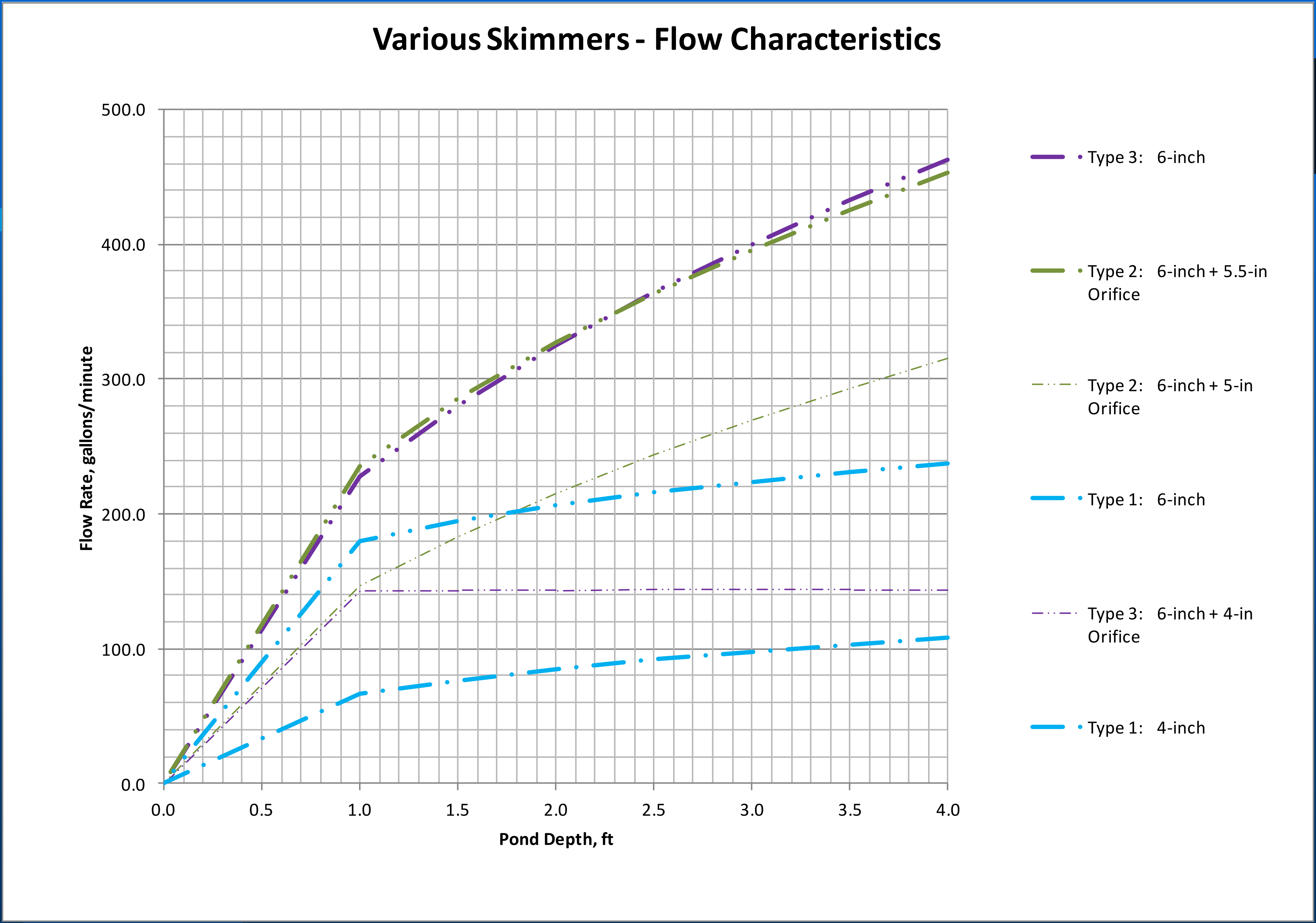
Skimmer Flow Rate, gal/min

Water Depth, ft	Skimmer												
	Type 2: 2-inch + 1-in Orifice	Type 4: 1.5-inch	Type 4: 2.5-inch	Type 1: 1.5-inch	Type 3: 1.5-inch + 1-in Orifice	Type 2: 2-inch	Type 3: 1.5-inch	Type 1: 2-inch	Type 2: 3-inch + 2-in Orifice	Type 3: 3-inch + 2-in Orifice	Type 2: 3-inch	Type 1: 3-inch	Type 3: 3-inch
4.0	8.4	10.1	10.5	12.3	12.4	23.8	26.2	30.0	26.4	35.2	47.3	53.3	90.1
3.5	7.8	9.4	10.0	11.8	12.1	22.6	24.9	27.9	25.2	34.7	46.2	51.5	88.0
3.0	7.2	8.5	9.5	11.3	11.7	21.4	23.4	25.6	24.0	34.2	45.1	49.4	85.7
2.5	6.5	7.7	8.9	10.6	11.3	20.0	21.8	23.2	22.6	33.5	43.7	47.0	83.0
2.0	5.8	6.7	8.2	9.9	10.7	18.4	20.0	20.5	21.1	32.8	42.1	44.2	79.8
1.5	5.0	5.6	7.4	9.1	10.1	16.5	17.9	17.5	19.2	31.9	40.1	40.9	75.9
1.0	4.1	4.4	6.3	8.0	9.3	14.2	15.2	14.0	16.8	30.6	37.5	36.7	70.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Various Skimmers - Flow Characteristics



Skimmer Flow Rate, gal/min						
Water Depth, ft	Skimmer					
	Type 1: 4-inch	Type 3: 6-inch + 4-in Orifice	Type 1: 6-inch	Type 2: 6-inch + 5-in Orifice	Type 2: 6-inch + 5.5-in Orifice	Type 3: 6-inch
4.0	108.1	143.7	237.0	315.7	453.3	463.2
3.5	103.2	143.7	230.8	293.2	425.6	432.6
3.0	97.7	143.6	223.9	269.2	395.8	399.8
2.5	91.7	143.5	215.9	243.4	363.1	364.1
2.0	84.8	143.4	206.6	215.1	326.8	324.8
1.5	76.7	143.3	195.1	183.5	285.4	280.4
1.0	66.6	143.2	180.1	146.6	235.7	227.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0


Various Skimmers - Flow Characteristics
Flow Rate, gallons/minute
Pond Depth, ft
500.0
400.0
300.0
200.0
100.0
0.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
Type 3: 6-inch
Type 2: 6-inch + 5.5-in Orifice
Type 2: 6-inch + 5-in Orifice
Type 1: 6-inch
Type 3: 6-inch + 4-in Orifice
Type 1: 4-inch

Skimmer Sizing Table

Example Shown: 125 ft x 125 ft x 4 ft deep pond; Drainage Time < 72 hours

Inputs	Calculations
Time to Drain, hrs =72	Calculated Pond Volume, ft³ =40833
Pond Depth, ft =4	Calculated Pond Volume, gal =3E+05
Pond Top Length, ft =125	No. of Depth Increments for Calcs, in. =20
Pond Top Width, ft =125	Depth Increments for Calcs, in. =2.4
Pond Bottom Length, ft =75	Note: Equations are from product testing:
Pond Bottom Width, ft =75	

Skimmer Size Selection Optimization

Skimmer Size, in / Orifice Size, in

Skimmer / Orifice	Type 1: 1.5 / 0.00	Type 1: 2.0 / 0.00	Type 1: 3.0 / 0.00	Type 3: 3.0 / 0.00	Type 1: 4.0 / 0.00	Type 1: 6.0 / 0.00	Type 3: 6.0 / 0.00
Flow Rate:	$7.9914 * depth^{0.3116}$	$13.985 * depth^{0.5514}$	$36.676 * depth^{0.2702}$	$70.714 * depth^{0.1747}$	$66.588 * depth^{0.3494}$	$180.07 * depth^{0.1981}$	$227.83 * depth^{0.5118}$

Water Level Depth, in.	Avg. Water Level Depth, in.	Incr. Depth, in	L	W	Incr. Dis-charge, ft3	Cumm. Dis-charge, ft3	Cumm. Dis-charge, gal	% of Total Volume Dis-charged	Type 1: 1.5 / 0.00 Skimmer Flow Rate, gal/min	Type 1: 1.5 / 0.00 Cumm. Drain Time, hrs.	Type 1: 2.0 / 0.00 Skimmer Flow Rate, gal/min	Type 1: 2.0 / 0.00 Cumm. Drain Time, hrs.	Type 1: 3.0 / 0.00 Skimmer Flow Rate, gal/min	Type 1: 3.0 / 0.00 Cumm. Drain Time, hrs.	Type 3: 3.0 / 0.00 Skimmer Flow Rate, gal/min	Type 3: 3.0 / 0.00 Cumm. Drain Time, hrs.	Type 1: 4.0 / 0.00 Skimmer Flow Rate, gal/min	Type 1: 4.0 / 0.00 Cumm. Drain Time, hrs.	Type 1: 6.0 / 0.00 Skimmer Flow Rate, gal/min	Type 1: 6.0 / 0.00 Cumm. Drain Time, hrs.	Type 3: 6.0 / 0.00 Skimmer Flow Rate, gal/min	Type 3: 6.0 / 0.00 Cumm. Drain Time, hrs.
48			125	125																		
45.6	46.8	2.4	123	123	3063	3063	22911	7.5%	12	31	30	13	53	7	90	4	107	4	236	2	457	1
43.2	44.4	2.4	120	120	2940	6003	44905	14.7%	12	62	29	26	52	14	89	8	105	7	233	3	445	2
40.8	42	2.4	118	118	2820	8824	66002	21.6%	12	92	28	38	51	21	88	12	103	10	231	5	433	2
38.4	39.6	2.4	115	115	2703	11527	86219	28.2%	12	121	27	51	51	28	87	16	101	14	228	6	420	3
36	37.2	2.4	113	113	2588	14115	105577	34.6%	11	149	26	63	50	34	86	20	99	17	225	8	407	4
33.6	34.8	2.4	110	110	2475	16590	124093	40.6%	11	177	25	75	49	41	85	24	97	20	222	9	393	5
31.2	32.4	2.4	108	108	2365	18955	141787	46.4%	11	204	24	88	48	47	84	27	94	23	219	10	379	6
28.8	30	2.4	105	105	2258	21213	158676	52.0%	11	230	23	100	47	53	83	31	92	26	216	12	364	6
26.4	27.6	2.4	103	103	2153	23366	174780	57.2%	10	256	22	112	46	58	82	34	89	29	212	13	349	7
24	25.2	2.4	100	100	2050	25417	190117	62.2%	10	282	21	124	45	64	81	37	86	32	209	14	333	8
21.6	22.8	2.4	98	98	1950	27367	204706	67.0%	10	306	20	136	44	70	79	40	83	35	204	15	316	9
19.2	20.4	2.4	95	95	1853	29220	218566	71.6%	9	331	19	148	42	75	78	43	80	38	200	16	299	9
16.8	18	2.4	93	93	1758	30978	231715	75.9%	9	355	17	161	41	81	76	46	77	41	195	18	280	10
14.4	15.6	2.4	90	90	1665	32643	244172	79.9%	9	379	16	174	39	86	74	49	73	44	190	19	261	11
12	13.2	2.4	88	88	1575	34219	255956	83.8%	8	403	15	187	38	91	72	51	69	47	184	20	239	12
9.6	10.8	2.4	85	85	1488	35707	267086	87.4%	8	427	13	201	36	96	69	54	64	50	176	21	216	13
7.2	8.4	2.4	83	83	1403	37110	277580	90.9%	7	451	11	216	33	102	66	57	59	53	168	22	190	14
4.8	6	2.4	80	80	1320	38430	287456	94.1%	6	477	10	234	30	107	63	59	52	56	157	23	160	15
2.4	3.6	2.4	78	78	1240	39670	296735	97.2%	5	505	7	255	26	113	57	62	44	59	142	24	123	16
0	1.2	2.4	75	75	1163	40833	305433	100.0%	4	542	4	292	20	120	47	65	30	64	114	25	70	18

Lowest depth that can still drain through skimmer.

Skimmer / Orifice Combinations with Sufficient Flow:	Type 1: 1.5 / 0.00	Type 1: 2.0 / 0.00	Type 1: 3.0 / 0.00	Type 3: 3.0 / 0.00	Type 1: 4.0 / 0.00	Type 1: 6.0 / 0.00	Type 3: 6.0 / 0.00
	no	**no**	**no**	**Type 3: 3.0 / 0.00**	**Type 1: 4.0 / 0.00**	**Type 1: 6.0 / 0.00**	**Type 3: 6.0 / 0.00**

Discussion

- Unique skimmer types are often categorized based on the nominal diameter of the rigid tube, or inlet, used in the skimmer. Yet, the performance of different skimmer types of the same nominal size inlet can be vastly different.
- For instance, a “Type 3” 3-inch skimmer can have a flow rate (gallons/minute) 60% higher than a “Type 1” 3-inch skimmer at the maximum tested depth. If a skimmer specification referred only to inlet size, both of these skimmers could be used interchangeably to draw down a sediment pond of a certain size at a certain required rate. Yet, this would be a mistake as one skimmer type of a certain size would dewater at a significantly different rate than another type of the same size.

Discussion (continued)

- This performance difference between different skimmer types of the same size demonstrates the importance of product-specific testing.
- Further, once a product specific flow rate as a function of depth has been determined from testing, one may construct a table to determine the skimmer type and size necessary to meet the required draw down time for a specific sediment pond, basin, or trap.
- The table can use the equations for the product-specific flow vs. depth curves from testing, along with the project-specific pond size.

Conclusions

- Floating pond skimmers are a useful tool for improving the performance of a sediment pond or basin by reducing retention time associated with meeting a desired water quality standard, discharging cleaner water, and providing more consistent, predictable draw down times, especially when compared with a traditional perforated riser.
- However, the unique design of a skimmer and its associated hydraulics can greatly affect the rate at which it is able to dewater a sediment pond, trap, or basin.
- Thus, determining product specific flow rates based on each unique design through full-scale, “as installed” testing is of the utmost importance.

GSWCC Implementation in 6th Edition

Sk – SELECTING A SKIMMER: Choose the skimmer that best matches the required "time-to-drain" specified for a project.

- **The volume (or dimensions) of the sediment pond, trap, or basin must be known, as well as, the number of days to drain the basin.**
- **With this information, a draw-down rate calculation is made for each product and size using the product-specific flow rates determined from product-specific testing (see Addendum A).**

Acknowledgement

The authors would like to recognize the Georgia Soil and Water Conservation Commission for making this testing/research possible through a 319 grant.

THANKS!

Q and A