StormTrap®

APPENDIX C
NJCAT Testing Report

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NJCAT TECHNOLOGY VERIFICATION

StormTrap SiteSaver®- 4 Hydrodynamic Separator

FreshCreek Technologies, Inc.

June 2017

TABLE OF CONTENTS

List of Tables

List of Figures

1. Description of Technology

SiteSaver® is a manufactured treatment device, developed by FreshCreek Technologies®, that improves the quality of stormwater runoff. The device contains and removes suspended particulates using an insert that promotes gravity settling and is typically housed within a concrete vault structure. The insert is comprised of settling plates, baffles and weirs. **Figures 1** and **2.**

Stormwater enters through an inflow pipe and exits through an outflow pipe that is placed at virtually the same elevation. Upon entering the system, floating matter such as hydrocarbons and other floatable solids are captured on the inlet side of the insert. Stormwater is then conveyed through the insert, first through a perforated baffle and then into the inclined plate settling area where sedimentation removal occurs. The stormwater then travels through a perforated weir prior to discharge via the outlet pipe. During high flow events, the weir also acts as an internal bypass when flows exceed the capacity of the inclined plates. A hinged baffle is also attached to the weir to decrease resuspension of captured pollutants.

SiteSaver also contains and removes gross pollutants, such as trash, debris and rubbish, using netting components that can also be housed within the same structure as the inclined plates, baffles and weir insert. If the netting component is utilized, the stormwater travels through the netting prior to entering the insert of inclined settling plates in order to avoid clogging the insert with large debris. Hydrocarbons are contained within the device throughout the entire footprint area prior to the hydraulic relief weir and to a depth from the invert of the outlet pipe to the top of the orifice openings in the perforated baffles.

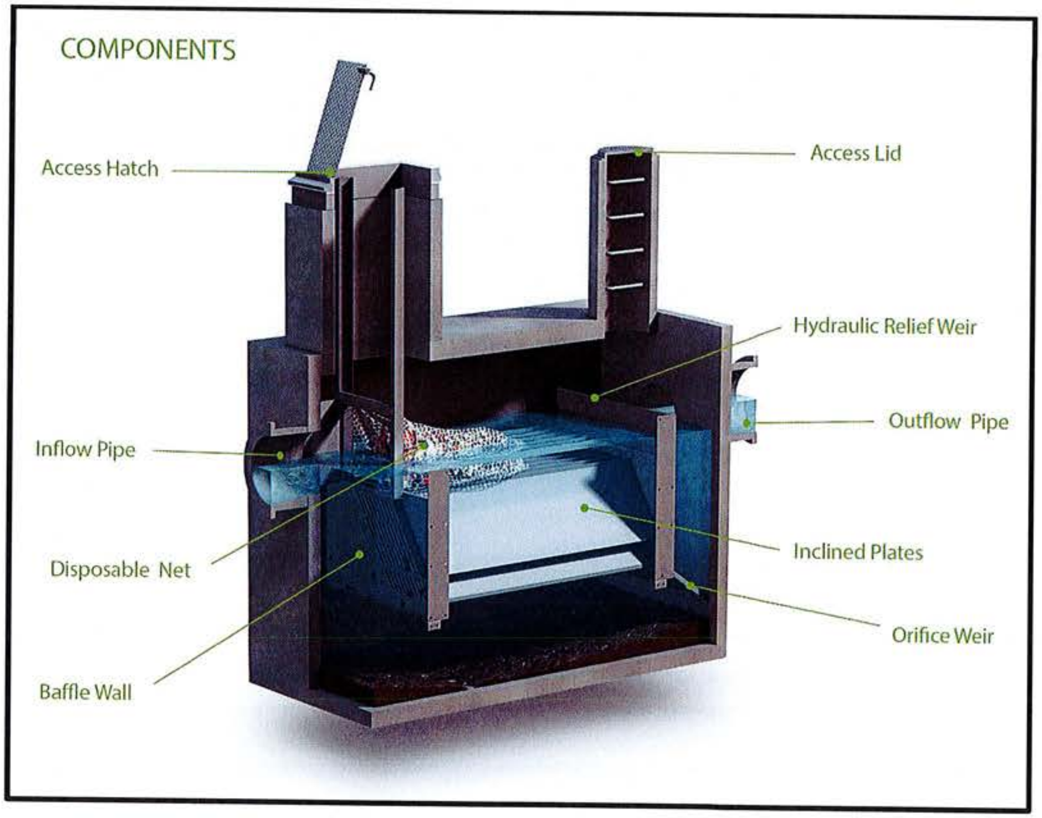

Figure 1 SiteSaver® Rendering

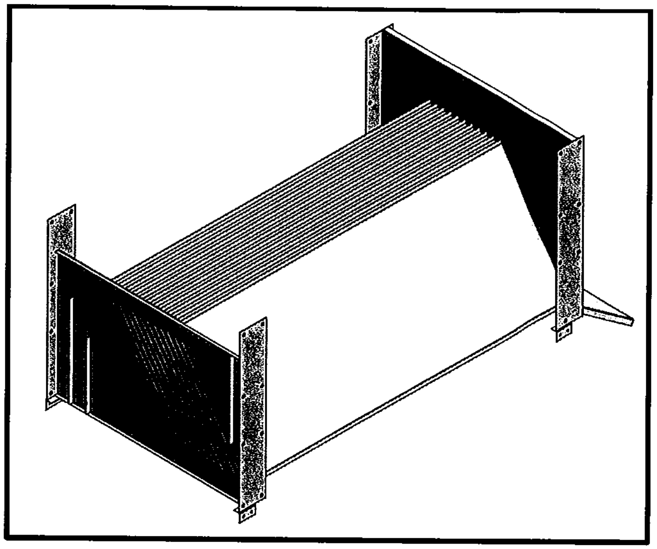

Figure 2 SiteSaver® Internal Components

This verification report only covers the StormTrap SiteSaver 4 (STSS-4) hydrodynamic separator.

2. Laboratory Testing

The test program, including sediment blending, was conducted by the manufactured treatment device manufacturer, FreshCreek Technologies, Inc. (FCT) under the direct supervision and direction of Good Harbour Laboratories (GHL) staff. GHL is an independent water technology testing lab based in Ontario, Canada. Sediment blending occurred in Morris, IL in October 2016 and testing occurred from March - April 2017. The model that was tested was identical to a commercially available unit with the exception that it did not have a concrete hatch that would be associated with a unit installed below grade. For performance testing, there was no need for the hatch and not having one in place in no way affected the test results.

Laboratory testing was done in accordance with the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2013). Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

2.1 Test Setup

The treatment device tested was a full-scale, commercially available StormTrap SiteSaver four-cell unit (STSS-4), dimensional details are provided in **Table 1**. This unit had a total sedimentation area of 84 ft^2 and a maximum treatment flow rate (MTFR) of 4.32 cfs (1940 gpm).

Table 1 SiteSaver®4 Dimensions

SiteSaver Models	MTFR (cfs)	50% Maximum Sediment Storage Volume (ft^3)	Oil Capacity (Gallons)[1]	Physical Exterior Dimensions			Physical Interior Dimensions			Effective Treatment Area (ft^2)
				Length (ft)	Width (ft)	Depth (ft)	Length (ft)	Width (ft)	NWL to Floor Invert (ft)	
4	4.32	28	178	15	6.83	11.17	14	6	6.26	84

NWL – Normal Water Level

[1] When hydrocarbons are a pollutant of concern, it is recommended that absorptive oil booms are placed into the unit to prevent hydrocarbon wash out during high flow events in on-line installations.

The laboratory test setup was a single-pass system filled with potable water; the test apparatus is illustrated in **Figure 3**. The setup was comprised of water reservoirs, pumps, receiving tank and flow and temperature sensors, in addition to the STSS-4. The maximum water capacity of the water supply tanks was 147,000 gallons.

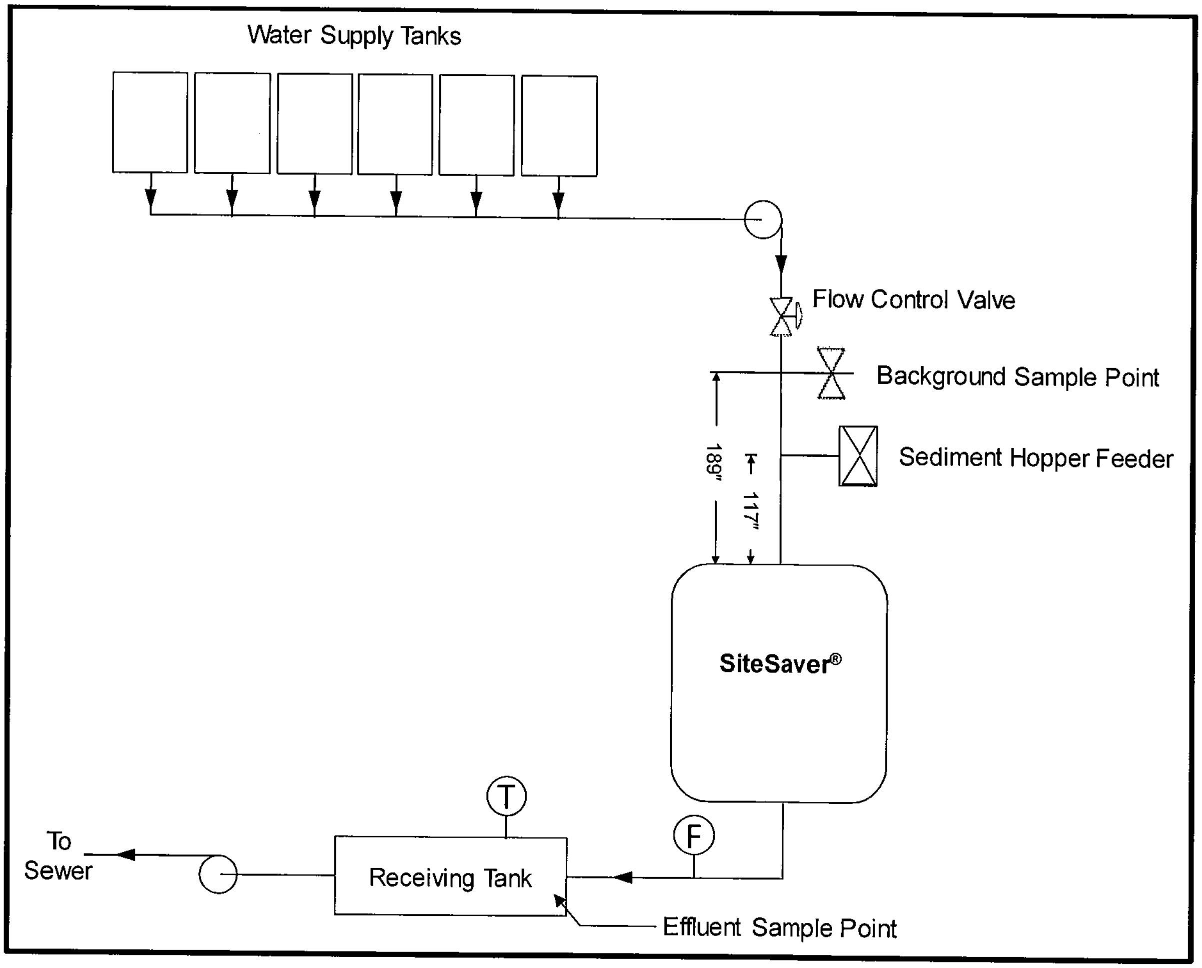

Figure 3 Test Flow Apparatus

Water Flow and Measurement

From the water supply tanks, water was pumped using a 12″ X 8″ DV-200c centrifugal pump (4,600 gpm capacity) through a 24″ SDR17 HDPE line to the SiteSaver. The flow rate was controlled using a gate valve located on the discharge side of the pump. Flow measurements were made with a Greyline Instruments area-volume flow meter (Model AVFM 5.0) equipped with a data logger. The flow sensor was in the 24″ effluent line of the SiteSaver and the data logger was configured to record a flow measurement once every minute.

Water flow exited the SiteSaver and terminated with a free-fall into the Receiving Tank. From the Receiving Tank, water was pumped to sewer.

Sample Collection

Background water samples were collected in a 500-mL jar from a sampling port located approximately 189" (8 pipe diameters) upstream of the SiteSaver. The sampling port was controlled manually by a ball valve (**Figure 4**) that was opened approximately 5 seconds prior to sampling.

Effluent samples were also grabbed by hand. The effluent pipe drained freely into the Receiving Tank and the effluent sample was taken at that point (**Figure 5**). The sampling technique was to take the grab sample by sweeping a 500-mL jar through the stream of effluent flow.

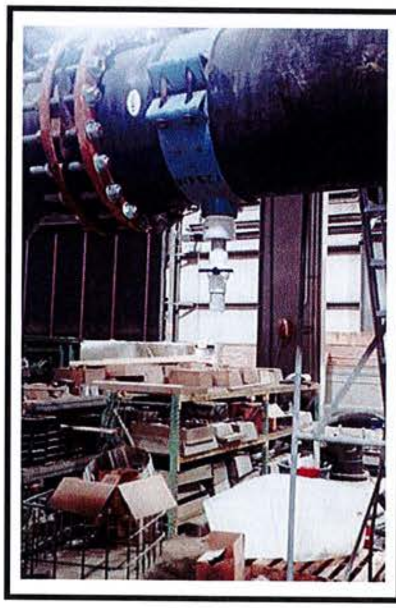

Figure 4 Background Sampling Point

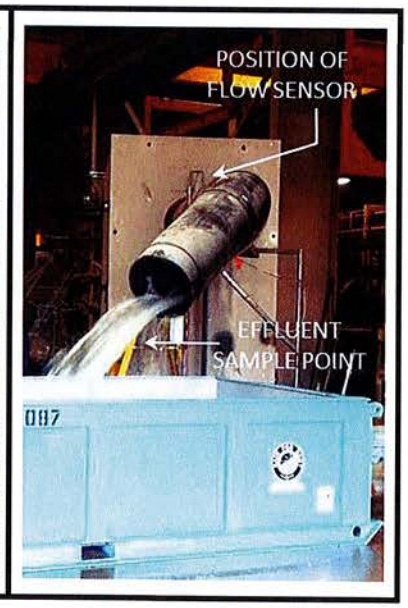

Figure 5 Effluent Sampling Point

Duplicate samples were taken for both background and effluent. The primary set was analysed and reported while the second set was held by the testing lab in case there was a need for an investigation following an aberrant result.

Other Instrumentation and Measurement

Effluent water temperature was taken from the Receiving Tank, using a MadgeTech temperature data logger, Model MicroTemp. The data logger was configured to record a temperature reading once every minute.

Run and sampling times were measured using a NIST traceable stopwatch, Control Company Model 1042.

Sediment addition occurred through the crown of the inlet pipe (**Figure 6**), 117 inches (4.9 pipe diameters) from the SiteSaver inlet. The sediment feeder was an ACRISON Model W105Z Dry Solids Feeder with a 3-cubic foot hopper. The sediment feed samples that were taken during the run were collected in 1000-mL jars and weighed on an analytical balance (Veritas M1203i).

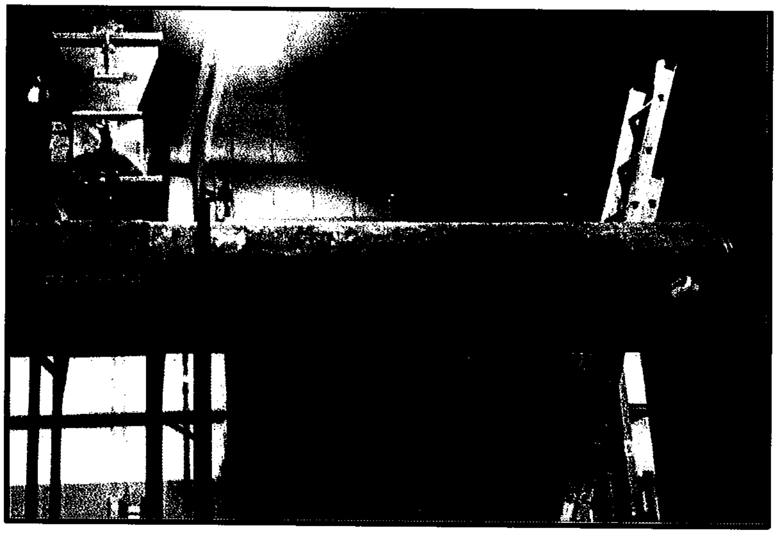

Figure 6 Sediment Addition Point

2.2 Test Sediment

Removal Efficiency Test Sediment

The test sediment used for the removal efficiency study (1-1000 μm) was a custom blend of commercially available silica sediments. The blend ratio was determined such that the particle size distribution of the resulting blended sediment would meet the specification for the test protocol. The sediment was blended using a cement mixer in 11 batches. Following the blending of each batch, the sediment was sampled and the samples were placed in each of three separate buckets, the samples were taken from random positions throughout the cement mixer. The final blended sediment was stored in security sealed plastic-lined drums until needed. All seals were broken by GHL staff.

Each of the three sample buckets was mixed and then split into quarters. One of the quarters was then transferred into two separate jars, one to be sent for analysis and the other to be retained. The three sediment samples for analysis were sent to Interra in Bolingbrook, IL for particle size analysis using the methodology of ASTM method D422-63. The test results are summarized in **Table 2** and shown graphically in **Figure 7.**

Table 2 Particle Size Distribution of 1- 1000 µm Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100	100
500	96.3	96.3	96.4	96	95
250	90.2	90.4	89.8	90	90
150	77.5	77.9	78.0	78	75
100	67.4	66.8	67.3	67	60
75	55.6	55.6	56.1	56	50
50	51.5	51.5	51.0	51	45
20	39.4	39.7	41.7	40	35
8	22.0	21.0	19.5	21	20
5	15.7	13.4	13.4	14	10
2	7.5	7.5	8.0	8	5

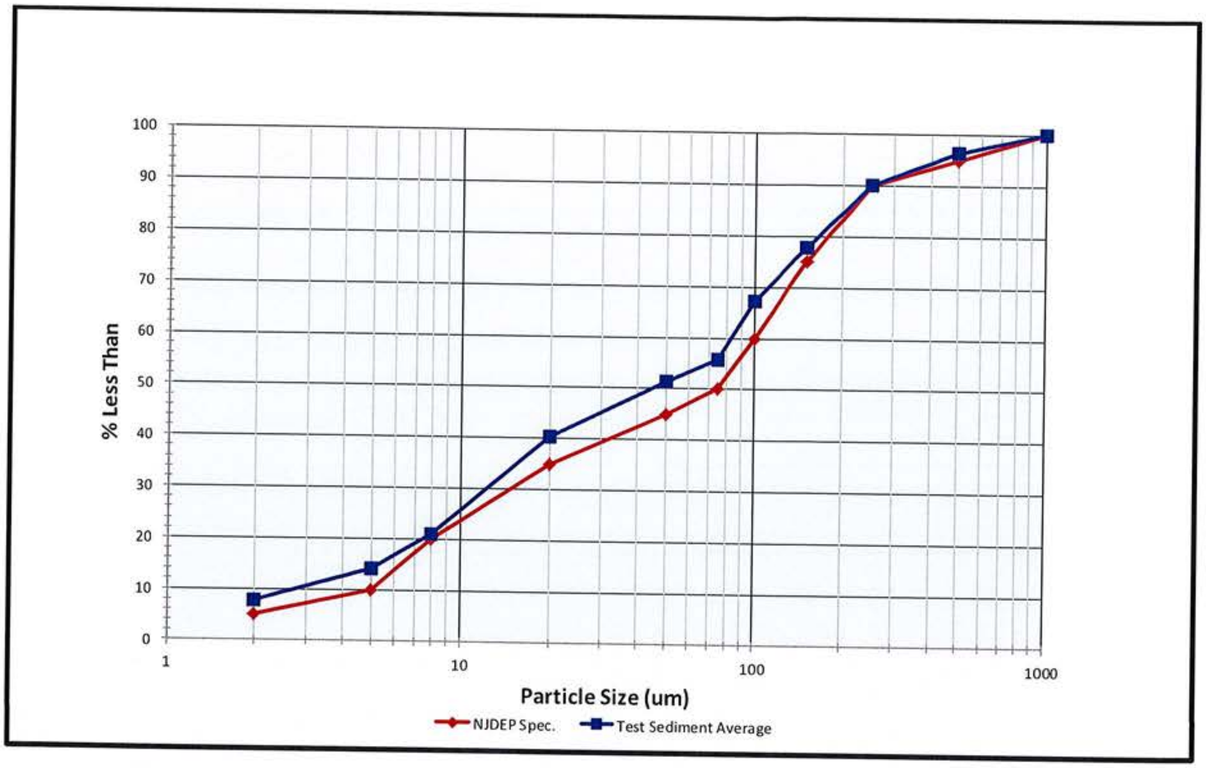

Figure 7 Average Particle Size Distribution of 1-1000 µm Test Sediment

In addition to particle size distribution, Interra also performed a moisture analysis of the test sediment and determined the water content to be < 0.1%.

The 1-1000 µm test sediment was found to meet the NJDEP particle size specification and was acceptable for use. With a d_{50} of 46 µm, the test sediment was finer than the sediment required by the NJDEP test protocol.

Scour Test Sediment

The test sediment used for the scour study (50-1000 µm) was supplied by AGSCO Corporation as a single, pre-blended batch, lot #101316. Three separate composite samples were created by randomly sampling 50% of all the bags received. The composite samples were well blended and quartered. One of the quarters from each composite was split in two, half was retained and the other half was sent to Interra for particle size distribution analysis. The test results are summarized in **Table 3** and shown graphically in **Figure 8**. The scour test sediment was finer than the sediment required by the NJDEP test protocol and therefore was acceptable for use.

Table 3 Particle Size Distribution of 50 - 1000 µm Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing)				NJDEP Specification (minimum % Passing)
	Sample 1	Sample 2	Sample 3	Average	
1000	100.0	100.0	100.0	100	100
500	97.7	97.8	97.4	97.6	90
250	68.2	67.9	68.9	68.3	55
150	52.0	52.1	52.8	52.3	40
100	29.5	29.4	31.3	30.1	25
75	14.8	14.9	15.5	15.1	10
50	12.0	12.0	10.1	11.4	0

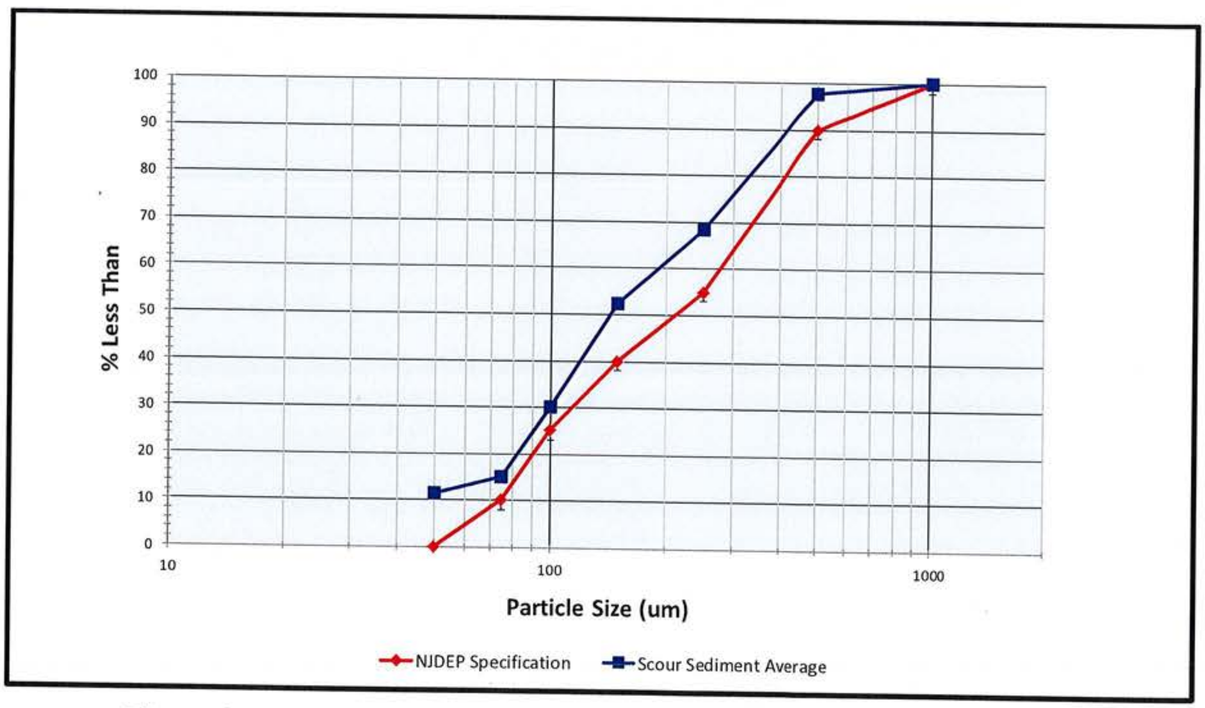

Figure 8 Average Particle Size Distribution of 50-1000 µm Test Sediment

2.3 Removal Efficiency Testing

Removal Efficiency Testing was conducted in accordance with Section 5 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs. Removal testing was conducted on a clean unit with a false floor installed at the 50% collection sump sediment storage depth of 4-inches above the device floor. Testing was completed at flow rates of 25%, 50%, 75%, 100%, and 125% MTFR (475 gpm - 2448 gpm) and at a target influent sediment concentration of 200 mg/L.

The test sediment was sampled 6 times per run to confirm the sediment feed rate. Each sediment feed rate sample was a minimum of 100 mL and collected in a 1000 mL jar.

Effluent grab sampling began following three MTD detention times after the initial sediment sample. The time interval between sequential samples was 1 minute, however, when the test sediment feed was interrupted for measurement, the next effluent sample was collected following three MTD detention times from the time the sediment feed was re-established. A total of 15 effluent samples were taken during each run.

Background water samples were taken with the odd-numbered effluent samples.

As specified in the NJDEP test protocol, analysis of Total Suspended Solids (TSS) samples were done in accordance with ASTM D 3977-97 (re-approval 2007) "Standard Test Methods for Determining Sediment Concentrations in Water Samples" and reported as Suspended Sediment Concentration (SSC).

2.4 Scour Testing

Prior to the start of testing the false floor was removed, and sediment was loaded into the sump of the STSS-4 and leveled at a depth of 4 inches. Measurements were taken at over a dozen locations by GHL staff. The final height of the sediment was at an elevation equivalent to 50% of the maximum sediment storage capacity of the MTD. After loading of the sediment, the unit was gradually filled with clear water, so as not to disturb the sediment, to the invert of the inlet pipe. The filled unit was allowed to sit overnight.

The scour test was conducted at a flow rate of 4200 gpm, over two times the MTFR. In order to achieve this flow, a larger pump was required. The DV200c pump was replaced with a 12″ X 12″ DV-300i centrifugal pump, rated for 6,900 gpm. Additionally, the AVFM flow sensor was relocated to the inlet pipe, through the opening used for sediment addition for the removal efficiency test (**Figure 9**). It was found that this location for the flow sensor provided for more stable flow readings at the scour flow rate.

During the scour test, the water flow rate and temperature were recorded once every minute. Testing commenced by gradually increasing the water flow into the system until the target flow rate was achieved (within 3 minutes of commencing the test). Background and effluent sampling began four minutes after adding water to the system. Sampling of background and effluent was completed as per the removal efficiency test. An effluent grab sample was taken once every two minutes, starting 4 minutes after flow to the system began, until a total of 15 effluent samples were taken. A total of eight background water samples were collected at evenly spaced intervals throughout the scour test.

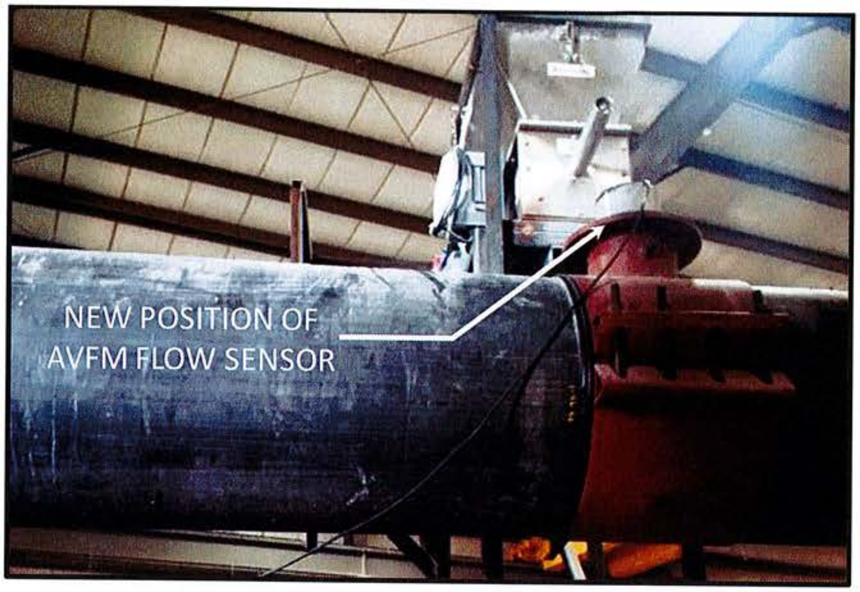

Figure 9 Position of AVFM Flow Sensor for Scour Test

3. Performance Claims

Per the NJDEP verification procedure, the following are the performance claims made by FreshCreek Technologies and/or established via the laboratory testing conducted for the StormTrap SiteSaver®4 (STSS-4) Hydrodynamic Separator.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the STSS-4 was calculated using the weighted method required by the NJDEP HDS MTD protocol. Based on a MTFR of 4.32 cfs (1940 gpm), the STSS-4 achieved a weighted TSS removal rate of at least 50%.

Maximum Treatment Flow Rate (MTFR).

The STSS-4 unit had a total sedimentation area of 84 ft^2 and a maximum treatment flow rate (MTFR) of 4.32 cfs (1940 gpm), which corresponds to a surface loading rate of 23.1 gpm/ft^2 of sedimentation area.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 8" which equates to 56 ft^3 of sediment storage volume. A sediment storage depth of 4 inches corresponds to 50% full sediment storage capacity (28 ft^3).

Effective Treatment/Sedimentation Area

The effective treatment area is 84 ft^2.

Detention Time and Wet Volume

The wet volume for the STSS-4 is 3,934 gallons. The detention time of the STSS-4 is dependent upon flow rate. The detention time, calculated by dividing the treatment volume by the MTFR, is 122 seconds at 1,940 gpm.

Online Installation

Based on the laboratory scour testing, the STSS-4 qualifies for online installation.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation test runs; spreadsheets containing original data from all performance test runs; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP and it was agreed that as long as such documentation could be made available by NJCAT upon request that it would not be prudent or necessary to include all this information in this verification report. All supporting documentation will be retained securely by GHL and has been provided to NJCAT.

4.1 Removal Efficiency Testing

A total of 5 removal efficiency testing runs were completed in accordance with the NJDEP HDS protocol. The target flow rate ranged from 25 – 125% MTFR and the target influent sediment concentration was 200 mg/L. The results from all 5 runs were used to calculate the overall removal efficiency of the STSS-4.

The total water volume and average flow rate per run were calculated from the data collected by the flow data logger, one reading every minute. The average influent sediment concentration for each test flow was determined by mass balance. The amount of sediment fed into the auger feeder during dosing, and the amount remaining at the end of a run, was used to determine the amount of sediment fed during a run. The sediment mass was corrected for the mass of the six feed rate samples taken during the run. The mass of the sediment fed was divided by the volume of water that flowed through the MTD during dosing to determine the average influent sediment concentration for each run.

Six feed rate samples were collected at evenly spaced intervals during the run to ensure the rate was stable. The COV of the samples had to be < 0.10 per the NJDPE protocol. The feed rate samples were also used to calculate an influent concentration in order to double check the concentration calculated by mass balance.

The average effluent sediment concentration was adjusted for the background sediment concentration. Removal efficiency for each test run was computed as follows:

$$Removal\ Efficiency\ (\%) = \left(\frac{\begin{matrix} Average\ Influent \\ Concentration \end{matrix} - \begin{matrix} Adjusted\ Average \\ Effluent\ Concentration \end{matrix}}{\begin{matrix} Average\ Influent \\ Concentration \end{matrix}} \right) \times 100\%$$

The data collected for each removal efficiency run is presented below:

25% MTFR

Table 4 Sampling Schedule - 25% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
25.33		1	1
26.33			2
27.33	2	2	3
52.67			4
53.67		3	5
54.67	3		6
80.00		4	7
81.00			8
82.00	4	5	9
107.33			10
108.33		6	11
109.33	5		12
134.66		7	13
135.66			14
136.66	6	8	15
137.78	End of Testing		
MTD Detention Time = 8.111 minutes Sediment Sampling Time = 1 minute			

Table 5 Water Flow and Temperature - 25% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	485	475	-2.1%	0.022	54.9
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

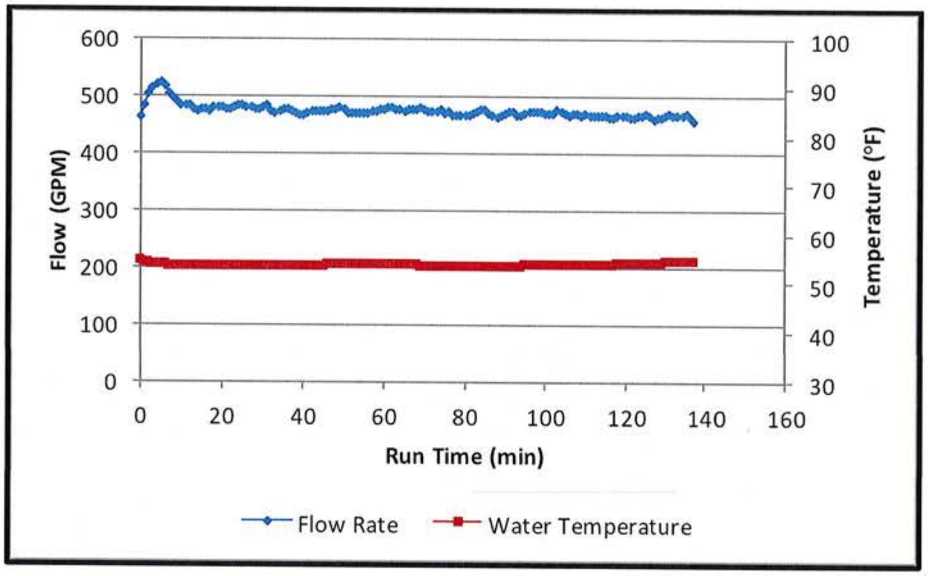

Figure 10 Water Flow and Temperature - 25% MTFR

Table 6 Sediment Feed Summary – 25% MTFR

Sediment Feed (g) – Sampling Time 1.0 min		Sediment Mass Balance	
1	422.179	Starting Weight of Sediment (lbs.)	300.00
2	372.215		
3	344.136	Recovered Weight of Sediment (lbs.)	189.69
4	354.725		
5	368.734	Mass of Sediment Used (lbs.)	110.31
6	390.696	Volume of Water Through MTD During Dosing (gal)	62,612
Average	375.448		
COV	0.074	Average Influent Sediment Concentration (mg/L)	201.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 7 SSC and Removal Efficiency - 25% MTFR

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	88.4	88.0	86.8	98.3	100	101	104	103	102	100	97.8	101	105	106	100
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	86.4	86.0	84.8	96.3	98.0	99.0	102	101	100	98.0	95.8	99.0	103	104	98.0

Average Adjusted Effluent Concentration	96.8 mg/L	Removal Efficiency	**52.1%**

50% MTFR

Table 8 Sampling Schedule - 50% MTFR

Runtime (min)	**Sampling Schedule**		
	Sediment Feed	**Background**	**Effluent**
0	1		
13.17		1	1
14.17			2
15.17	2	2	3
28.33			4
29.33		3	5
30.33	3		6
43.50		4	7
44.50			8
45.50	4	5	9
58.67			10
59.67		6	11
60.67	5		12
73.83		7	13
74.83			14
75.83	6	8	15
76.95	End of Testing		
MTD Detention Time = 4.055 minutes Sediment Sampling Time = 1 minute			

Table 9 Water Flow and Temperature - 50% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	970	974	+0.4%	0.013	54.0
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

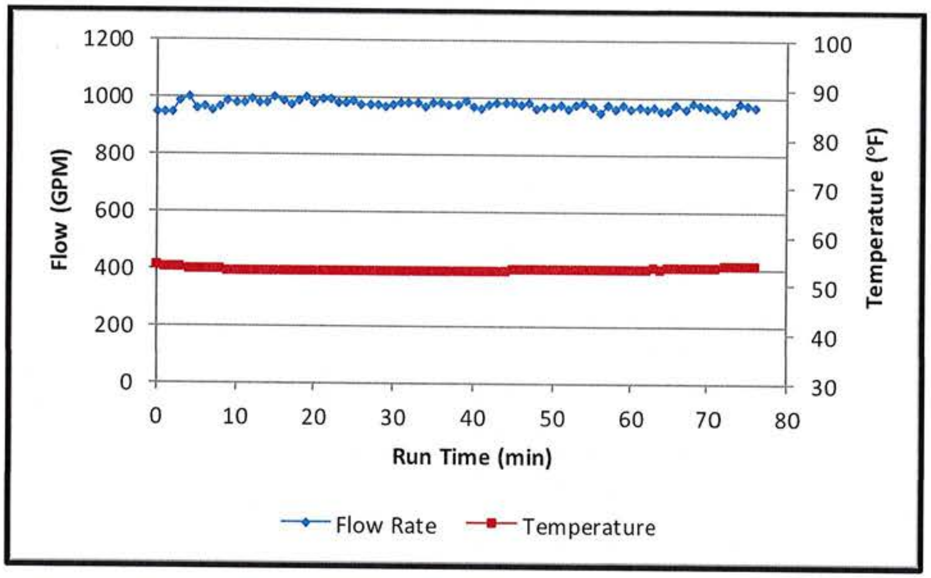

Figure 11 Water Flow and Temperature - 50% MTFR

Table 10 Sediment Feed Summary – 50% MTFR

Sediment Feed (g) – Sampling Time 1.0 min		Sediment Mass Balance	
1	839.115	Starting Weight of Sediment (lbs.)	300.00
2	662.805		
3	711.109	Recovered Weight of Sediment (lbs.)	179.69
4	726.493		
5	677.573	Mass of Sediment Used (lbs.)	120.31
6	723.758	Volume of Water Through MTD During Dosing (gal)	69,089
Average	723.476		
COV	0.086	Average Influent Sediment Concentration (mg/L)	192.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 11 SSC and Removal Efficiency - 50% MTFR

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	83.8	84.8	83.8	91.5	88.8	94.8	93.8	94.3	94.3	94.0	94.3	97.5	94.8	67.8	89.5
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	81.8	82.8	81.8	89.5	86.8	92.8	91.8	92.3	92.3	92	92.3	95.5	92.8	65.8	87.5

Average Adjusted Effluent Concentration	87.9	Removal Efficiency	**54.3%**

75% MTFR

Table 12 Sampling Schedule - 75% MTFR

Runtime (min)	**Sampling Schedule**		
	Sediment Feed	**Background**	**Effluent**
0	1		
9.11		1	1
10.11			2
11.11	2	2	3
20.22			4
21.22		3	5
22.22	3		6
31.33		4	7
32.33			8
33.33	4	5	9
42.44			10
43.44		6	11
44.44	5		12
53.55		7	13
54.55			14
55.55	6	8	15
56.07	End of Testing		
MTD Detention Time = 2.704 minutes Sediment Sampling Time = 0.5 minutes			

Table 13 Water Flow and Temperature - 75% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1455	1509	+3.7%	0.018	58
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

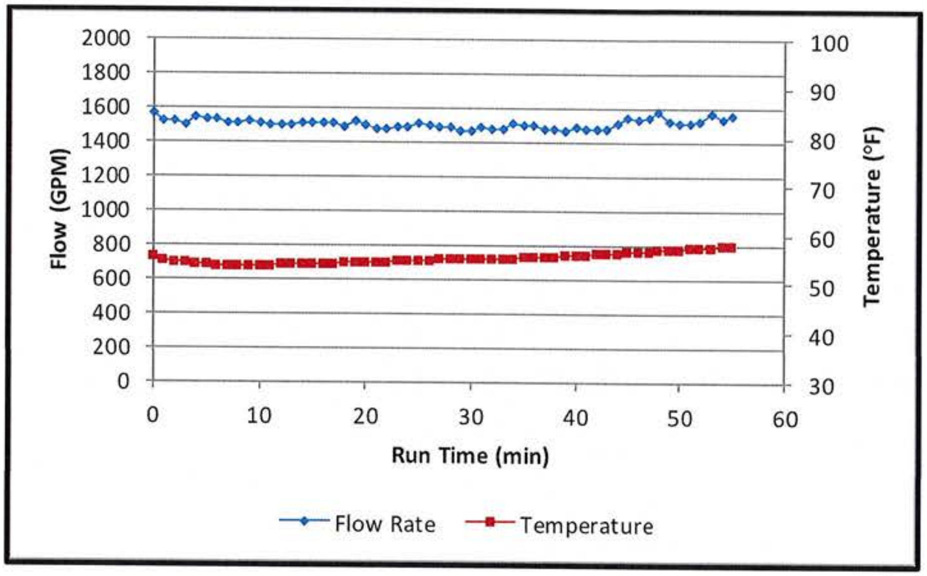

Figure 12 Water Flow and Temperature - 75% MTFR

Table 14 Sediment Feed Summary – 75% MTFR

Sediment Feed(g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	522.156	Starting Weight of Sediment (lbs.)	300.00
2	541.690		
3	523.642	Recovered Weight of Sediment (lbs.)	171.39
4	510.451		
5	533.598	Mass of Sediment Used (lbs.)	128.61
6	498.222	Volume of Water Through MTD During Dosing (gal)	80,053
Average	521.627		
COV	0.030	Average Influent Sediment Concentration (mg/L)	182.4*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 15 SSC and Removal Efficiency - 75% MTFR

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	74.3	76.8	81.3	87.5	85.5	86.3	84.8	88.8	86.5	90.8	84.3	62.5	80.8	84.0	78.3
Background	2.6		5.8		2.0		2.0		2.0		2.0		2.5		2.0
Adjusted Effluent	72.3	72.9	75.5	83.6	83.5	84.3	82.8	86.8	84.5	88.8	82.3	60.3	78.3	81.8	76.3
Average Adjusted Effluent Concentration				79.6 mg/L			Removal Efficiency					**56.4%**			

100% MTFR

Table 16 Sampling Schedule - 100% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
6.58		1	1
7.58			2
8.58	2	2	3
15.17			4
16.17		3	5
17.17	3		6
23.75		4	7
24.75			8
25.75	4	5	9
32.34			10
33.34		6	11
34.34	5		12
40.92		7	13
41.92			14
42.92	6	8	15
43.42	End of Testing		
MTD Detention Time = 2.028 minutes Sediment Sampling Time = 0.5 minutes			

Table 17 Water Flow and Temperature - 100% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1940	1908	-1.6%	0.012	57.2
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

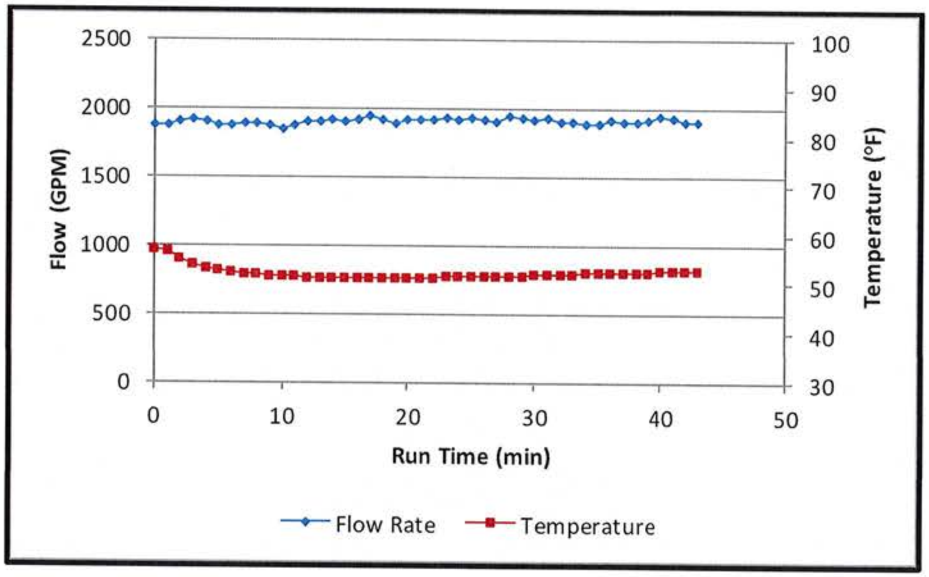

Figure 13 Water Flow and Temperature - 100% MTFR

Table 18 Sediment Feed Summary – 100% MTFR

Sediment Feed (g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	721.122	Starting Weight of Sediment (lbs.)	300.00
2	763.852		
3	767.382	Recovered Weight of Sediment (lbs.)	160.81
4	751.594		
5	771.685	Mass of Sediment Used (lbs.)	139.19
6	737.996	Volume of Water Through MTD During Dosing (gal)	77,049
Average	752.272		
COV	0.026	Average Influent Sediment Concentration (mg/L)	201.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 19 SSC and Removal Efficiency - 100% MTFR

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	88.0	93.8	82.5	94.3	77.3	91.8	89.8	88.5	84.8	98.0	102	86.0	106	92.5	81.8
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	86.0	91.8	80.5	92.3	75.3	89.8	87.8	86.5	82.8	96.0	100	84.0	104	90.5	79.8

Average Adjusted Effluent Concentration	88.5 mg/L	Removal Efficiency	**56.0%**

125% MTFR

Table 20 Sampling Schedule - 125% MTFR

Runtime (min)	**Sampling Schedule**		
	Sediment Feed	**Background**	**Effluent**
0	1		
5.37		1	1
6.37			2
7.37	2	2	3
12.73			4
13.73		3	5
14.73	3		6
20.10		4	7
21.10			8
22.10	4	5	9
27.46			10
28.46		6	11
29.46	5		12
34.83		7	13
35.83			14
36.83	6	8	15
37.83	End of Testing		
MTD Detention Time = 1.622 minutes Sediment Sampling Time = 0.5 minutes			

Table 21 Water Flow and Temperature - 125% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	2425	2448	+0.9%	0.012	53.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

During the run, just before the 19-minute mark, the flow meter display froze, displaying a value of zero. The power to the flow meter was cut by unplugging the flow meter display and plugging it back in. After re-initializing, the flow meter was working normally, displaying the correct flow rate. This entire process of restarting the flow meter took less than 1 minute.

The zero reading of the flow meter display was logged by the data logger for the 19-minute mark of the run; however, this reading was obviously incorrect as the reading was due to an electronics error, and not a physical change to the system flow. The flow readings at the 18 and 20 minute marks were 2,451 and 2,444 gpm respectively, a difference of only 0.3%, confirming that there was no actual change in flow. For the purposes of reporting the flow for the 19-minute mark, the average of the flow at 18 and 20 minutes was used **(see Figure 14).**

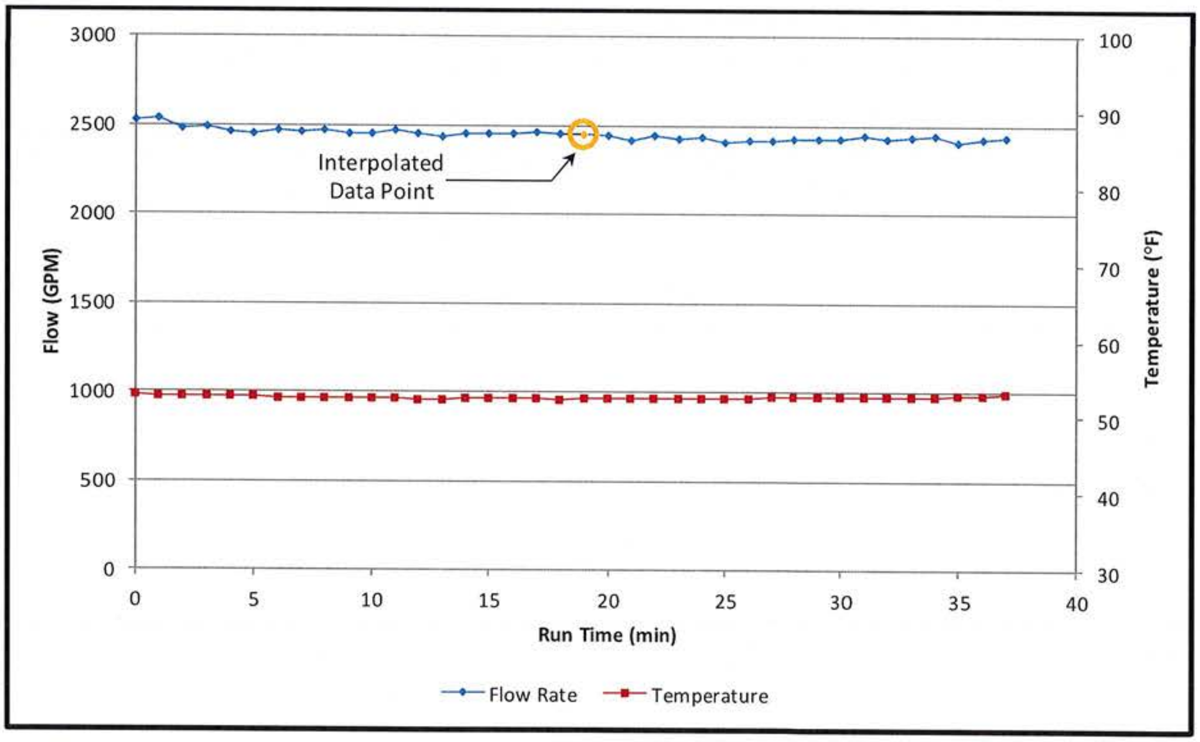

Figure 14 Water Flow and Temperature - 125% MTFR

Table 22 Sediment Feed Summary – 125% MTFR

Sediment Feed (g) – Sampling Time 0.5 min		Sediment Mass Balance	
1	917.949	Starting Weight of Sediment (lbs.)	300.00
2	894.979		
3	890.201	Recovered Weight of Sediment (lbs.)	155.23
4	854.205		
5	869.684	Mass of Sediment Used (lbs.)	144.77
6	884.004	Volume of Water Through MTD During Dosing (gal)	85,233
Average	885.170		
COV	0.025	Average Influent Sediment Concentration (mg/L)	187.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 23 SSC and Removal Efficiency - 125% MTFR

	Suspended Sediment Concentration (mg/L)														
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	7	**8**	9	**10**	**11**	**12**	**13**	**14**	**15**
Effluent	78.0	78.4	86.0	93.5	78.0	85.5	82.8	81.0	86.5	93.3	87.0	86.3	89.8	78.5	97.8
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	76.0	76.4	84.0	91.5	76.0	83.5	80.8	79.0	84.5	91.3	85.0	84.3	87.8	76.5	95.8

Average Adjusted Effluent Concentration	83.5	Removal Efficiency	**55.4%**

Annualized Weighted Removal Efficiency

The annualized weighted removal efficiency for sediment in stormwater has been calculated using the rainfall weighting factors provided in the NJDEP laboratory test protocol. The SiteSaver 4 annual weighted removal for a MTFR of 1940 gpm is 54.5%, as shown in **Table 24**.

Table 24 Annualized Weighted Removal Efficiency for SiteSaver®4

%MTFR	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	52.1	0.25	13.0
50	54.3	0.30	16.3
75	56.3	0.20	11.3
100	56.0	0.15	8.4
125	55.4	0.10	5.5
Annualized Weighted Removal Efficiency			**54.5%**

4.2 Scour Testing

Scour testing was conducted in accordance with Section 4 of the NJDEP Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation MTD. Testing was conducted at a target flow rate of 4,200 gpm, over 200% of the maximum treatment flow rate (MTFR).

In preparation for the scour test, the sump of the STSS-4 was cleaned out to remove all of the accumulated sediment from the previous removal efficiency testing. The false floor inside the unit sump was removed. The sump was then loaded with scour test sediment. When levelled, the sediment formed a layer at least 4 inches deep, confirmed by measuring the sediment depth with a yard stick at approximately two dozen locations throughout the sump. After sediment loading, the sump was filled with water. The water was added in such a way as to avoid disturbing the sediment bed. The STSS-4 was allowed to sit overnight before commencing the Scour Test.

Scour testing began by gradually increasing the flow rate to the target flow within a 3-minute period. Effluent and background samples were taken from the same locations as for the removal efficiency testing, starting 4 minutes after flow was initiated. The sampling frequency is summarized in **Table 25**.

Table 25 Scour Test Sampling Frequency

Sample/ Measurement Taken	Run Time (min.)															
	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
Effluent		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Background	X		X		X		X		X		X		X		X	

Note: The Run time of 0 minutes is the time the 1st background sample was taken, following the 4 minute flow equilibration period.

Table 26 Water Flow and Temperature - Scour Test

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	4,200	4,182	-0.4%	0.017	57.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

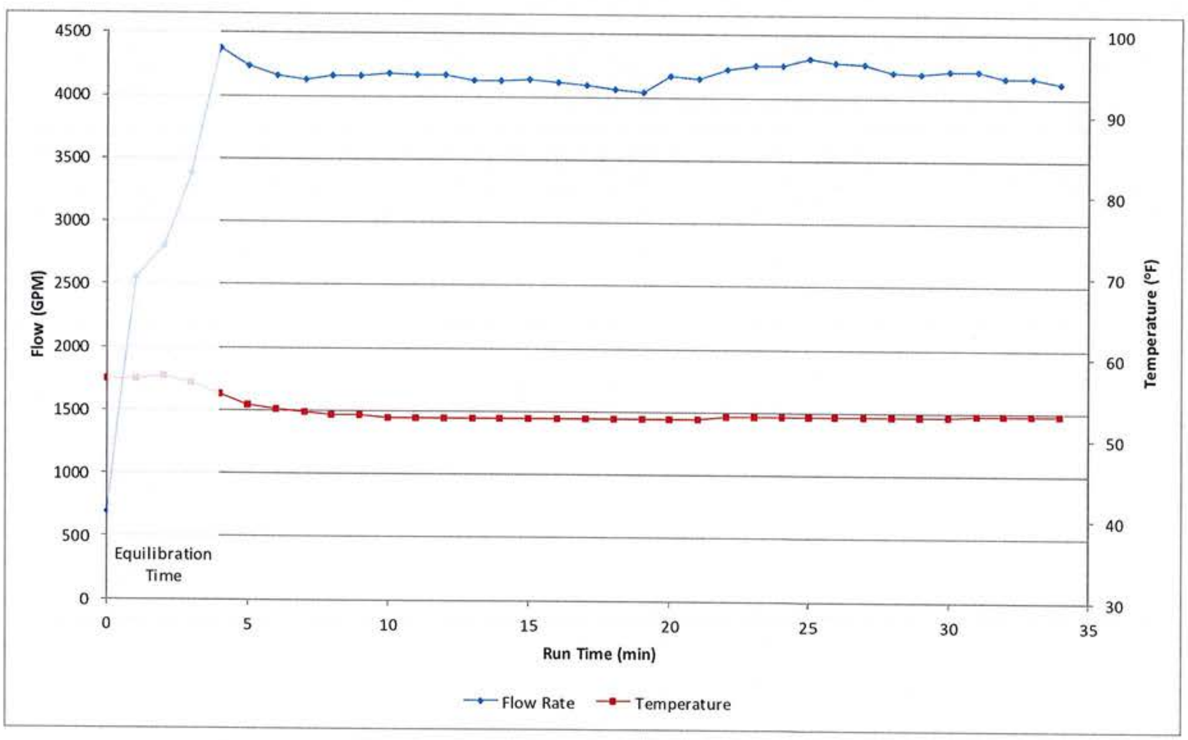

Figure 15 Water Flow and Temperature - Scour Test

The effluent and background SSC results are reported in **Table 27**. The adjusted effluent concentration was calculated as:

$$Adjusted\ Effluent\ Concentration\ \left(\frac{mg}{L}\right) = Effluent\ Concentration - Background\ Concentration$$

For effluent samples that did not have a corresponding background sample, the background value was interpolated from the previous and subsequent samples. The average adjusted effluent concentration was 7.03 mg/L, therefore when operated at 200% of the MTFR, the STSS-4 meets the criteria for online use.

Table 27 Suspended Sediment Concentrations for Scour Test

	Scour Suspended Sediment Concentration (mg/L)															
Sample #		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Effluent		13.3	13.5	12.0	12.5	8.50	10.3	9.60	11.0	9.50	8.50	7.50	8.50	8.00	7.75	6.00
Background	3.5		2.4		2.5		3.0		2.75		2.75		2.5		3.0	
Adjusted Effluent		10.4	11.1	9.55	10.0	5.75	7.30	6.73	8.25	6.75	5.75	4.88	6.00	5.25	4.75	3.00
Average Adjusted Effluent Concentration							**7.03 mg/L**									

5. Design Limitations

The SiteSaver is an engineered system designed to meet site-specific requirements. Design parameters and limitations are listed below.

Soil Characteristics

SiteSaver specifies that stone backfill be used. SiteSaver modules are typically placed on a level, 6" foundation of ¾" aggregate extending 2'-0" past the outside of the system in accordance with ASTM C891 "Standard practice for installation of underground precast utility structures". Native soils can be used as backfill provided that FreshCreek engineers review the soil characteristics prior to installation to confirm that the native material conforms to the backfill specifications.

Slope of Drainage Pipe

There are no specific drainage pipe slope limitations provided that both the inlet and outlet pipe elevations are identical. When utilizing a netting bag to contain floating debris, it is recommended that the inflow velocity be below 7 ft/sec. If the inflow velocity exceeds 7 ft/sec contact FreshCreek for design options to accommodate the larger inflow velocity.

Maximum Treatment Flow Rate

The maximum treatment flow rate for the STSS-4 is 4.32 cfs (1940 gpm). FreshCreek engineers can assist with site design engineers to ensure an appropriate design.

Maintenance Requirements

SiteSaver should be inspected and maintained following the recommendations and guidelines included in the current SiteSaver® Inspection and Maintenance Instruction Manual at: http://stormtrap.com/wp-content/uploads/2016/05/SiteSaver-OM.pdf

Section 6 of this report includes a detailed description of inspection and maintenance requirements.

Driving Head

SiteSaver does not require a certain driving head to operate effectively.

Installation Limitations

FreshCreek will provide contractors with specific pick weights prior to delivery.

Configurations

It is recommended that SiteSaver be installed inline. FreshCreek advises draining multiple inlets to the SiteSaver. This method shifts maintenance from multiple inlets to maintenance at a single point in order to ease site maintenance and reduce maintenance frequencies.

Structural Load Limitations

Standard SiteSaver modules are designed for HS-20 loading. Contact FreshCreek if design loadings are anticipated to exceed HS-20.

Pre-treatment Requirements

SiteSaver has no pre-treatment requirements.

Depth to Seasonal High-Water Table

SiteSaver performance is independent of high groundwater conditions. Contact FreshCreek if groundwater is above system invert for site specific structural/floatation calculations.

6. Maintenance Plans

Regular inspections are recommended to ensure that the system is functioning as designed. Please contact your Authorized SiteSaver Representative if you have questions in regard to the inspection and maintenance of the SiteSaver system. SiteSaver does not require entry into the system for maintenance; however, it is prudent to note that prior to entry into any underground storm sewer or underground structure, appropriate OSHA and local safety regulations and guidelines should be followed.

Inspection Scheduling

SiteSaver systems are recommended for inspection whenever the upstream and downstream catch basins and stormwater pipes of the stormwater collection system are inspected or maintained. This will economize the cost of the inspection if it is done at the same time. If inspected on an annual basis, the inspection should be conducted before the stormwater season begins to ensure that the system is functioning properly for the upcoming storm season.

Inspection Process

Inspections should be done such that a sufficient time has lapsed since the most recent rain event to allow for a static water condition. Visually inspect the system at all manhole locations. For debris accumulation, visually inspect the netting component (if utilized) to determine bag capacity. For sediment accumulation, utilize a sediment pole to measure and document the amount of sediment accumulation. To determine the amount of sediment in the system first insert the pole to the top of the sediment layer and record the depth. Then, insert the pole to the bottom of the system and record the depth. The difference in the two measurements corresponds to the amount of sediment in the system. Eight-inches of sediment accumulation corresponds to the maximum sediment storage capacity. NJDEP requires sediment removal on or before it reaches a maximum depth of 4-inches (50% of the MTD's maximum storage depth). Finally, inspect the inlet pipe opening to ensure that the silt level or any foreign objects are not blocking the pipe.

Maintenance Process

Maintenance should be done such that a sufficient time has lapsed since the most recent rain event to allow for a static water condition for the duration of the maintenance process. For floatable debris removal, remove the netting bag by lifting the bag by the netting frame moving it upwards along the netting support frame. Once the netting component is fully removed from the system, it should be properly disposed of per local, state, and federal guidelines and regulations. Typically, the netting component can be disposed of in a common dumpster receptacle. For sediment removal, the SiteSaver is designed with clear access at both the inlet and outlet. A vacuum truck, or similar trailer mounted equipment, can be used to remove the sediment, hydrocarbons, and water within the unit. For more effective removal it is recommended to use sewer jetting equipment or a spray lance to force the sediment to the vacuum hose. When the floor is sufficiently cleaned, fill the system back to its normal water elevation (to the pipe inverts) Finally, install a new net assembly by sliding the netting frame down the support frame and ensure the netting lays over the plate assembly. Secure the access openings and properly dispose of the sediment per local, state, and federal guidelines and regulations.

Proof of inspections and maintenance is the responsibility of the owner. All inspection reports and data should be kept on site or at a location where they will be accessible for years in the future. Some municipalities require these inspection and cleaning reports to be forwarded to the proper governmental permitting agency on an annual basis. Refer to your local and national regulations for any additional maintenance requirements and schedules not contained herein. Inspections should be a part of the standard operating procedure.

7. Statements

The following attached pages are signed statements from the manufacturer (FreshCreek Technologies), the independent observer (Good Harbour Labs), and NJCAT. These statements are a requirement of the verification process.

In addition, it should be noted that this report has been subjected to public review (e.g. stormwater industry) and all comments and concerns have been satisfactorily addressed.

FreshCreek

May 15, 2017

To: Dr. Richard Magee, Sc.D., P.E. BCEE
Executive Director
New Jersey Corporation for Advanced Technology
c/o Center for Environmental Systems
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

Subject: Submittal of the laboratory verification report for SiteSaver® STSS-4

Dr. Magee,

FreshCreek Technologies Inc. certifies that the protocol requirements of "New Jersey Department of Environment Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", dated January 25, 2013, were met or exceeded.

Sincerely
Fresh Creek Technologies Inc.

Dan Fajman
General Manager

PHONE 973 237 9099
FAX 973 237 0744
WEB www.freshcreek.com
EMAIL fresh@freshcreek.com
1384 Pompton Ave. Suite 2
Cedar Grove, New Jersey 07009

Good Harbour Laboratories

May 10, 2017

Dr. Greg Williams, Managing Director
Good Harbour Laboratories Ltd.
2596 Dunwin Dr.
Mississauga, ON L5L 1J5

Dr. Richard Magee
Executive Director
New Jersey Corporation for Advancement of Technology

RE: Third party observation of testing of the STSS4 according to the **New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January 25, 2013)**

Dear Dr. Magee,

This purpose of this letter is to confirm that Good Harbour Laboratories staff, specifically Joe Costa, De Wu Zhang or I, witnessed all of the STSS4 testing conducted at the FreshCreek Technologies facility in Morris, Illinois from October 16, 2016 to April 5, 2017 that is included in the report to NJCAT. I can attest that the testing was done in accordance with the above referenced protocol, as required by the **Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology, for use in accordance with the Stormwater Management Rules N.J.A.C. 7:8 (January 25, 2013).**

Prior to testing we confirmed that the instrumentation being used was calibrated and we witnessed the blending of sediment delivered from Agsco directly to FreshCreek. All sediment was sealed and unsealed under supervision. We also took physical measurements and pictures of the test set up.

During the testing we witnessed the sampling during every run and verified all mass measurements. We also verified all sample bottle labels and confirmed the chains of custody for all analyzed samples.

After the testing I reviewed all of the data, calculations and conclusions contained in the report **NJCAT TECHNOLOGY VERIFICATION StormTrap SiteSaver® Hydrodynamic Separator, FreshCreek**

Good Harbour Laboratories
T: 905.696.7276 | F: 905.696.7279
A: 2596 Dunwin Drive, Mississauga, ON L5L 1J5
www.goodharbourlabs.com

Technologies, Inc. (May, 2017). I can confirm that the report accurately represents what we observed. Furthermore, we have retained copies of the background data, analytical reports and calibration certificates, as well as the calculations, in an independent and secure location on the GHL server. This supporting information is available to you upon request.

Sincerely,

Greg Williams

Greg Williams, Ph.D., P.Eng.

CC: Dan Fajman, FreshCreek Technologies Inc.

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www.goodharbourlabs.com

Good Harbour Laboratories

May 16, 2017

Dr. Richard Magee, ScD., P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology (NJCAT)

Re: Performance Verification of the FreshCreek Technologies STSS-4

Dear Dr. Magee,

Good Harbour Laboratories was contracted by FreshCreek Technologies Inc. to witness the performance testing of their STSS-4 in accordance with New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January, 2013).

Good Harbour Laboratories (GHL), a wholly owned subsidiary of Monteco Ltd., is an independent hydraulic test facility located in Mississauga, Ontario, Canada. GHL provides testing and verification services for numerous water treatment technologies including stormwater treatment devices. GHL has had several different stormwater equipment manufacturers as clients and we have accumulated considerable experience in testing these devices. In order to be able to make this experience available to as many potential clients as possible, GHL is careful to maintain its position as an independent service provider.

With the above in mind I, the undersigned, on behalf of GHL and Monteco, confirm:

-that I do not have any conflict of interest in connection to the contracted testing. Potential conflict of interest may arise in particular as a result of economic interests, political or national affinities, family or emotional ties, or any other relevant connection or shared interest;

-that I will inform NJCAT, without delay, of any situation constituting a conflict of interest or potentially giving rise to a conflict of interest;

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Good Harbour Laboratories

-that I have not granted, sought, attempted to obtain or accepted and will not grant, seek, attempt to obtain, or accept any advantage, financial or in kind, to or from any party whatsoever, constituting an illegal or corrupt practice, either directly or indirectly, as an incentive or reward relating to the award of the contract.

Sincerely,

Greg Williams

Dr. Greg Williams, P.Eng.
Managing Director
Good Harbour Laboratories

Date

May 16/17

CC: Dan Fajman, FreshCreek Technologies

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Center for Environmental Systems

Stevens Institute of Technology

One Castle Point

Hoboken, NJ 07030-0000

May 18, 2017

Shashi Nayak
NJDEP
Division of Water Quality
Bureau of Non-Point Pollution Control
401-02B
PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Nayak,

Based on my review, evaluation and assessment of the testing conducted on the StormTrap SiteSaver® - 4 Hydrodynamic Separator (STSS-4) by FreshCreek Technologies and observed by Dr. Gregory Williams, P.E. of Good Harbour Laboratories, Ltd., Mississauga, Ontario, the test protocol requirements contained in the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP HDS Protocol) were met or exceeded. Specifically:

Test Sediment Feed

The mean PSD of the FreshCreek test sediments comply with the PSD criteria established by the NJDEP HDS protocol. The FreshCreek removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be finer than the sediment blend specified by the protocol (<75μm); the test sediment d_{50} was 46 microns. The scour test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification and shown to be finer than specified by the protocol and therefore acceptable for use.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the STSS-4, a commercially available unit, to establish the ability of the STSS-4 to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. The STSS-4 demonstrated 54.5% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The flow rates, feed rates and influent concentration all met the NJDEP HDS test protocol's coefficient of variance requirements and the background concentration for all five test runs never exceeded 20 mg/L.

Scour Testing

To demonstrate the ability of the STSS-4 to be used as an online treatment device scour testing was conducted at greater than 200% of MTFR in accordance with the NJDEP HDS Protocol. The average flow rate during the online scour test was 4,182 gpm, which represents 216% of the MTFR (MTFR = 1,940 gpm). Background concentrations were <3.5 mg/L throughout the scour testing, which complies with the 20 mg/L maximum background concentration specified by the test protocol. Unadjusted effluent concentrations ranged from 6 mg/L to 13.5 mg/L. When adjusted for background concentrations, the effluent concentrations range from 3 to 11 mg/L with a mean of 7 mg/L. These results confirm that the STSS-4 did not scour at 216% MTFR and meets the criteria for online use.

Maintenance Frequency

The predicted maintenance frequency of the STSS-4 is 47 months. The sediment removal interval was calculated using the "monthly" calculation in Section B, Appendix A of the NJDEP HDS protocol.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE
Executive Director

8. References

1. NJDEP 2013. New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology. January 25, 2013.

2. NJDEP 2013. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device. January 25, 2013.

VERIFICATION APPENDIX

Introduction

- Manufacturer: FreshCreek Technologies, Inc., 1384 Pompton Ave, Suite 2, Cedar Grove, New Jersey, 07009. *General Phone: (973) 237-9099.* Website: www.freshcreek.com.

- MTD: StormTrap SiteSaver® - 4 (STSS-4) Hydrodynamic Separator

- TSS Removal Rate: 50%

- Offline or Online installation

Detailed Specification

- This verification report only covers the STSS-4 model hydrodynamic separator.

- The STSS-4 model hydrodynamic separator has a maximum treatment flow rate (MTFR) of 4.32 cfs (1940 gpm), which corresponds to a surface loading rate of 23.1 gpm/ft^2 of sedimentation area.

- FreshCreek provides contractors with project-specific unit pick weights and installation instructions as warranted prior to delivery.

- Maximum recommended sediment depth prior to cleanout is 4 inches.

- Maintenance frequency[1] is 47 months.

- A SiteSaver® Operations and Maintenance Instruction Manual is available at: http://stormtrap.com/wp-content/uploads/2016/05/SiteSaver-OM.pdf

- According to N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the StormTrap SiteSaver® to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

[1]Sediment removal interval calculated using the "monthly" calculation in Section B, Appendix A of the NJDEP HDS protocol.