NJCAT Technology Verification (112 micron)

Section E

NJCAT TECHNOLOGY VERIFICATION

SciClone™ Hydrodynamic Separator

Performance Verification of Sediment Capture and Light Liquid Retention

Bio Clean Environmental Services Inc.

September 2017

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1. Introduction

The SciClone™ is a manufactured treatment device (MTD) designed by Bio Clean Environmental Services Inc., a Forterra Company. The SciClone is designed to remove pollutants from stormwater runoff using a series of flow splitters, weirs and baffles. The device traps suspended particulates by promoting gravity separation, as well as being able to capture and retain floatables and light liquids, such as oil.

The test program was conducted by Good Harbour Laboratories (GHL), an independent water technology testing lab based in Ontario, Canada. The study results were submitted to the New Jersey Corporation for Advanced Technology (NJCAT) for verification. NJCAT is a private/public partnership that provides independent technology verification, education and information on emerging environmental and energy technology fields.

This testing program was based primarily on the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 25, 2013)*. However, the particle size distribution (PSD) of the test sediment used is larger than what is required for NJDEP approval. This larger PSD is common in many regions throughout the nation and thus more applicable in these areas.

In addition to sediment capture, the testing program incorporated an assessment for the retention of light liquids. This portion of the study was based on the Canada Environmental Technologies Verification (ETV) procedure: *Procedure for Laboratory Testing of Oil-Grit Separators (Version 3.0)*. The performance test results have been submitted to NJCAT for verification only.

2. Description of Technology

The SciClone™ system captures the following pollutants: total suspended solids, particulate bound nutrients and metals, debris, floatables and free-floating oil from contaminated runoff.

The SciClone™ is designed to maximize the flow path of entering stormwater thus optimizing its ability to capture suspended solids efficiently with minimal surface area. The system has no moving parts and operates utilizing the principles of gravity separation and flow path maximization to increase settling of finer particulates. It is composed of three components as shown in **Figure 1**.

Runoff is directed into the system via the inflow pipe and enters the flow splitter deck, as illustrated in **Figure 2**. From the flow splitter, water is channeled along the chamber wall on both sides of the inlet pipe. This splitting of the flow reduces inlet velocity into the system and channels flow along the walls of the chamber. As the split flow encounters the oil/floatables skimmer wall, it is directed along the skimmer wall toward the center of the chamber. At the center of the chamber the flow paths from both sides meet one another. As this occurs the flow path from both directions circles back toward the inlet pipe. This configuration directs the flow back toward the inlet and underneath the flow splitter deck thus maximizing the flow path. Finer sediments are directed into the sump chamber below the flow splitter to the chamber wall under the inlet as shown in **Figure 3**.

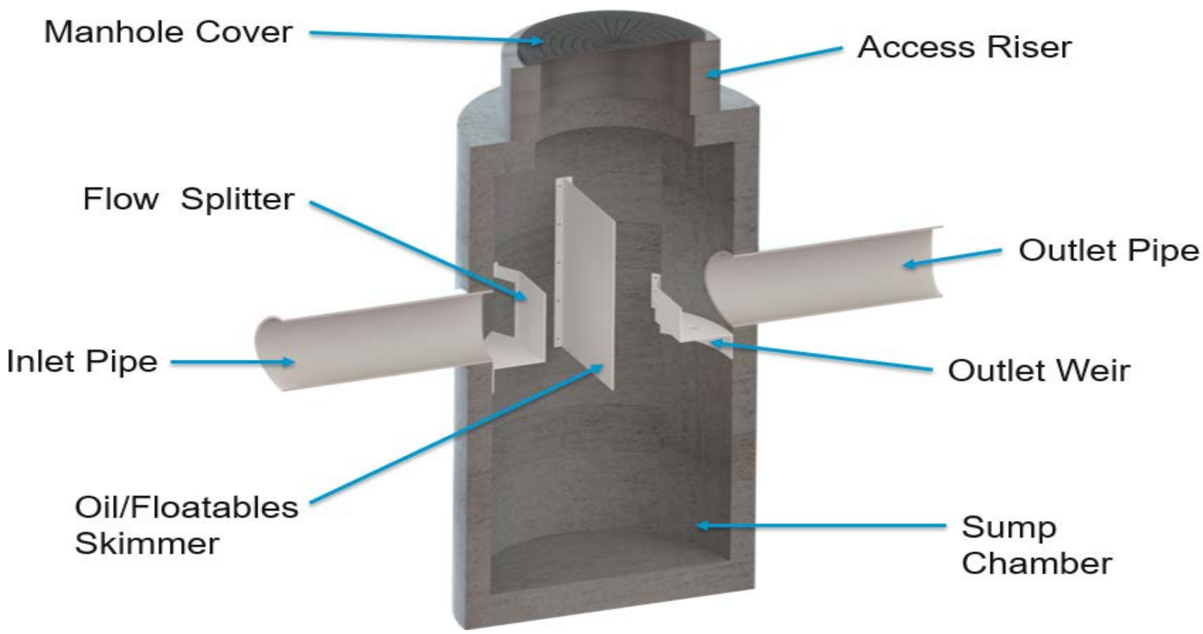

Figure 1 Cut-Away View

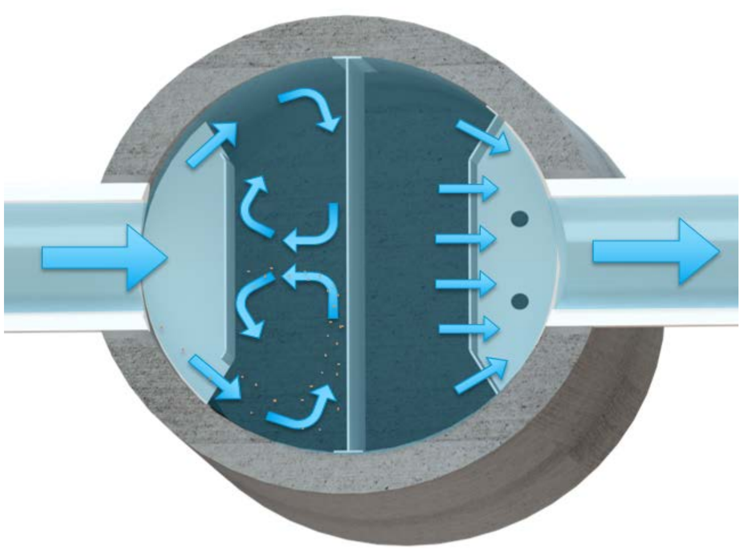

Figure 2 Operational Diagram

The oil/floatables skimmer is installed in the middle of the chamber and extends downward and upward to isolate free-floating oils and floatable trash and debris. Flows are forced to travel under the skimmer in the center of the system where the system is the widest thus creating a laminar flow under the weir and minimizing velocity. As water passes under the oil/floatables skimmer it rises back up and toward the outlet weir. The outlet weir extends across width of the outlet pipe and protrudes up slightly above the outlet pipe invert. The outlet weir is much wider than the pipe and creates a laminar flow from the system into the outlet pipe to reduce entrance velocity back into the pipe and preventing channeling of flow as shown in **Figure 3**.

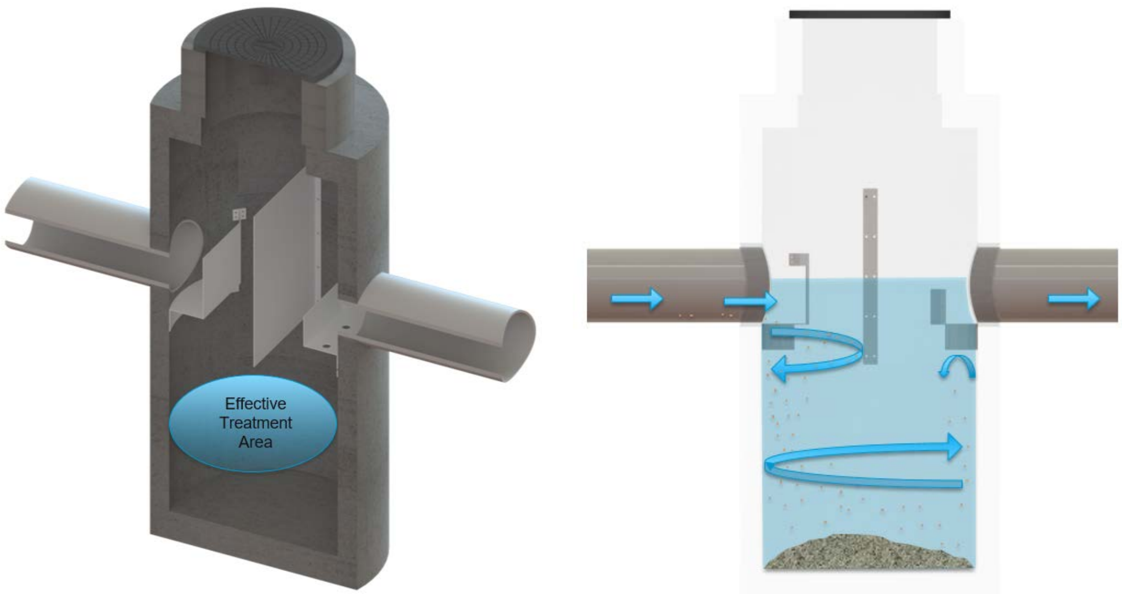

Figure 3 Effective Treatment Area and Flow Path Diagram

The unique design of the SciClone™, with a flow splitter, oil/floatables skimmer, and outlet weir maximizes the flow path and minimizes velocity for maximum performance. The system is designed to be installed online and process high flows internally. Higher flows are able to pass over the top of the flow splitter without impedance, under the oil/floatables skimmer and to the outlet. The outlet weir creates less turbulent conditions into the pipe and thus reduces head-loss during peak flow conditions as shown in **Figure 4**.

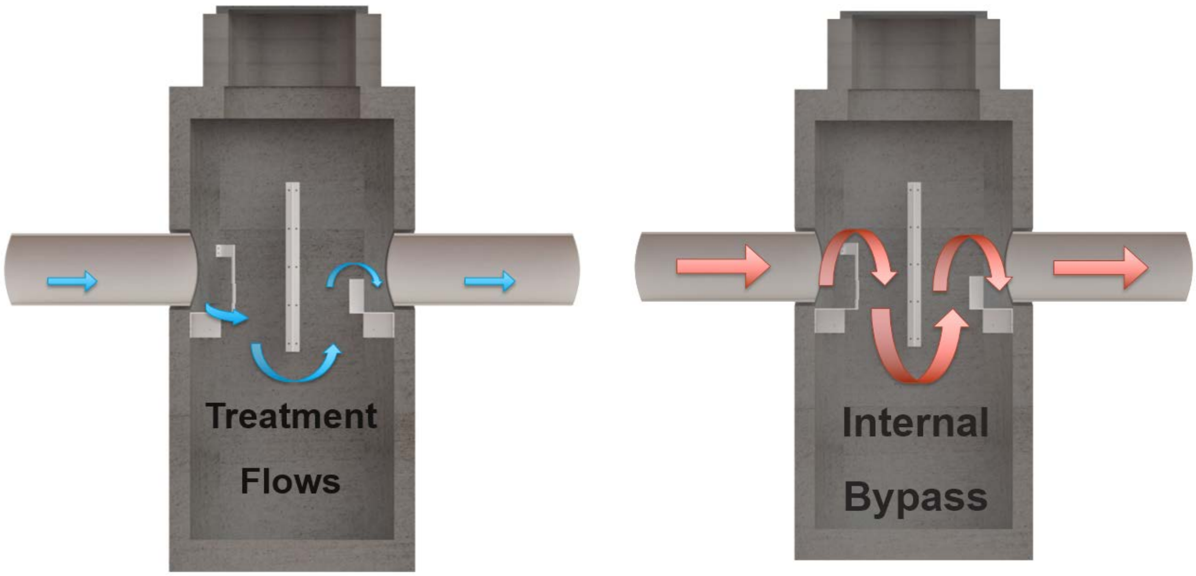

Figure 4 View During Treatment and Bypass Flows

3. Laboratory Testing

The device tested was a four-foot diameter SciClone™ unit (Model SC-4) consisting of internal components housed in a metal manhole. In commercial systems, the internal components are typically housed in a concrete manhole. The metal manhole of the test unit was equivalent to commercial concrete manholes in all key dimensions. The use of a metal manhole was proposed due to the difficulties associated with transporting and physically supporting the weight of a concrete vessel. Using a metal manhole in lieu of concrete did not impact system performance.

3.1 Test Setup

The specifications of the tested SciClone™ Hydrodynamic Separator (HDS) (Model SC-4) are provided in **Table 1**. The test unit had a total sedimentation volume of 62.8 ft^3 and a maximum treatment flow rate (MTFR) of 0.702 cfs (315 gpm).

Table 1 SciClone™ Model SC-4 Dimensions

MTFR (cfs)	Diameter (ft)	50% of Sediment Storage Volume (ft^3)	Oil Capacity (Gal)	Effective Treatment Volume (ft^3)
0.702	4	9.4	15.4	62.8

The laboratory test set-up was a water flow loop, capable of moving water at a rate of up to 2.2 cfs. The test loop, illustrated in **Figure 5**, was comprised of water storage tanks, pumps, sediment filter, receiving tank and flow meters.

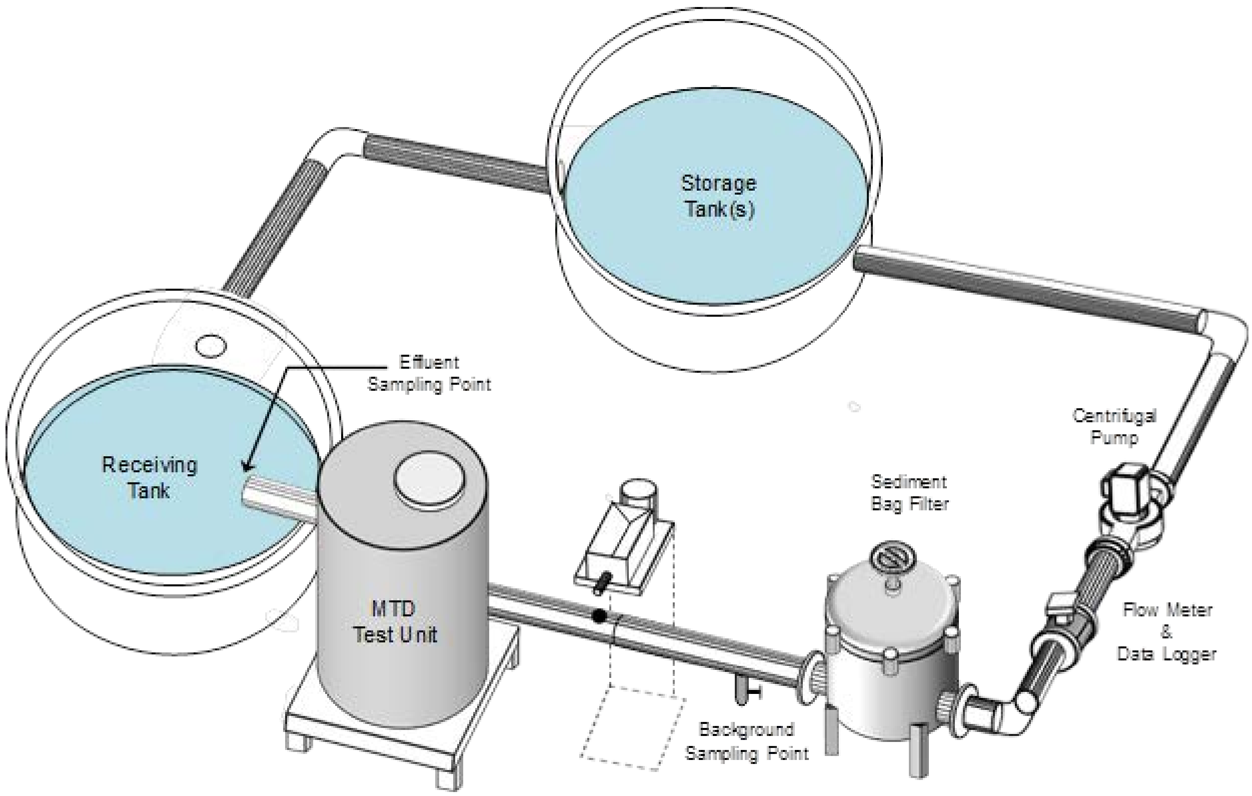

Figure 5 Test Flow Apparatus

Water Flow and Measurement

From the water supply tanks, water was pumped using either a WEG Model FC00312 (1 – 200 gpm) or an Armstrong Model 8X8X10 4380 (200 – 1000 gpm) centrifugal pump. Flow measurement was done using either a 3” Toshiba Model GF630 electromagnetic type flow meter with an accuracy of ± 0.5% of reading (1 – 200 gpm) or a MJK Magflux Type 7200 flow meter Model 297237 with an accuracy of ± 0.25% of reading (100 – 1000 gpm). The data logger used was a MadgeTech Process 101A data logger, configured to record a flow measurement once every minute.

The water in the flow loop was circulated through a filter housing containing high-efficiency pleated bag filters with a 0.5 µm absolute rating. The influent pipe was 24 inches in diameter and 132 inches long. Sediment addition was done through a port at the crown of the influent pipe, 118 inches upstream of the SciClone™. The sediment feeder was an Auger Feeders Model VF-1 volumetric screw feeder with vibratory hopper. The feeder had a 10-gallon hopper above the auger screw to provide a constant supply of sediment.

Water flow exited the SciClone™ and terminated with a free-fall into the receiving tank to complete the flow loop.

Sample Collection

Background water samples were collected in a 1 L jar from a sampling port located upstream of the auger feeder. The sampling port was controlled manually by a ball valve (**Figure 6**) 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 7**). The sampling technique was to take the grab sample by sweeping a 1 L jar through the stream of effluent flow such that the jar was full after a single pass.

Figure 6 Background Sampling Point

Figure 7 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 under refrigerated conditions in case there was a need for an investigation following an aberrant result.

Other Instrumentation and Measurement

Effluent water temperature was taken as it exited the effluent pipe stub, using a Kangaroo digital, thermometer, Model 21800-068.

Run and sampling times were measured using a NIST traceable stopwatch, Control Company Model 62379-460.

The sediment feed samples that were taken during the run were collected in 500 mL jars and weighed on an analytical balance (Mettler Toledo, AB204-S).

3.2 Test Sediment

The test sediment was fed through an opening in the crown of the influent pipe, 118" upstream of the SciClone™. A funnel was used to direct the sediment into the pipe (**Figure 8**). The test sediment used for the removal efficiency study was commercially available silica sediment supplied by AGSCO Corporation, generally referred to as #110 but labeled #140-200. This particular batch was lot # 03311724648. Three samples of sediment were sent out for particle size analysis using the methodology of ASTM method D422-63. The samples were composite samples created by taking a sediment sample from the hopper before the start of each of the five runs. The testing lab was Maxxam Analytics, an independent test lab also located in Ontario, Canada. The PSD results are summarized in **Table 2** and shown graphically in **Figure 9.**

Figure 8 Sediment Addition Point

Table 2 Particle Size Distribution of #110 Test Sediment

Particle Size (μm)	Test Sediment Particle size (%passing)			
	Sample 1	Sample 2	Sample 3	Average
1000	100	100.0	100.0	100.0
500	99.8	99.7	99.6	99.7
250	96.1	95.7	95.1	95.6
150	79.5	78.4	76.5	78.1
100	42.9	39.7	39.4	40.7
75	21.2	20.0	21.2	20.8
50	3.3	2.0	2.1	2.5
20	0	0	0	0
8	0	0	0	0
5	0	0	0	0
2	0	0	0	0
d_{50} (μm)	109	113	114	112

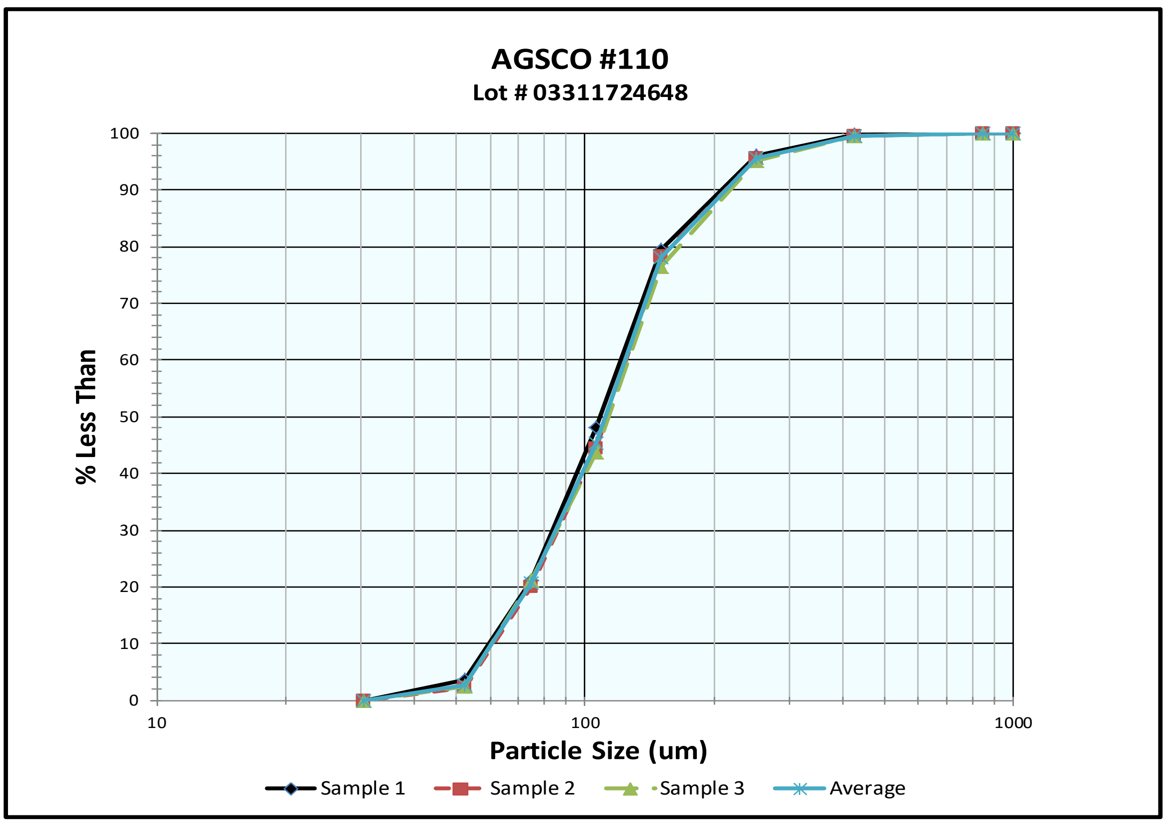

Figure 9 Particle Size Distribution of Test Sediment

For the scour test, the NJDEP specified scour test sediment was used. The sediment was blended by GHL using commercially available silica sands and the PSD of the sediment meet the specifications for the scour test sediment specified in the NJDEP laboratory test protocol. The scour test sediment PSD results are summarized in **Table 3** and shown graphically in **Figure 10**.

Table 3 Particle Size Distribution of Scour Test Sediment

Particle Size (µm)	Test Sediment Particle Size (% Less Than)				NJDEP Specification (Minimum % Less Than)
	Sample 1	Sample 2	Sample 3	Average	
1000	100	99	100	100	100
500	95	92	94	94	90
250	63	58	61	61	55
150	52	43	46	47	40
100	33	20	23	25	25
75	22	10	13	15	10
50	14	4	6	8	0

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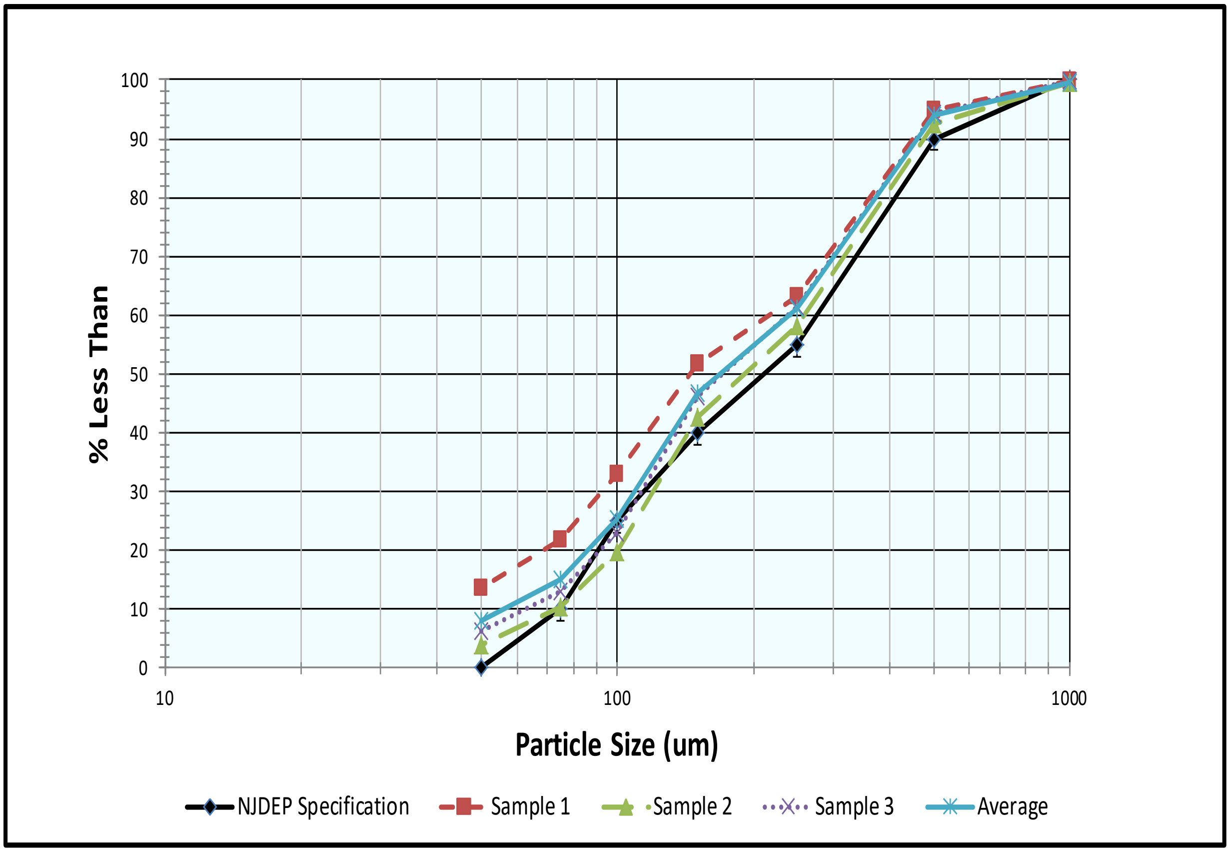

Figure 10 Particle Size Distribution of Scour Test Sediment

3.3 Removal Efficiency Testing

Removal efficiency testing was conducted on a clean unit with a false floor installed at 50% of the sump sediment storage depth, 9 inches above the device floor. Removal Efficiency Testing was based on Section 5 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs.

The test sediment was sampled six times per run to confirm the sediment feed rate. Each sediment feed rate sample was collected in a 500-mL jar over an interval timed to the nearest second and was a minimum 0.1 liter or the collection interval did not exceed one minute, whichever came first.

Effluent grab sampling began following three MTD detention times after the initial sediment feed sample. The time interval between sequential samples was 1 minute, however, if 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.

3.4 Scour Testing

Prior to the start of testing, sediment was loaded onto a 5-inch false floor of the sump of the SciClone™ and leveled at a depth of 4 inches. 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 for 89 hours.

The scour test was conducted at a flow rate of 630 gpm (1.4 cfs), two times the MTFR.

During the scour test, the water flow rate and temperature were recorded once every minute using a MadgeTech Process 101 data logger and a MicroTemp data logger. Testing commenced by gradually increasing the water flow into the system until the target flow rate was achieved (within five minutes of commencing the test). Background and effluent sampling began five 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 after achieving the target flow rate, 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.

3.5 Light Liquid Re-Entrainment Simulation Test

The objective of this test was to assess whether light liquids captured in the SciClone™ are effectively retained at design flow rates. The test used low density polyethylene (LDPE) plastic beads as a surrogate for light liquids. The specifications of the LDPE beads are provided in **Table 4**. Since the density of the beads is similar to that of motor oil, the beads mimic the behaviour of light liquids trapped in a hydrodynamic separator.

Table 4 LDPE Bead Specifications

Manufacturer	Dow Chemical
Product Name	DOWLEX™ 2517 Polyethylene Resin
Batch Number	D204F5D01E
Density	0.9166 g/cm^3
Bulk Density	0.56074 g/cm^3

This test was run with clean water and with the false floor set at 50% of the maximum recommended sediment storage depth to ensure that the hydrodynamics of the SciClone™ were representative of an average condition. For the test, the SciClone™ was pre-loaded to its maximum recommended oil storage capacity, 15.4 gallons, with LDPE beads.

The potential for oil re-entrainment and washout was determined at five flow rates, ranging from 25% to 125% MTFR, increased in 5-minute intervals. Flow rates were recorded once every 30 seconds over the duration of the test and maintained within ±10% of the target flow rate with a COV of less than 0.03. The time to increase the flow initially, and from one rate to the next, did not exceed 1 minute.

All effluent during the test was screened for the entire duration of the test. The screen mesh size used ensured that all plastic beads washed out of the SciClone™ were retained on the screens while allowing water to pass through. The way the LDPE beads were collected and quantified ensured that they were associated with the flow rate interval in which they were washed out. Beads that washed out during a transition flow were associated with the higher target flow rate.

The volume, mass, and percentage of plastic beads washed out of the SciClone™ were determined for each flow rate.

4. Performance Claims

The following are the performance claims made by Bio Clean Environmental Services and/or established via the laboratory testing conducted for the SciClone™ Hydrodynamic Separator.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the SciClone™ using sediment with a median particle size (d_{50}) of 112 µm was determined using the weighted method specified by the NJDEP HDS MTD protocol. Based on a MTFR of 0.702 cfs, the SciClone™ achieved a weighted TSS removal rate, reported as Suspended Sediment Concentration (SSC) per the NJDEP protocol, of at least 80%.

Maximum Treatment Flow Rate (MTFR).

The SciClone™ unit had a total sedimentation volume of 62.80 ft^3 and a maximum treatment flow rate (MTFR) of 0.702 cfs (315 gpm), which corresponds to a loading rate of 5.02 gpm/ft^3 of sedimentation chamber volume.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 18" which equates to 18.8 ft^3 of sediment storage volume. A sediment storage depth of 9" corresponds to 50% full storage capacity (9.4 ft^3).

Effective Treatment/Sedimentation Volume

The effective treatment volume is 62.80 ft^3.

Detention Time and Wet Volume

The wet volume for the SciClone™ is 62.80 cu ft (470 gallons). The detention time of the SciClone™ is dependent upon flow rate. The minimum design detention time, calculated by dividing the treatment volume by the MTFR of 315 gpm, is 89.5 seconds.

Light Liquid Retention

Based on the laboratory testing using polyethylene beads as a surrogate for light liquids, the SciClone™ can retain a minimum of 98.7% (on a mass basis) of trapped light liquids up to a flow rate of 100% MTFR and 89.1% at 125% MTFR.

5. Supporting Documentation

To support the performance claims, 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. were made available to NJCAT for review. It was agreed that as long as such documentation could be made available 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.

5.1 Removal Efficiency

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 an annualized weighted removal efficiency for the SciClone™.

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 SciClone™ 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 NJDEP 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. In cases where the reported background sediment concentration was less than 2.3 mg/L (the method quantitation limit), 2 mg/L was used in calculating the adjusted effluent 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 5 Sampling Schedule - 25% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
18.91		1	1
19.91			2
20.91	2	2	3
39.81			4
40.81		3	5
41.81	3		6
60.72		4	7
61.72			8
62.72	4	5	9
81.62			10
82.62		6	11
83.62	5		12
102.53		7	13
103.53			14
104.53	6	8	15
105.53	End of Testing		
MTD Detention Time = 5.968 minutes Target Sediment Sampling Time = 60 seconds			

Table 6 Water Flow and Temperature - 25% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	78.8	78.9	0.181%	0.006	64.2
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

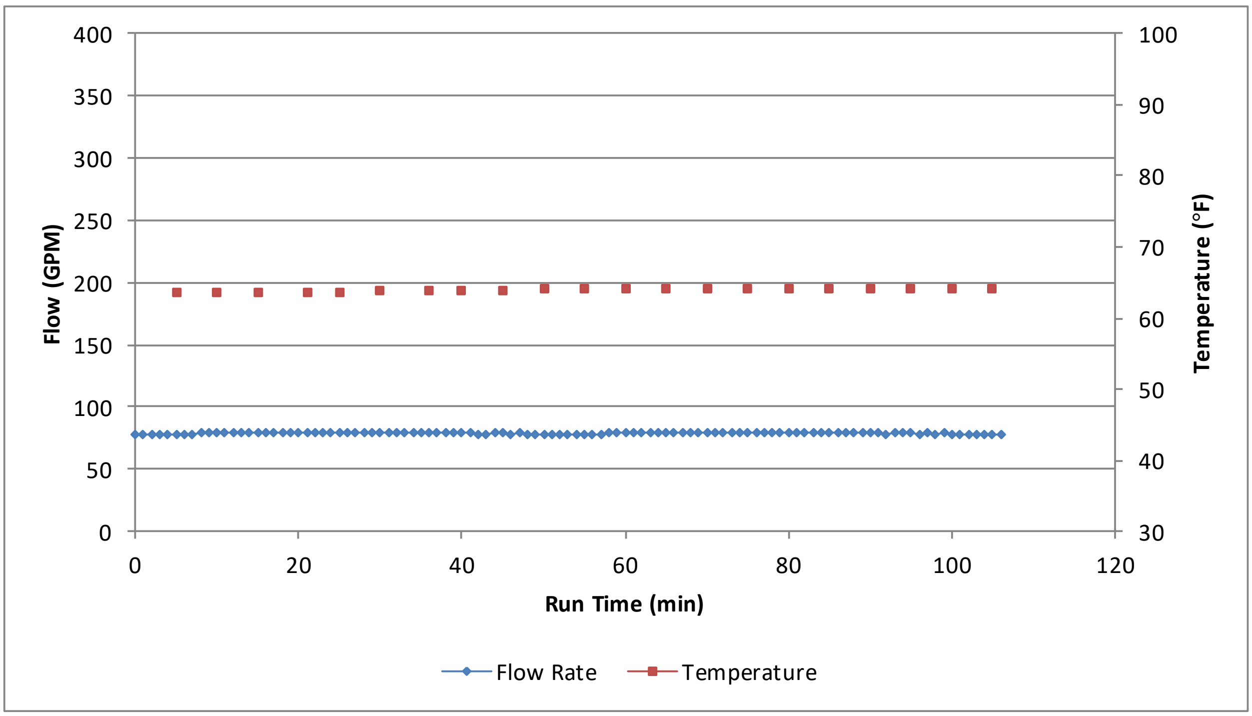

Figure 11 Water Flow and Temperature - 25% MTFR

Table 7 Sediment Feed Rate Summary – 25% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	59.404	Starting Weight of Sediment (lbs.)	58.081
2	60.125		
3	61.024	Recovered Weight of Sediment (lbs.)	43.850
4	62.398		
5	60.995	Mass of Sediment Used (lbs.)	14.231
6	62.439	Volume of Water Through MTD During Dosing (gal)	7,860
Average	61.064		
COV	0.020	Average Influent Sediment Concentration (mg/L)	204.7*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 8 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	6.9	7.4	6.5	6.9	7.4	6.6	6.9	7.5	6.7	7.3	7.5	7.9	6.7	6.8	7.3
Background	2		2		2		2		2		2		2		2
Adjusted Effluent	4.9	5.4	4.5	4.9	5.4	4.6	4.9	5.5	4.7	5.3	5.5	5.9	4.7	4.8	5.3

Average Adjusted Effluent Concentration	5.1 mg/L	Removal Efficiency	97.5%

50% MTFR

Table 9 Sampling Schedule - 50% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	Background	Effluent
0	1		
9.95		1	1
10.95			2
11.95	2	2	3
21.91			4
22.91		3	5
23.91	3		6
33.86		4	7
34.86			8
35.86	4	5	9
45.81			10
46.81		6	11
47.81	5		12
57.76		7	13
58.76			14
59.76	6	8	15
60.76	End of Testing		
MTD Detention Time = 2.984 minutes Target Sediment Sampling Time = 60 seconds			

Table 10 Water Flow and Temperature - 50% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	157.5	157.0	- 0.34%	0.010	64.4
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

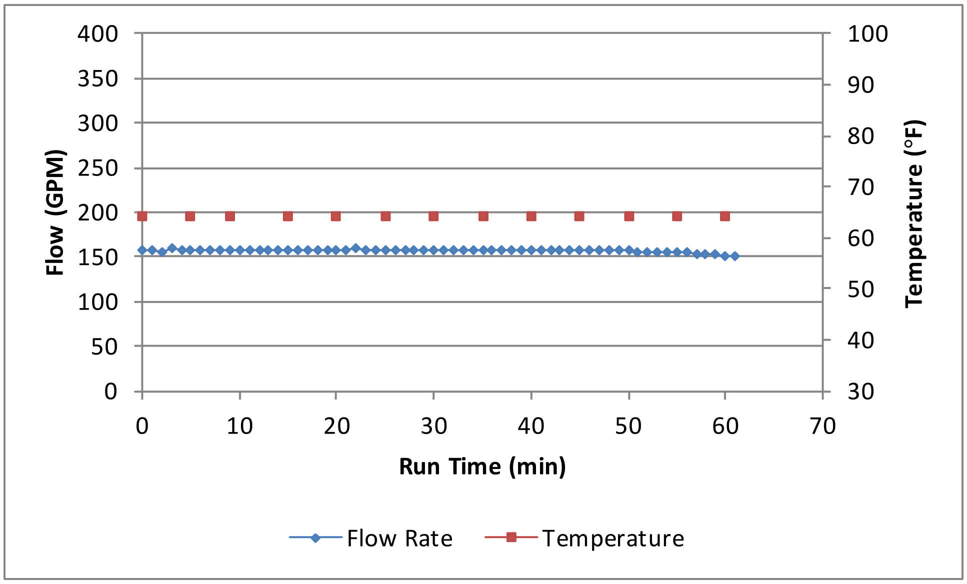

Figure 12 Water Flow and Temperature - 50% MTFR

Table 11 Sediment Feed Rate Summary – 50% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	120.296	Starting Weight of Sediment (lbs.)	62.26
2	119.098		
3	122.968	Recovered Weight of Sediment (lbs.)	45.91
4	123.317		
5	122.352	Mass of Sediment Used (lbs.)	16.35
6	124.900	Volume of Water Through MTD During Dosing (gal)	8,607
Average	122.155		
COV	0.017	Average Influent Sediment Concentration (mg/L)	205.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 12 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	28.8	28.1	28.4	29.0	29.4	31.4	28.8	28.9	26.4	28.5	27.9	30.2	33.2	30.9	31.8
Background	2		2		2		2		2		2		2		2
Adjusted Effluent	26.8	26.1	26.4	27.0	27.4	29.4	26.8	26.9	24.4	26.5	25.9	28.2	31.2	28.9	29.8
Average Adjusted Effluent Concentration						27.4			Removal Efficiency					86.6%	

75% MTFR

Table 13 Sampling Schedule - 75% MTFR

Runtime (min)	Sampling Schedule: Sediment Feed	Sampling Schedule: Background	Sampling Schedule: Effluent
0	1		
6.89		1	1
7.89			2
8.89	2	2	3
15.77			4
16.77		3	5
17.77	3		6
24.66		4	7
25.66			8
26.66	4	5	9
33.54			10
34.54		6	11
35.54	5		12
42.43		7	13
43.43			14
44.43	6	8	15
45.34	End of Testing		
MTD Detention Time = 1.989 minutes Target Sediment Sampling Time = 55 seconds			

Table 14 Water Flow and Temperature - 75% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	236.6	234.7	-0.818%	0.009	64.8
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

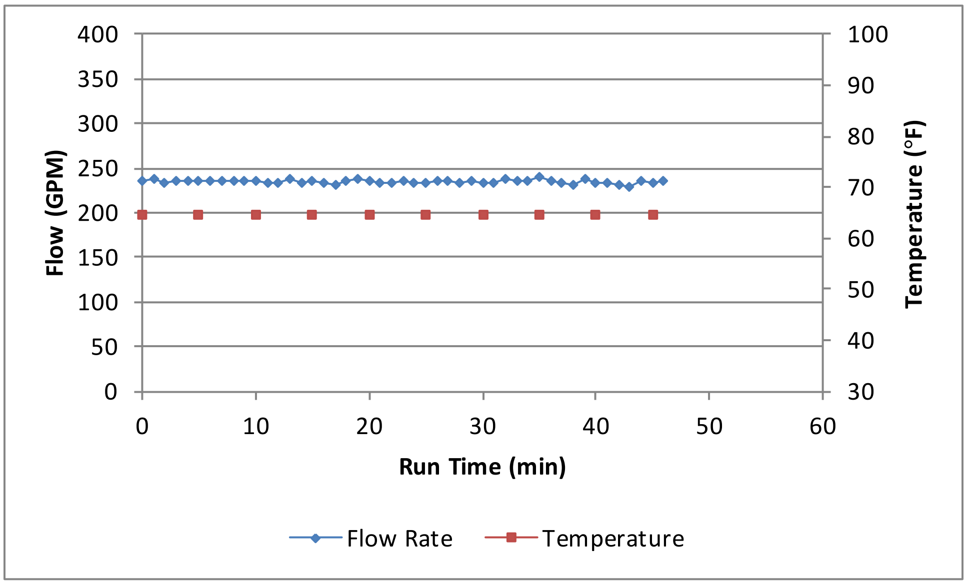

Figure 13 Water Flow and Temperature - 75% MTFR

Table 15 Sediment Feed Rate Summary – 75% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	170.186	Starting Weight of Sediment (lbs.)	72.95
2	169.005		
3	170.214	Recovered Weight of Sediment (lbs.)	55.96
4	169.504		
5	171.289	Mass of Sediment Used (lbs.)	16.99
6	169.844	Volume of Water Through MTD During Dosing (gal)	9,355
Average	170.007		
COV	0.005	Average Influent Sediment Concentration (mg/L)	191.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 16 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	46.0	47.4	46.2	44.8	52.0	51.7	55.2	48.4	51.5	57.1	54.2	53.2	51.7	49.6	51.0
Background	2		2		2		2		2		2		2		2
Adjusted Effluent	44.0	45.4	44.2	42.8	50.0	49.7	53.2	46.4	49.5	55.1	52.2	51.2	49.7	47.6	49.0

Average Adjusted Effluent Concentration	48.7 mg/L	Removal Efficiency	74.6%

100% MTFR

Table 17 Sampling Schedule - 100% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
5.14		1	1
6.14			2
7.14	2	2	3
12.29			4
13.29		3	5
14.29	3		6
19.43		4	7
20.43			8
21.43	4	5	9
26.57			10
27.57		6	11
28.57	5		12
33.72		7	13
34.72			14
35.72	6	8	15
36.38	End of Testing		
MTD Detention Time = 1.492 minutes Target Sediment Sampling Time = 40 seconds			

Table 18 Water Flow and Temperature - 100% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	315.0	310.6	-1.40	0.008	64.9
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

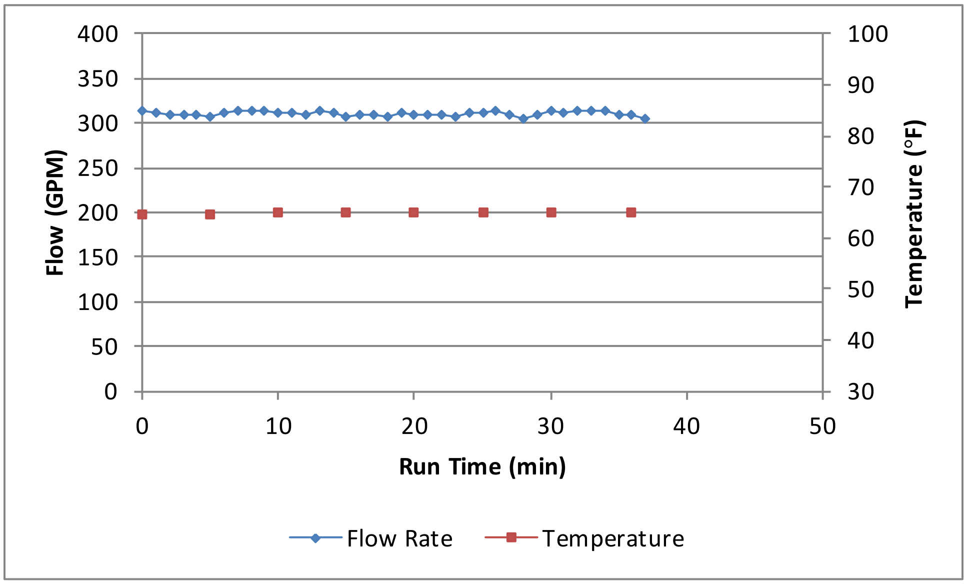

Figure 14 Water Flow and Temperature - 100% MTFR

Table 19 Sediment Feed Rate Summary – 100% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	238.018	Starting Weight of Sediment (lbs.)	63.43
2	235.121		
3	240.393	Recovered Weight of Sediment (lbs.)	44.26
4	237.182		
5	236.349	Mass of Sediment Used (lbs.)	19.17
6	239.425	Volume of Water Through MTD During Dosing (gal)	10,056
Average	237.748		
COV	0.008	Average Influent Sediment Concentration (mg/L)	203.4*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 20 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	68.9	66.7	59.6	75.0	69.2	70.0	73.3	74.1	71.6	72.9	71.3	75.1	73.4	78.8	72.6
Background	2		2		2		2		2		2		2		2
Adjusted Effluent	66.9	64.7	57.6	73.0	67.2	68.0	71.3	72.1	69.6	70.9	69.3	73.1	71.4	76.8	70.6
Average Adjusted Effluent Concentration				69.5 mg/L			Removal Efficiency						65.8%		

125% MTFR

Table 21 Sampling Schedule - 125% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	Background	Effluent
0	1		
4.08		1	1
5.08			2
6.08	2	2	3
10.16			4
11.16		3	5
12.16	3		6
16.24		4	7
17.24			8
18.24	4	5	9
22.32			10
23.32		6	11
24.32	5		12
28.41		7	13
29.41			14
30.41	6	8	15
30.91	End of Testing		
MTD Detention Time = 1.194 minutes Target Sediment Sampling Time = 30 seconds			

Table 22 Water Flow and Temperature - 125% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	393.8	388.6	-1.30%	0.009	65.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

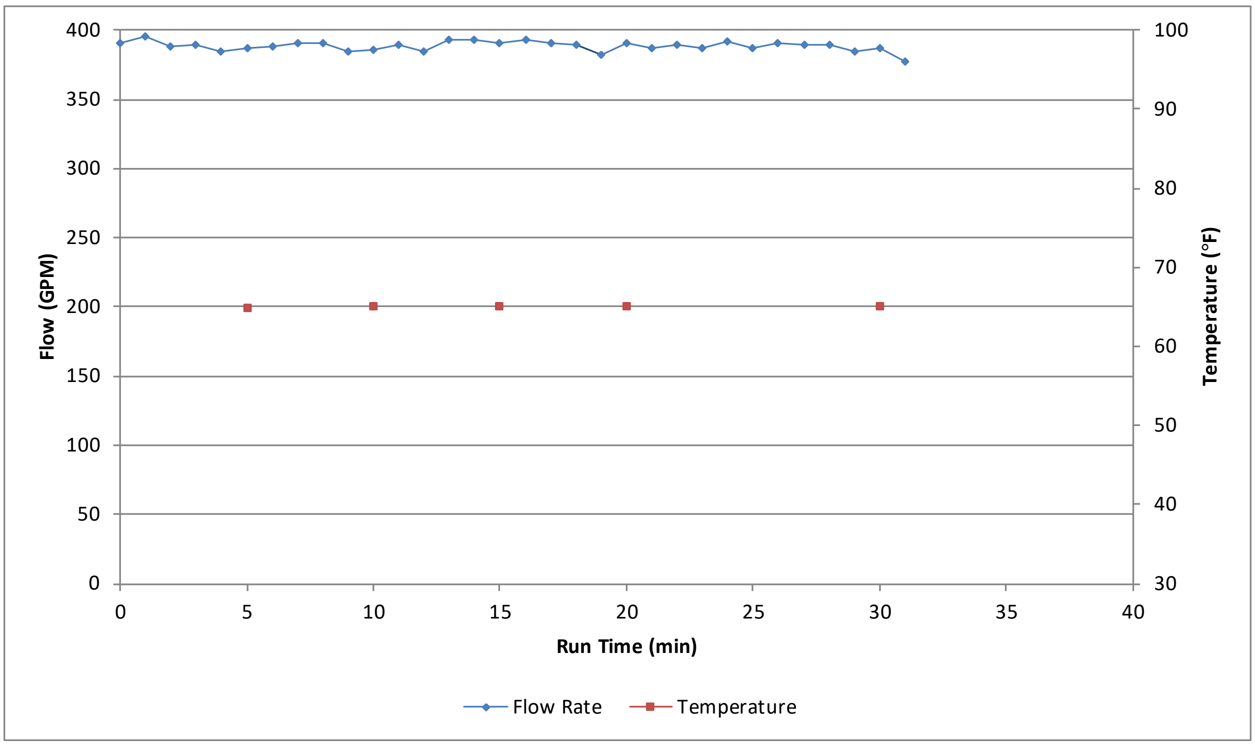

Figure 15 Water Flow and Temperature - 125% MTFR

Table 23 Sediment Feed Rate Summary – 125% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	295.648	Starting Weight of Sediment (lbs.)	63.63
2	295.912		
3	293.050	Recovered Weight of Sediment (lbs.)	43.30
4	300.450		
5	297.978	Mass of Sediment Used (lbs.)	20.33
6	297.430	Volume of Water Through MTD During Dosing (gal)	10,841
Average	296.745		
COV	0.008	Average Influent Sediment Concentration (mg/L)	203.0*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 24 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	84.2	83.2	94.6	96.6	89.4	89.2	99.7	92.5	95.2	99.0	98.8	95.2	100	94.0	98.4
Background	2		2		2		2		2		2		2		2
Adjusted Effluent	82.2	81.2	92.6	94.6	87.4	87.2	97.7	90.5	93.2	97.0	96.8	93.2	98.0	92.0	96.4

Average Adjusted Effluent Concentration	92.0	Removal Efficiency	54.7%

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 SciClone™ Hydrodynamic Separator annual weighted removal for a MTFR of 315 gpm is 80.6%, as shown in **Table 25.**

Table 25 Annualized Weighted Removal Efficiency for SciClone™ Model SC-4

%MTFR	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	97.5	0.25	24.4
50	86.6	0.30	26.0
75	74.6	0.20	14.9
100	65.8	0.15	9.87
125	54.7	0.10	5.47
Annualized Weighted Removal Efficiency			**80.6%**

5.2 Scour

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 630 gpm, 200% of the maximum treatment flow rate (MTFR).

In preparation for the scour test, the sump of the SciClone™ was cleaned out to remove all of the accumulated sediment from the previous removal efficiency testing. A false floor was installed 4 inches below the depth of the 50% maximum sediment storage height. The sump was then loaded with scour test sediment so that when levelled, the sediment formed a layer at least 4 inches thick, confirmed by measuring the sediment thickness with a yard stick. After sediment loading, the sump was filled with water and allowed to sit for 89 hours.

Scour testing began by gradually increasing the flow rate to the target flow within a 5-minute period. Effluent and background samples were taken from the same locations as for the removal efficiency testing, starting 5 minutes after flow was initiated. The sampling frequency is summarized in Table **26**.

Table 26 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 was the time that the 1st background sample was taken, just after achieving the target flow.

Water flow rate and water temperature measured during the scour testing are shown in **Table 27** and on **Figure 16**.

Table 27 Water Flow and Temperature - Scour Test

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	630	630.2	0.0032 %	0.005	72
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

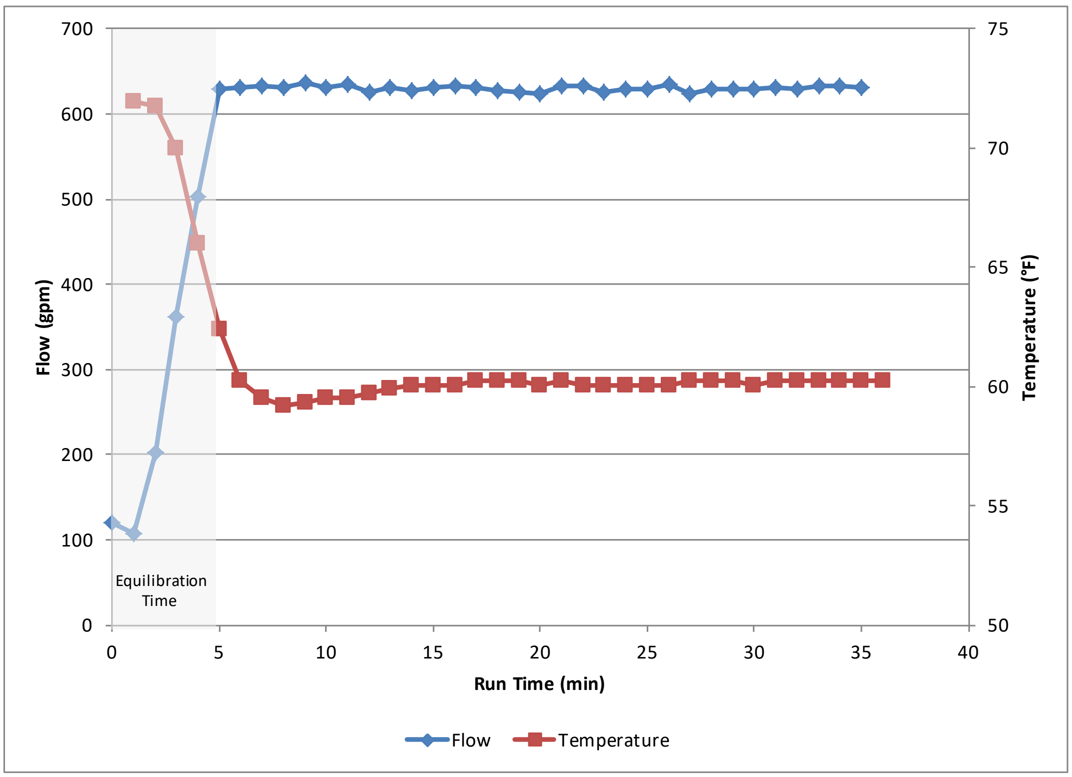

Figure 16 Water Flow and Temperature - Scour Test

The effluent and background SSC results are reported in **Table 28**. The adjusted effluent concentration was calculated as:

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

The SSC method reporting limit was 2.3 mg/L. Any results below this value were reported as 2 mg/L for calculation purposes. 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 0.2 mg/L; therefore, when operated at 200% of the MTFR, the SciClone™ meets the criteria for online use.

Table 28 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		2	2	2	2	2	2.3	2	2	2.4	2.6	2.3	2	2.6	2.9	2.5
Background	2		2		2		2		2		2		2.6		2	
Adjusted Effluent		0	0	0	0	0	0.3	0	0	0.4	0.6	0	0	0.3	0.9	0.5
Average Adjusted Effluent Concentration							0.2 mg/L									

5.3 Light Liquid Re-Entrainment

For the test, the SciClone™ had a false floor in place, set to represent 50% of the maximum recommended sediment storage depth, and the unit was pre-filled with clean water. The volume of beads added was 15.4 gallons, equivalent to 32.7 kg (72.1 lbs). The material was weighed into buckets and poured into the SciClone™ on the influent side of the Oil/Floatables Skimmer. To prevent the beads from traveling up the inlet pipe, a piece of acrylic sheet was placed over the mouth of the inlet and wedged in place. The acrylic sheet was pulled at the start of the test, immediately after the pump was started. The loaded SciClone™ is illustrated in **Figure 17**.

During the test, the effluent was screened through a mesh that captured any of the scoured beads (**Figure 18**). The captured beads were separated according to the scoured flow rate.

Following the test, the beads were dried in non-ferrous containers in an oven set at 103 °C until a constant weight was achieved. The mass, volume (calculated based on bulk density) and percentage of the pre-loaded beads scoured was determined for each flow rate.

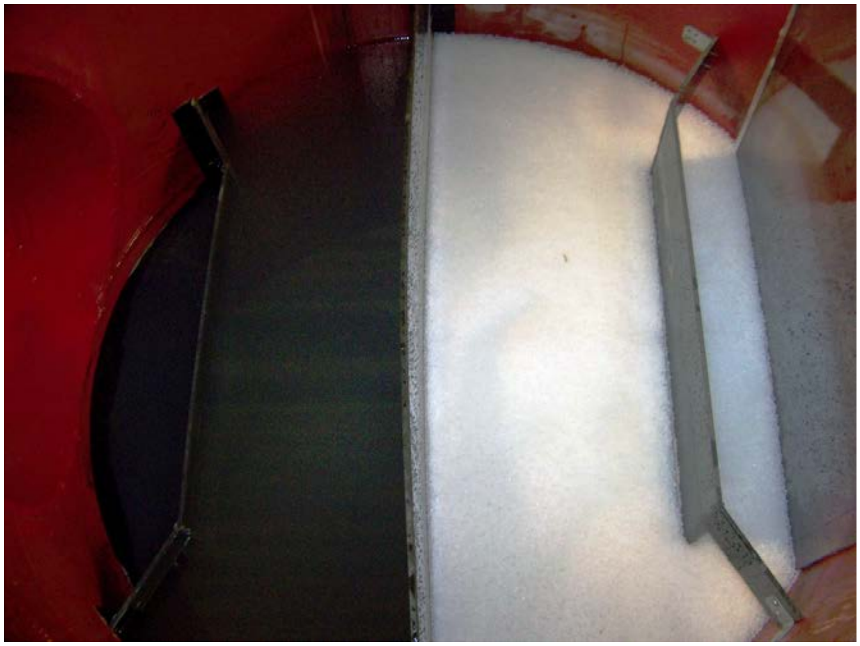

Figure 17 SciClone™ Inlet Loaded with LDPE Beads

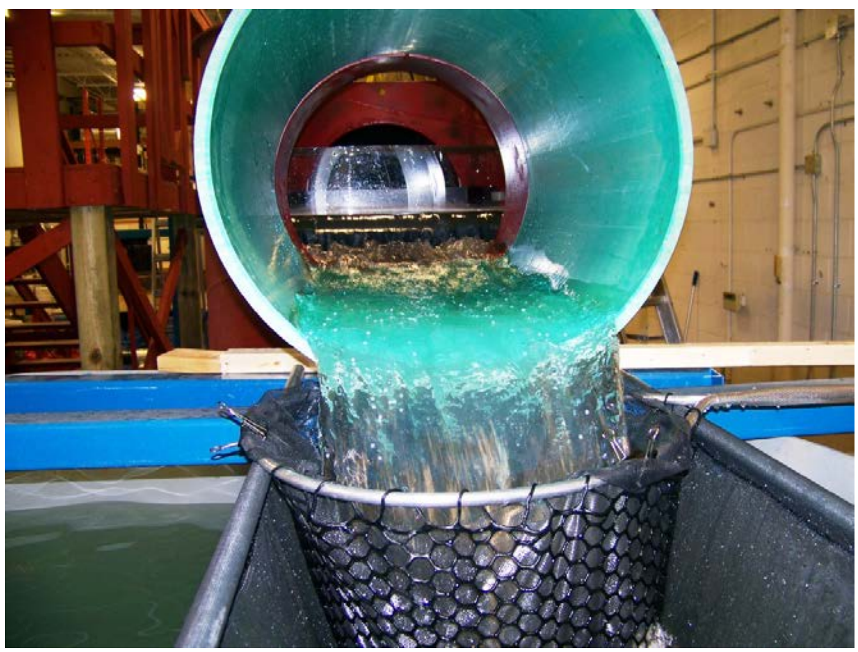

Figure 18 Screening of Scoured LDPE Beads

The flow rates for all five runs were recorded using a data logger, recording at 30 second intervals; the flow data is summarized in **Table 29**. The water temperature for the duration of the test was 74 °F.

Table 29 Light Liquid Re-Entrainment Testing Water Flow Rates

Target Flow Rate gpm	Actual Flow (gpm)			COV	QA/QC Compliance (COV < 0.03 and avg. ± 10% of target)
	Min	Max	Average		
78.8	77.3	83.8	80.1	0.022	Pass
157.5	153.8	158.3	155.9	0.010	Pass
236.7	236.5	239.6	237.9	0.004	Pass
315.0	313.9	318.7	316.0	0.004	Pass
393.8	390.2	396.1	392.5	0.005	Pass

The recovered scoured beads were dried to constant weight. **Table 30** summarizes the amount of beads scoured and captured at each flow rate. For flow rates up to the designed MTFR (315 gpm), the SciClone™ had retained 98.7% of the added LDPE beads. At 125% of the MTFR, the SciClone™ retained 89.1% of the LDPE beads.

Table 30 Amount of Scoured Beads Based on Flow Rate

Target Flow Rate (GPM)	Amount of Scoured Beads					
	Mass		Volume *		% of Total	Cumulative %
	g	lbs	L	gal		
78.8	0.44	0.0010	0.0008	0.0002	0.001	0.001
157.5	0.23	0.0005	0.0004	0.0001	0.001	0.002
236.7	131.86	0.2907	0.2352	0.0621	0.403	0.405
315.0	300.38	0.6622	0.5357	0.1415	0.918	1.323
393.8	3144.62	6.9327	5.6080	1.4815	9.608	10.930
Total	3577.53	7.8871	6.3880	1.6854	10.930	

* Determined from bead bulk density

6. Maintenance Plans

As with all stormwater BMPs inspection and maintenance on the SciClone™ Hydrodynamic Separator is necessary. Stormwater regulations require that all BMPs be inspected and maintained to ensure they are operating as designed to allow for effective pollutant removal and provide protection to receiving water bodies. It is recommended that inspections be performed multiple times during the first year to assess site specific loading conditions. This is recommended because pollutant loading can vary greatly from site to site. Variables such as nearby soil erosion or construction sites, winter sanding of roads, amount of daily traffic and land use can increase pollutant loading on the system. The first year of inspections can be used to set inspection and maintenance intervals for subsequent years. Without appropriate maintenance, a BMP can exceed its storage capacity which can negatively affect its continued performance in removing and retaining captured pollutants. The SciClone™ Operation & Maintenance Manual is available at: http://www.biocleanenvironmental.com

Inspection Equipment

Following is a list of equipment to allow for simple and effective inspection of the SciClone™ Hydrodynamic Separator:

- Bio Clean Environmental Inspection Form (contained in O&M Manual).
- Flashlight.
- Manhole hook or appropriate tools to access hatches and covers.
- Appropriate traffic control signage and procedures.
- Measuring pole and/or tape measure.
- Protective clothing and eye protection.
- Note: entering a confined space requires appropriate safety and certification. It is generally not required for routine inspections of the system.

Inspection Steps

The core to any successful stormwater BMP maintenance program is routine inspections. The inspection steps required on the SciClone™ Hydrodynamic Separator are quick and easy. As mentioned above, the first year should be seen as the maintenance interval establishment phase. During the first year more frequent inspections should occur in order to gather loading data and maintenance requirements for that specific site. This information can be used to establish a base for long-term inspection and maintenance interval requirements.

The SciClone™ Separator can be inspected though visual observation without entry into the system. All necessary pre-inspection steps must be carried out before inspection occurs, especially traffic control and other safety measures to protect the inspector and near-by pedestrians from any dangers associated with an open access hatch or manhole. Once these access covers have been safely opened the inspection process can proceed:

- Prepare the inspection form by writing in the necessary information including project name, location, date & time, unit number and other info (see inspection form).

- Observe the inside of the system through the access hatches. If minimal light is available and vision into the unit is impaired utilize a flashlight to see inside the system.
- Look for any out of the ordinary obstructions in the inflow pipe, sump chamber, or outflow pipe. Write down any observations on the inspection form.
- Through observation and/or digital photographs estimate the amount of floatable debris accumulated on the influent side of the oil/floatables skimmer. Record this information on the inspection form. Next utilizing a tape measure or measuring stick estimate the amount of sediment accumulated in the sump. Record this depth on the inspection form.
- Finalize inspection report for analysis by the maintenance manager to determine if maintenance is required.

Maintenance Indicators

Based upon observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components.
- Obstructions in the system or its inlet or outlet.
- Excessive accumulation of floatable in the sump chambers in which the length and width of the chambers behind oil/floatables skimmer is fully impacted extending down more than 9”.
- Excessive accumulation of sediment in the sump chamber of more than 18” in depth.

Maintenance Equipment

It is recommended that a vacuum truck be utilized to minimize the time required to maintain the SciClone™ Separator:

- Bio Clean Environmental Maintenance Form (contained in O&M Manual).
- Flashlight.
- Manhole hook or appropriate tools to access hatches and covers.
- Appropriate traffic control signage and procedures.
- Protective clothing and eye protection.
- Note: entering a confined space requires appropriate safety and certification. It is generally not required for routine maintenance of the system.
- Vacuum truck (with pressure washer attachment preferred).

Maintenance Procedures

It is recommended that maintenance occurs at least three days after the most recent rain event to allow for drain down of any associated upstream detention systems. Maintaining the system while flows are still entering it will increase the time and complexity required for maintenance. Cleaning of the sump chamber can be performed from the finish surface without entry into the vault utilizing a vacuum truck. Once all safety measures have been set up cleaning of the sump chamber can proceed as followed:

- Using an extension on a vacuum truck position the hose over the opened access hatch and lower into the center of the sump chamber on the inlet side of the oil/floatables skimmer. Remove all floating debris, standing water and sediment from the sump chamber. Access to the bottom of the sump chamber is unimpeded. The vac hose can be moved from side-to-side to fully remove sediments at the corners. A power washer can be used to assist if sediments have become hardened and stuck to the walls or the floor of the chamber. Repeat the same procedure on the effluent side of the oil/floatables skimmer to remove any remaining sediment. This completes the maintenance procedure required on the sump chamber and the SciClone™ Separator.

- The last step is to close and replace all access hatches and remove all traffic control.
- All removed debris and pollutants shall be disposed of following local and state requirements.
- Disposal requirements for recovered pollutants and spent cartridges may vary depending on local guidelines. In most areas the sediment, once dewatered, can be disposed of in a sanitary landfill. It is not anticipated that the sediment would be classified as hazardous waste.
- In the case of damaged components, replacement parts can be ordered by the manufacture.

7. Scaling

Based on the test results of the SciClone™ Hydrodynamic Separator (model SC-4), the capacity of other model sizes has been determined based on a standard ratio of MTFR to effective treatment volume.

Table 31 Scaling of SciClone™ Models

Model #	Diameter (ft)	Maximum Treatment Flow Rate[1] (cfs)	Sediment Chamber Depth[2] (ft)	Wet Volume (cu ft)	Storage Capacity (cu ft)
SC-4	4	0.702	5	62.80	19
SC-5	5	1.32	6	117.75	29
SC-6	6	2.21	7	197.82	42
SC-7	7	3.44	8	307.72	58
SC-8	8	5.05	9	452.16	75
SC-9	9	7.11	10	635.85	95
SC-10	10	9.65	11	863.50	118
SC-11	11	12.74	12	1139.82	142
SC-12	12	16.43	13	1469.52	170

[1]Based on a verified volume loading rate of 5.02 gpm/ft^3 for sediment with a mean particle size of 112 µm and an annualized weighted TSS removal of at least 80% using the method specified in the current NJDEP HDS protocol.

[2]Minimum depth from outlet pipe invert to bottom of separation/sump chamber.

8. Statements

The following attached pages are signed statements from the manufacturer (Bio Clean Environmental), the independent testing lab (Good Harbour Labs), and NJCAT. These statements are included to document that the requirements of the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 25, 2013) were followed with the exceptions as noted.

Bio Clean
A Forterra Company

Date: 7/7/2017

To Whom It May Concern,

We are providing this letter as our statement certifying that the protocol titled "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (NJDEP HDS Protocol, January 2013) has been strictly followed. In addition, we certify that all requirements and criteria were met and/or exceeded during testing of the SciClone™ Hydrodynamic Separator.

If you have any questions please contact us at your convenience.

Sincerely,

Zachariha J. Kent
Director of Research & Development
Bio Clean, a Forterra Company.

Signature: ______________________ Date: 7/7/2017

P O Box 869 Oceanside CA 92049
(760) 433-7640 • Fax (760) 433-3176
www.BioCleanEnvironmental.net

Good Harbour

July 7, 2017

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

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

RE: Third party testing of the SciClone using Agsco 110

Dear Dr. Magee,

This purpose of this letter is to confirm that all of the testing described in the report **SciClone™ Hydrodynamic Separator - Performance Verification of Sediment Capture and Light Liquid Retention** (July 2017) was conducted at the Good Harbour Laboratories (GHL) facility in Mississauga, Ontario, in May and June of 2017.

The sediment and plastic beads used were delivered directly to GHL and were under our control at all times. Prior to testing we confirmed that the instrumentation being used was calibrated and in good working order. Testing was done and log books were maintained as required by our ISO 9001:2008 certification. GHL staff verified all sample bottle labels and confirmed the chains of custody for all samples sent to Maxxam.

After the testing was completed GHL wrote the test report, except for the sections not related to performance testing, and separately reviewed all of the data, calculations and conclusions contained in the report. 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: Zach Kent, Bio Clean Environmental Services Inc.

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

Good Harbour

July 7, 2017

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

Re: Performance Verification of the Bio Clean Environmental Services SciCLone HDS using Agsco 110

Dear Dr. Magee,

Good Harbour Laboratories was contracted by Bio Clean Environmental Servicers to test the performance of their SciClone using a coarser material than that specified by the New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January, 2013). While the testing was not intended for submission to NJDEP the intent was to follow best practices for independent verification of the results.

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;

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

-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,

Date

Greg Williams

July 7/17

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

CC: Zach Kent, Bio Clean Environmental Services

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

Center for Environmental Systems

Stevens Institute of Technology

One Castle Point

Hoboken, NJ 07030-0000

August 20, 2017

Mr. Zach J. Kent
VP of Product Development & Regulatory Compliance
Bio Clean Environmental Services Inc.
398 Via El Centro
Oceanside, CA 92058

Dear Mr. Kent,

Based on my review, evaluation and assessment of the testing on the SciClone™ Hydrodynamic Separator (Model SC-4) conducted by Good Harbour Laboratories, Ltd., Mississauga, Ontario, Canada, 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 with two exceptions. The deviations from the protocol were: 1) the use of a courser test sediment, and 2) the addition of a light liquid entrainment test.

Test Sediment Feed -The mean PSD of the test sediment utilized for removal efficiency testing was significantly courser than the PSD criteria established by the NJDEP HDS protocol (112 µm vs 75 µm).

Removal Efficiency Testing **–** The New Jersey annualized weighted TSS removal efficiency was calculated to be 80.6% at an MTFR of 0.70 cfs for the courser sediment.

Scour Testing **–** Scour testing was conducted with the NJDEP scour test sediment PSD requirement met, at a flow rate meeting the 200% MTFR requirement. The results qualified the SciClone™ Hydrodynamic Separator for online installation.

All other criteria and requirements of the NJDEP protocol were met. These include: flow rate measurements COV <0.03; test sediment influent concentration COV <0.10; test sediment influent concentration within 10% of the targeted value of 200 mg/L; influent background concentrations <20 mg/L; water temperature <80 ^{o}F; and adjusted scour effluent concentration <20 mg/L.

An additional test, based on the Canadian Environmental Technology Verification (CETV) *Procedure for Laboratory Testing of Oil-Grit Separators, June 6, 2014 – Version 3.0*, was conducted to demonstrate the light liquid retention capability of the SciClone™ Hydrodynamic Separator.

Sincerely,

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

9. 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.

3. Canadian Environmental Technology Verification Program (CETV) Procedure for Laboratory Testing of Oil-Grit Separators, June 6, 2014 – Version 3.0.

4. GHL Laboratory Notebook: A016, pp. 59 – 125.