NJCAT TECHNOLOGY VERIFICATION

Debris Separating Baffle Box (DSBB™) Stormwater Treatment System

Bio Clean Environmental Services Inc.

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Contents

List of Tables **Page**

List of Figures Page

1. Description of Technology

The Debris Separating Baffle Box hydrodynamic separator (DSBB) is a manufactured treatment device (MTD) designed by Bio Clean Environmental Services Inc., a Forterra Company. The DSBB is an advanced stormwater treatment system utilizing a screening system and hydrodynamic separation to capture pollutants. The self-cleaning clog-resistant screening system stores trash and debris in a dry state, suspended above the sedimentation chambers, reducing nutrient leaching, bacterial growth, bad odors, and allows for easier cleaning. The DSBB's triple chamber design provides high removal of total suspended solids over a wide range of particle sizes. The deflector shields ensure minimal scouring of captured sediments during high flow. This feature allows the system to be installed online, thus eliminating the need for diversion structures. A flow control weir is connected to the outlet wall and optimizes water detention time and reduces turbulence in order to maximize the removal efficiency of finer particles at lower flows. The weir stretches across two-thirds the width of the outlet wall and includes a drain orifice to allow the water level to return to a level equal to the invert of the outlet pipe. The oil skimmer and hydrocarbon booms trap oil. The DSBB is approved by the California State Water Board for "full capture" which is defined as 100% removal of trash and debris down to 5 mm up to the screen treatment flow rate. All internal components and screening are 304 stainless steel.

The DSBB is designed to evenly distribute entering stormwater thus optimizing its ability to capture suspended solids. The system has no moving parts within the system. However, the optional hydrocarbon boom that resides in the fixed cage is buoyant and will float within the cage as the water level changes in the system. The DSBB operates utilizing the principles of gravity separation and flow path maximization to increase settling of finer particulates. It is composed of various components as shown in **Figure 1**.

Runoff is directed into the system via the inflow pipe and enters the area above the first sediment chamber, as illustrated in **Figure 2.** The flow is split into two directions down the middle by the splitter screen and toward the screens along both sides of the system. As water travels along the splitter screen, debris and trash are directed into the screens and clean water passes through the screen. The openings of the splitter screen face the opposite direction of the water flow hindering the screen from being blocked and creating a passive self-cleaning effect as shown in **Figure 3**.

As the water passes over the first sediment chamber the larger sediments settle to the bottom before reaching the screens. This prevents larger sediments from entering the screens. The debris ramp directs the flow upward into the screens to insure 100% capture of all floatable material. As water passes over the first baffle wall, all trash and debris equal to or greater than 5 mm have been directed onto the screens to be retained. At this point in the system flow has become more spread out across its width to reduce velocity and increase settling of finer sediments. The screens utilize the same self-cleaning screens as the splitter screen, and also face the opposite direction of the flow. The screens are elevated 3" above the outlet pipe invert and standing water level. During storm events, water can exit the screens through the bottom and side screens. Since the openings face the opposite direction of the water flow this further reduces velocity and increases the flow path. The second sediment chamber collects medium to finer sediments as water passes overhead toward the third sediment chamber and oil skimmer wall.

The oil skimmer wall protrudes downward below the standing water to capture and trap free-floating oils and hydrocarbons. The oil skimmer wall has a hydrocarbon boom and cage mounted to its influent side to provide increased capture of these hydrocarbons; the boom, since optional, was not included with the system during this performance test. As water passes under the oil skimmer and into the third sediment chamber, the remaining finer particulates and sediments are settled out. The second and third sediment chambers include turbulence deflectors to minimize scouring during higher flows.

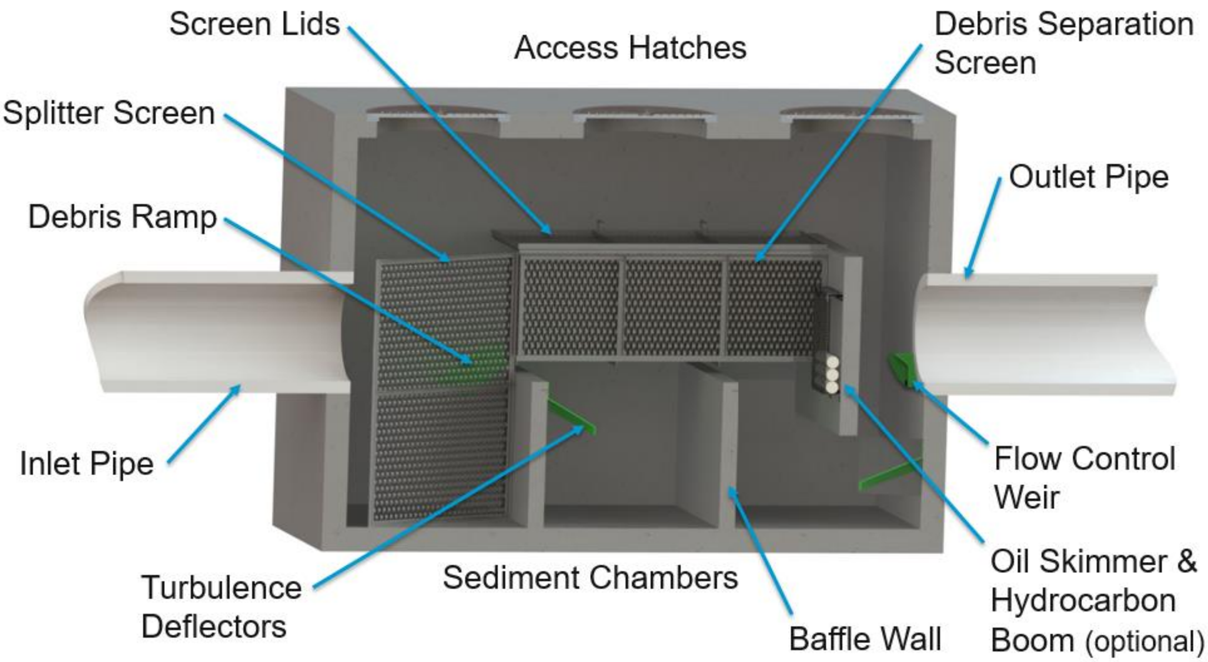

Figure 1 Cut-Away View

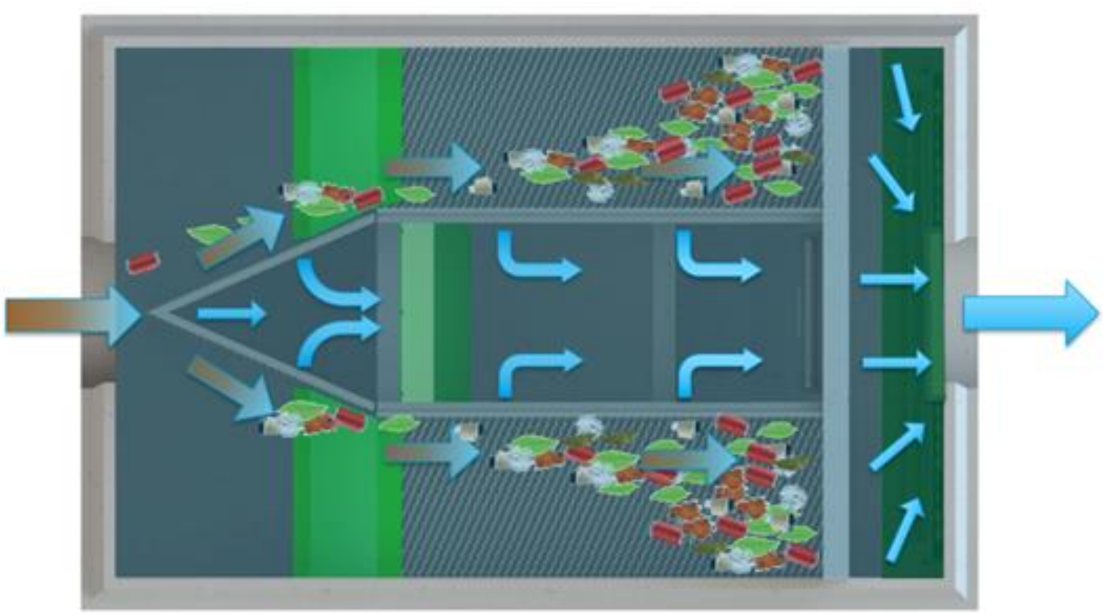

Figure 2 Operational Diagram – Top View

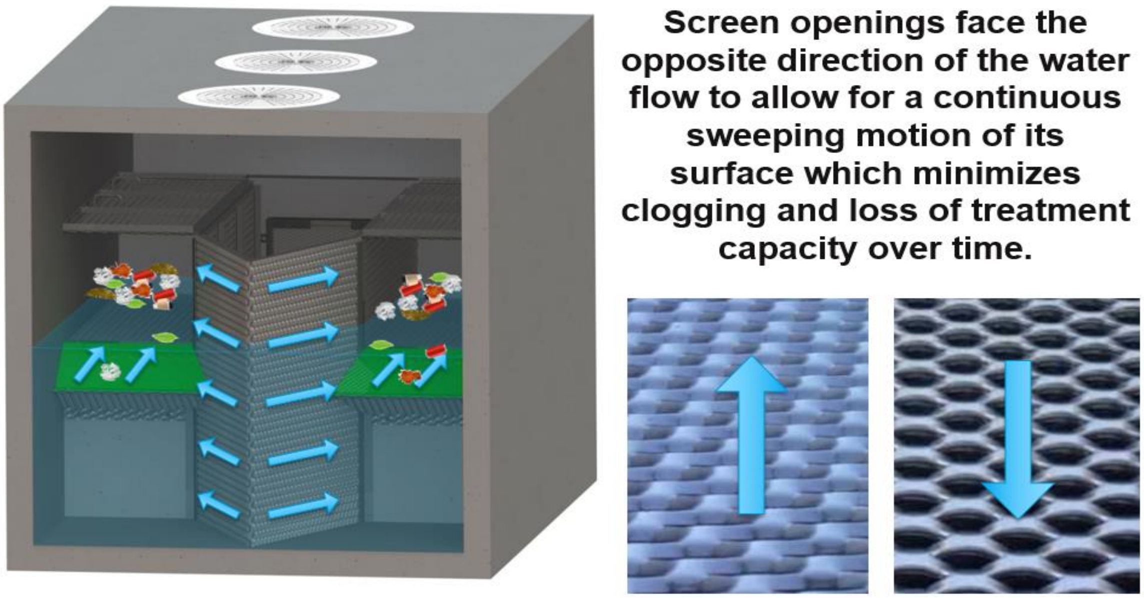

Figure 3 Operational Diagram – Front View and Screen Detail

The DSBB is designed to be installed online with minimal scouring and handle large flow rates with minimal head loss. During larger storm events, water passes over the top of the splitter screen and debris separation screens, bypassing treatment. The debris separation screens have sliding or hinged tops that prevent loss of captured trash and debris during higher flows. High flows have a direct path over the top of and between the screens toward the outlet side of the system, as shown in **Figure 4,** to minimize head loss. **Figure 5** is a cut sheet of the test unit (Model DSBB-2.5-5).

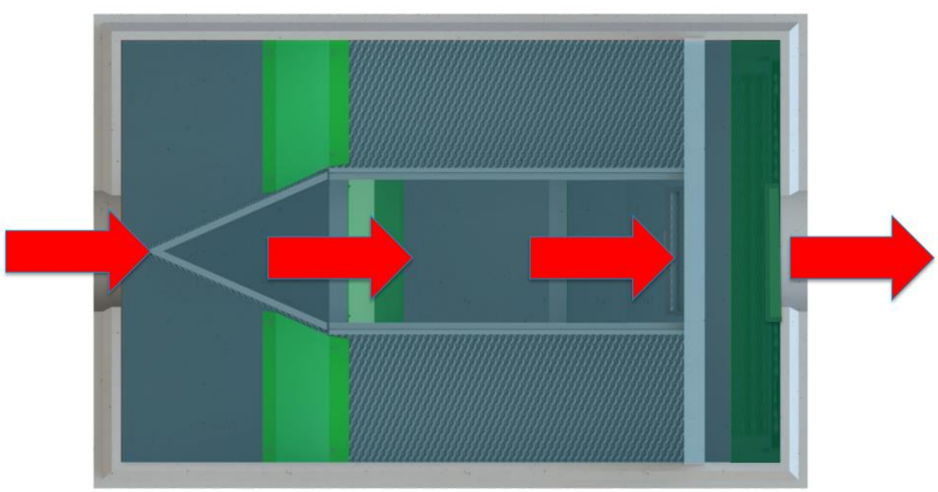

Figure 4 High Flow Bypass – Top View

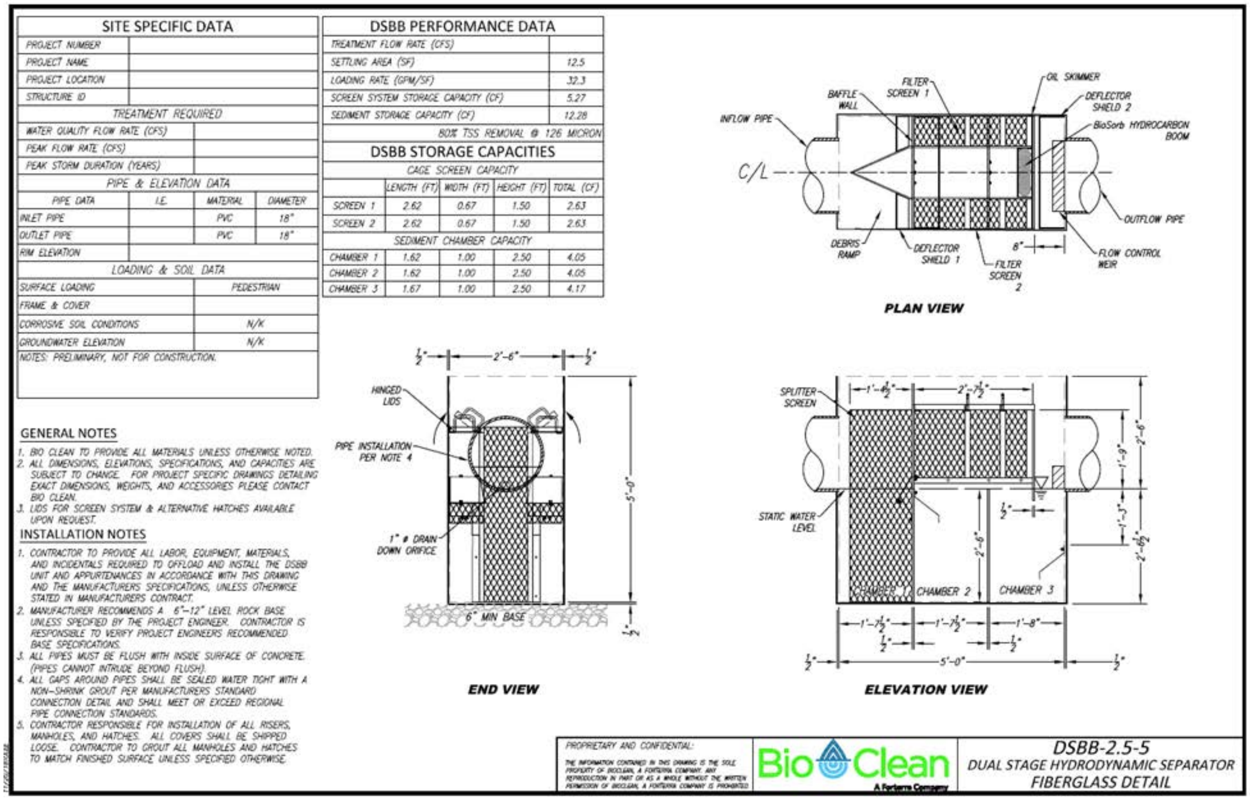

Figure 5 Cut Sheet of Test Unit

2. Laboratory Testing

The device tested was a 60-inch X 30-inch DSBB unit (DSBB-2.5-5) consisting of internal components housed in a plywood vault (**Figure 6**). In commercial systems, the internal components are generally housed in a concrete vault. At times, due to certain design constraints other materials can and have been used such as fiberglass or plastic. The plywood vault and baffle walls of the test unit were equivalent to commercial concrete vaults in all key dimensions. The internals of the DSBB were supplied by Bio Clean. The flow control weir tested is 6” high and spans 19” in length. This is a ratio of 63% the width of the box. This ratio is maintained for all DSBB models.

The use of a wooden vault was proposed due to the difficulties associated with transporting and physically supporting the weight of a concrete unit. Using plywood in lieu of concrete did not have an impact on system performance. The vault construction and the installation of the internals were completed by GHL. Testing of the unit occurred in January 2019.

Figure 6 Debris Separating Baffle Box in Plywood Vault

2.1 Test Setup

The design specifications of the DSDB are provided in **Table 1**. The test unit had a total sedimentation area of 12.5 ft^2 and a maximum treatment flow rate (MTFR) of 1.1 cfs (494 gpm).

Table 1 Debris Separating Baffle Box Dimensions

Model Number	MTFR		Dimensions, L X W (inch)	Surface Loading Area (ft^2)	Surface Loading Rate (gpm/ft^2)	Sediment Storage Capacity (ft^3)
	cfs	gpm				
DSBB-2.5-5	1.1	494	60 X 30	12.5	39.5	12.2

The laboratory test set-up was a water flow loop, capable of moving water at a rate of up to 2.4 cfs. The test loop, illustrated in **Figure 7**, was comprised of water reservoirs, pumps, sediment filter, receiving tank and flow meters.

Water Flow and Measurement

From the water storage tanks, water was pumped using an Armstrong Model 8X8X10 4380 (100 - 1,100 gpm) centrifugal pump. Flow measurement was done using a calibrated MJK Magflux Type 7200 flow meter Model 297237 with an accuracy of ± 0.25% of reading (100 – 1,100 gpm). The data logger used was a MadgeTech Process 101A data logger, configured to record a flow measurement once every minute.

For the removal efficiency testing, the water in the flow loop was circulated through a closed filtration system (Fil-Trek model ELPA30-1012-8F-150, **Figure 8**), where the influent water was filtered through 0.5 or 1 µm absolute pleated bag filters. For the scour test, the pleated filters were replaced with 1 µm nominal bag filters to reduce head loss.

The influent pipe to the DSBB was 18 inches in diameter and 150 inches long. The effluent pipe was 18 inches in diameter and 37 inches long. Water flow exited the DSBB and terminated with a free-fall into the Receiving Tank to complete the hydraulic circuit.

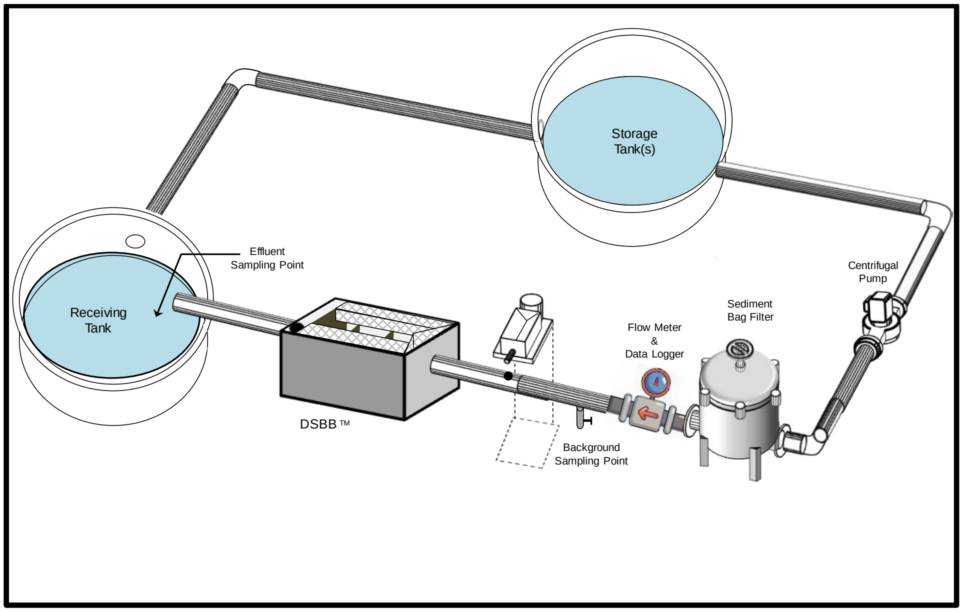

Figure 7 Test Flow Apparatus

Figure 8 Fil-Trek Filtration System

Sample Collection

Background water samples were collected in 1L jars from a sampling port located upstream of the auger feeder and downstream of the filtration system. The sampling port was controlled manually by a ball valve (**Figure 9**) 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 10**). The sampling technique was to take the grab sample by sweeping a 1 L wide-mouth jar through the stream of effluent flow such that the jar was full after a single pass.

Other Instrumentation and Measurement

Effluent water temperature was taken using a calibrated MadgeTech MicroTemp data logger, configured to take a reading once every minute. The sensor was suspended in the compartment closest to the influent pipe.

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 to the nearest 0.1 mg on an analytical balance (Mettler Toledo, AB204-S).

The total amount of sediment fed during the removal efficiency runs was determined by mass-balance. The auger feeder was emptied out at the end of each test and the sediment was weighed using a Mettler Toledo BBA231-3BB35A/S industrial balance.

Figure 9 Background Sampling Point

Figure 10 Effluent Sampling Point

2.2 Test Sediment

The test sediment used for the removal efficiency (RE) study was custom blended by GHL using various commercially available silica sands; this particular batch was GHL lot # A020-054. Three samples of sediment were sent out for particle size analysis using the methodology of ASTM method D422-63 (reapproved 2007). The samples were composite samples created by taking samples throughout the blending process and in various positions within the blending drum. 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 11**. The sediment had an average moisture content of < 0.30%. Because of the low moisture content, no adjust was made to the sediment mass for this study.

The test sediment used for the scour test was commercially available silica sediment supplied by AGSCO Corporation, generally referred to as #110 but labeled #140-200. This particular batch was composed of five separate sediment lots that were blended by GHL; the GHL internal lot number for the blend was A022-020. During blending, three representative sediment samples were taken of the batch and analysed for particle size distribution using the methodology of ASTM method D422-63 (reapproved 2007). The testing was completed by GHL and the PSD results are summarized in **Table 3** and shown graphically in **Figure 12.** The moisture content of the sediment was found to be below the method detection limit of 0.068%.

Table 2 Particle Size Distribution of RE Test Sediment, GHL Lot # A020-054

Particle Size (microns)	Test Sediment Particle Size (% Less Than)[1]				NJDEP Specification[2] (minimum % Less Than)	QA/QC
	Sample 1	Sample 2	Sample 3	Average		
1000	100	100	100	100	100	PASS
500	94	94	94	94	95	PASS
250	87	87	89	88	90	PASS
150	78	78	79	78	75	PASS
100	58	58	59	59	60	PASS
75	50	51	51	51	50	PASS
50	42	45	43	43	45	PASS
20	36	35	36	36	35	PASS
8	20	18	19	19	20	PASS
5	13	12	11	12	10	PASS
2	7	5	6	6	5	PASS
d_{50}	74 µm	73 µm	71 µm	73 µm	≤ 75 µm	PASS

[1] Where required, particle size data has been interpolated to allow for comparison to the required particle size specification.

[2] A measured value may be lower than a target minimum % less than value by up to two percentage points provided that the measured d_{50} value does not exceed 75 microns.

Table 3 Particle Size Distribution of Scour Test Sediment, GHL Lot #A022-020

Particle Size (microns)	Test Sediment Particle size (%passing)				NJDEP Specification (minimum % Less Than)	QA/QC
	Sample 1	Sample 2	Sample 3	Average		
1000	100	100	100	100	100	PASS
500	100	100	100	100	90	PASS
250	97	97	97	97	55	PASS
150	73	73	75	73	40	PASS
100	26	25	28	26	25	PASS
75	8	8	10	9	10	PASS
d_{50} (µm)	126	127	124	126	N/A	N/A

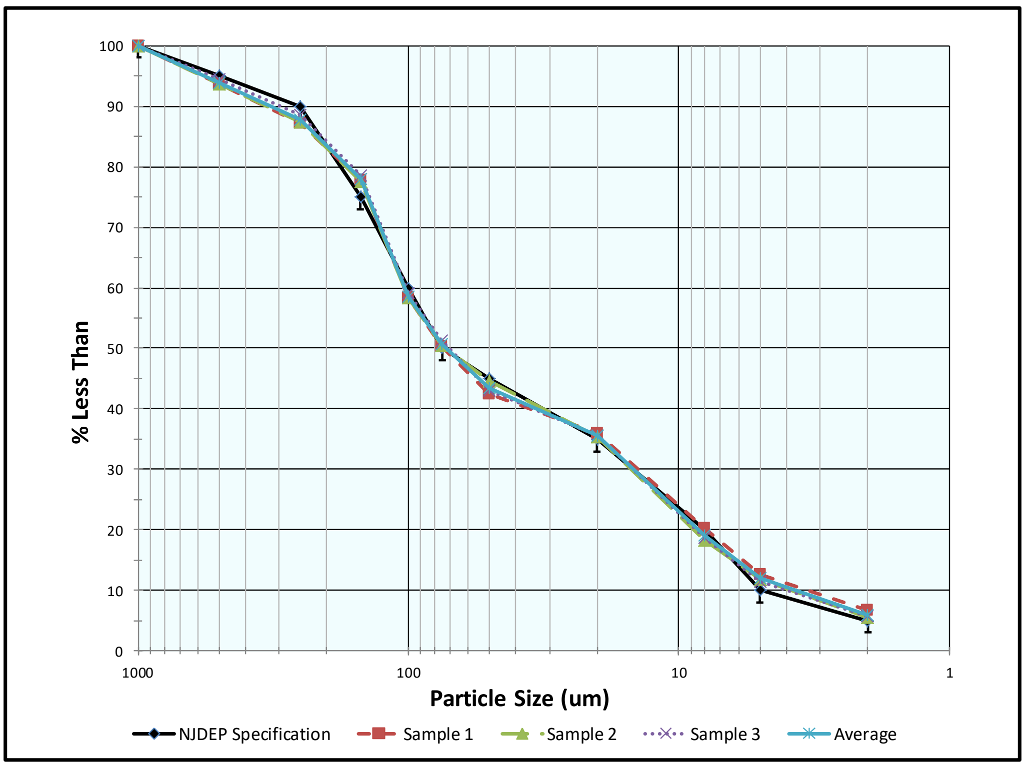

Figure 11 Particle Size Distribution of RE Test Sediment, GHL Lot #A020-054

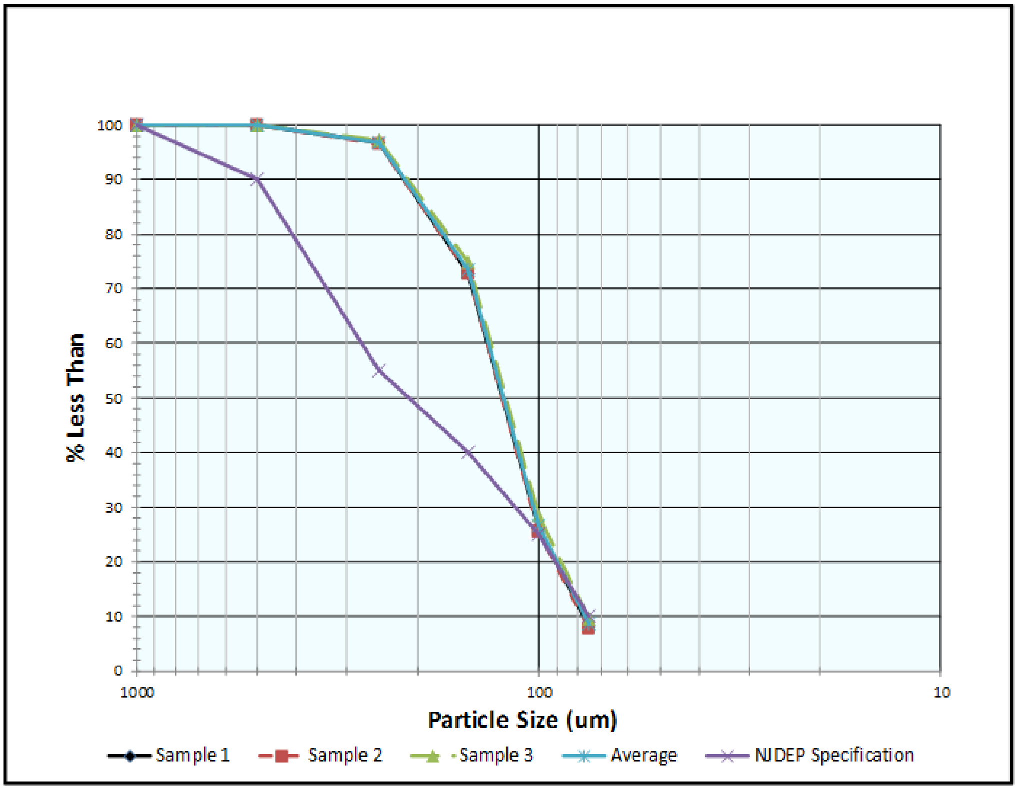

Figure 12 Particle Size Distribution of Scour Test Sediment, GHL Lot #A022-020

2.3 Removal Efficiency Testing

The DSBB has a maximum sump sediment storage depth of 12 inches. Removal testing was conducted on a clean unit with a false floor installed in each compartment at 50% of the sump sediment storage depth, 6 inches above the vault floor. Removal Efficiency Testing followed Section 5 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs.

The test sediment was fed through an opening in the crown of the effluent pipe, 90 inches (5 pipe diameters) upstream of the DSBB. 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. A funnel was used to direct the sediment into the pipe (**Figure 13**).

Figure 13 Sediment Addition Point

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 0.01 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 30 seconds; 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. All background and effluent samples were analysed by GHL for suspended sediment concentration (SSC) using the methodology of ASTM method D3977-97 (reapproved 2013).

2.4 Scour Testing

Prior to the start of testing, a false floor was installed 4 inches lower than 50% of the maximum sediment storage depth, 2 inches above the vault floor, and sediment was loaded into each compartment of the DSBB and leveled at a depth of 4 inches. The final height of the sediment was at an elevation equivalent to 50% of the maximum sump 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 90 hours. The scour test was conducted at a target flow rate of 2.4 cfs (1,077 GPM), more than 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. Flow to the system was increased gradually, over a five-minute period, until the target flow rate was achieved.

Sampling of background and effluent was conducted in the same manner as for the removal efficiency test. An effluent grab sample was taken once every two minutes, starting 2 minutes after achieving the target flow rate (7 minutes after initiating flow to the system), until a total of 15 effluent samples were taken. A total of eight background water samples were collected, simultaneously with the even-numbered effluent samples.

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 of an aberrant result.

3. Performance Claims

Per the NJDEP verification procedure, the following are the performance claims made by Bio Clean Environmental Services Inc. and established via the laboratory testing conducted for the Debris Separating Baffle Box (Model Number DSBB-2.5-5).

Total Suspended Solids (TSS) Removal Efficiency

The TSS removal efficiency of the DSBB was determined using the weighted method specified by the NJDEP HDS MTD protocol. Based on a MTFR of 1.1 cfs, the DSBB achieved a weighted TSS removal efficiency of 51.8%.

Maximum Treatment Flow Rate (MTFR).

The DSBB unit tested had a total sedimentation area of 12.5 ft^2 and a maximum treatment flow rate (MTFR) of 1.1 cfs (494 gpm). The maximum treatment loading rate is 39.5 gpm/ft^2 of sedimentation area.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth is 12" which equates to 12.2 ft^3 of sediment storage volume.

Effective Treatment/Sedimentation Area

The effective treatment area of the unit tested was 12.5 ft^2.

Detention Time and Wet Volume

The maximum wet volume for the DSBB is 281 gallons. The detention time of the DSBB is dependent upon flow rate. The minimum design detention time, calculated by dividing the treatment volume by the MTFR of 494 gpm, is 34.1 seconds.

Online/Offline Installation

Based on the laboratory scour testing results, the DSBB qualifies for online installation.

4. 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.

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 an annualized weighted TSS removal efficiency for the DSBB.

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 DSBB 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 sediment 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), 2.0 mg/L was used in calculating the adjusted effluent concentration.

Removal efficiency for each test run was computed as follows:

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

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		
7.82		1	1
8.32			2
8.82	2	2	3
16.64			4
17.14		3	5
17.64	3		6
25.45		4	7
25.95			8
26.45	4	5	9
34.27			10
34.77		6	11
35.27	5		12
43.09		7	13
43.59			14
44.09	6	8	15
45.09	End of Testing		
MTD Detention Time = 2.273 minutes Target Sediment Sampling Time = 60 seconds			

Table 5 Water Flow and Temperature - 25% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	123.4	122.4	-0.843 %	0.014	69.8
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

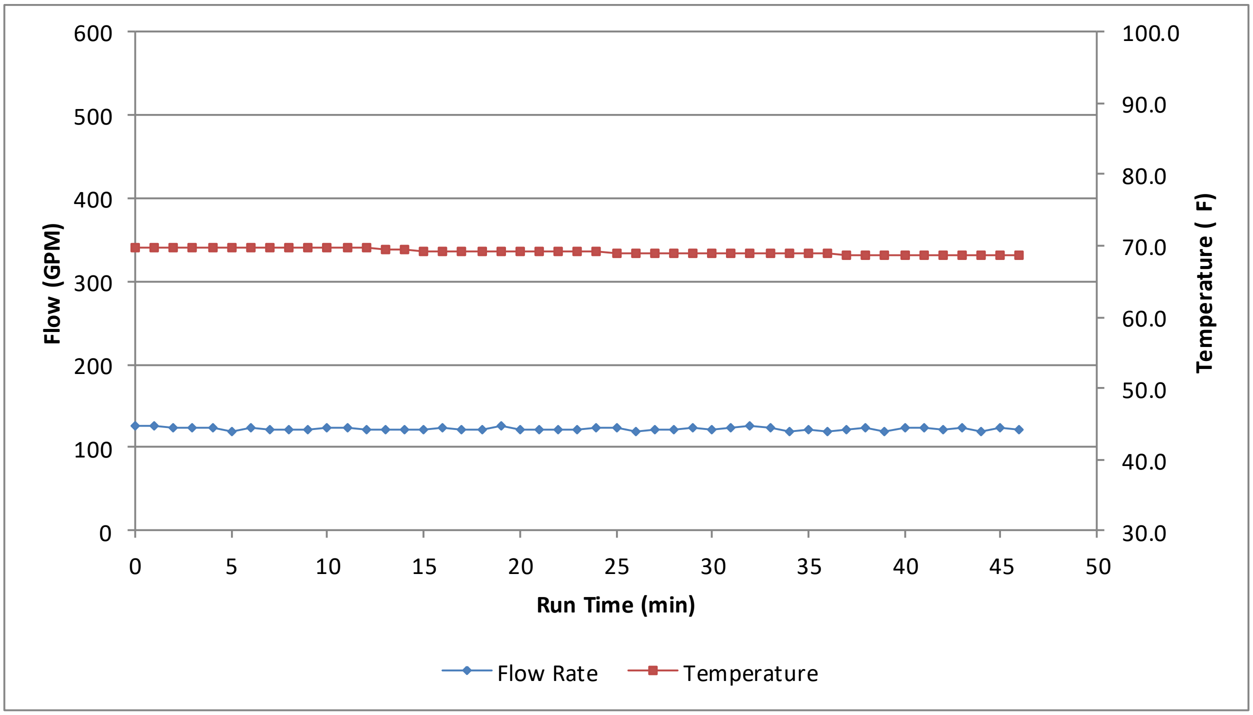

Figure 14 Water Flow and Temperature - 25% MTFR

Table 6 Sediment Feed Rate Summary – 25% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	93.710	Starting Weight of Sediment (lbs.)	51.246
2	96.232		
3	96.224	Recovered Weight of Sediment (lbs.)	41.612
4	95.159		
5	97.357	Mass of Sediment Used (lbs.)	9.634
6	97.141	Volume of Water Through MTD During Dosing (gal)	4790
Average	95.971		
COV	0.014	Average Influent Sediment Concentration (mg/L)	209.3*
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	78.5	78.1	80.9	80.6	82.2	81.2	80.4	80.5	81.1	78.1	80.6	79.1	83.1	82.9	85.9
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	76.5	76.1	78.9	78.6	80.2	79.2	78.4	78.5	79.1	76.1	78.6	77.1	81.1	80.9	83.9

Average Adjusted Effluent Concentration	78.9 mg/L	Removal Efficiency	62.3 %

50% MTFR

Table 8 Sampling Schedule - 50% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
4.26		1	1
4.76			2
5.26	2	2	3
9.52			4
10.02		3	5
10.52	3		6
14.78		4	7
15.28			8
15.78	4	5	9
20.04			10
20.54		6	11
21.04	5		12
25.30		7	13
25.80			14
26.30	6	8	15
27.15	End of Testing		
MTD Detention Time = 1.136 minutes Target Sediment Sampling Time = 51 seconds			

Table 9 Water Flow and Temperature - 50% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	246.9	246.8	-0.049 %	0.009	71.2
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

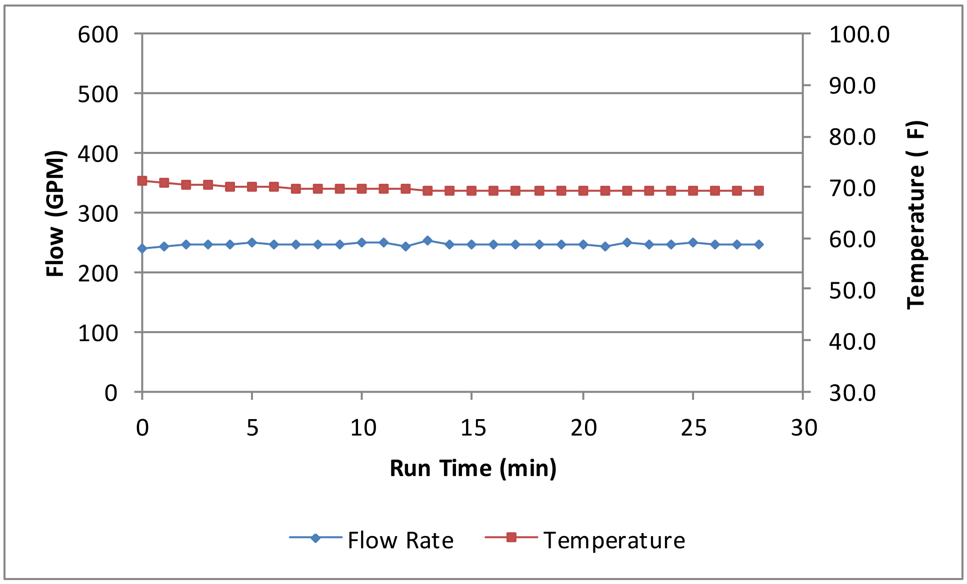

Figure 15 Water Flow and Temperature - 50% MTFR

Table 10 Sediment Feed Rate Summary – 50% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	181.534	Starting Weight of Sediment (lbs.)	57.618
2	186.224		
3	189.394	Recovered Weight of Sediment (lbs.)	46.529
4	181.396		
5	183.295	Mass of Sediment Used (lbs.)	11.089
6	188.355	Volume of Water Through MTD During Dosing (gal)	5447
Average	185.033		
COV	0.019	Average Influent Sediment Concentration (mg/L)	198.2*
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	87.6	83.3	88.3	90.6	90.5	90.6	92.1	90.9	88.2	89.5	88.3	87.5	86.9	89.8	93.7
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	85.6	81.3	86.3	88.6	88.5	88.6	90.1	88.9	86.2	87.5	86.3	85.5	84.9	87.8	91.7

Average Adjusted Effluent Concentration	87.2 mg/L	Removal Efficiency	56.0 %

75% MTFR

Table 12 Sampling Schedule - 75% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
2.84		1	1
3.34			2
3.84	2	2	3
6.68			4
7.18		3	5
7.68	3		6
10.52		4	7
11.02			8
11.52	4	5	9
14.36			10
14.86		6	11
15.36	5		12
18.20		7	13
18.70			14
19.20	6	8	15
19.76	End of Testing		
MTD Detention Time = 0.758 minutes Target Sediment Sampling Time = 34 seconds			

Table 13 Water Flow and Temperature - 75% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	370.3	369.5	-0.216 %	0.007	69.3
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

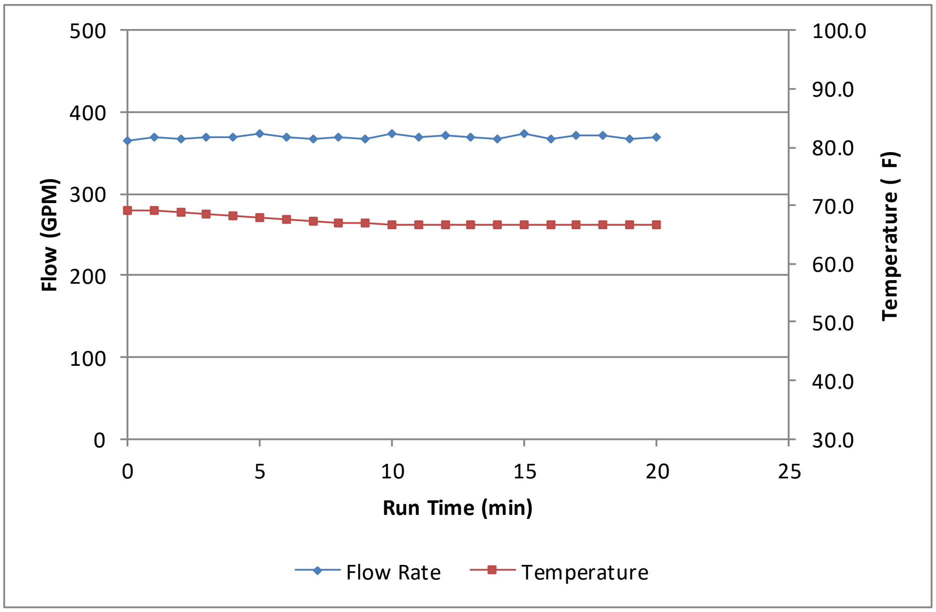

Figure 16 Water Flow and Temperature - 75% MTFR

Table 14 Sediment Feed Rate Summary – 75% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	263.220	Starting Weight of Sediment (lbs.)	57.078
2	266.404		
3	269.572	Recovered Weight of Sediment (lbs.)	45.294
4	272.705		
5	268.367	Mass of Sediment Used (lbs.)	11.784
6	269.926	Volume of Water Through MTD During Dosing (gal)	6048
Average	268.366		
COV	0.012	Average Influent Sediment Concentration (mg/L)	193.7*
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	101.0	106.0	98.5	108.0	98.2	100.0	99.6	105.0	108.0	99.9	101.0	106.0	104.0	102.0	108.0
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	99.0	104.0	96.5	106.0	96.2	98.0	97.6	103.0	106.0	97.9	99.0	104.0	102.0	100.0	106.0
Average Adjusted Effluent Concentration				101.0 mg/L			Removal Efficiency					47.9 %			

100% MTFR

Table 16 Sampling Schedule - 100% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	Background	Effluent
0	1		
2.14		1	1
2.64			2
3.14	2	2	3
5.28			4
5.78		3	5
6.28	3		6
8.41		4	7
8.91			8
9.41	4	5	9
11.55			10
12.05		6	11
12.55	5		12
14.69		7	13
15.19			14
15.69	6	8	15
16.12	End of Testing		
MTD Detention Time = 0.568 minutes Target Sediment Sampling Time = 26 seconds			

Table 17 Water Flow and Temperature - 100% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	493.7	493.6	-0.020 %	0.006	68.9
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

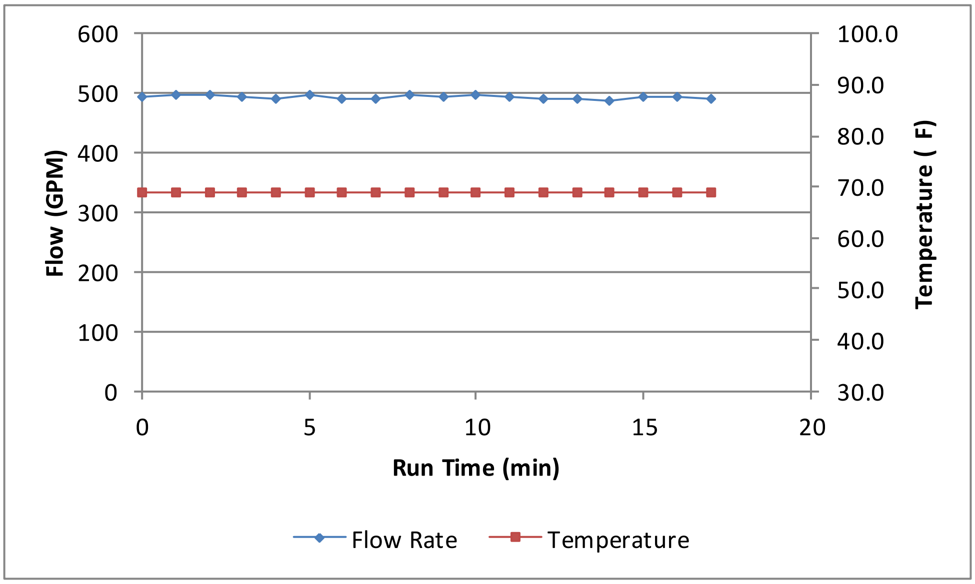

Figure 17 Water Flow and Temperature - 100% MTFR

Table 18 Sediment Feed Rate Summary – 100% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	356.316	Starting Weight of Sediment (lbs.)	61.795
2	362.418		
3	362.104	Recovered Weight of Sediment (lbs.)	48.876
4	358.905		
5	371.866	Mass of Sediment Used (lbs.)	12.919
6	364.500	Volume of Water Through MTD During Dosing (gal)	6679
Average	362.685		
COV	0.015	Average Influent Sediment Concentration (mg/L)	194.6*
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	112.0	107.0	120.0	115.0	110.0	116.0	115.0	112.0	122.0	113.0	116.0	122.9	118.0	114.0	117.0
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	110.0	105.0	118.0	113.0	108.0	114.0	113.0	110.0	120.0	111.0	114.0	120.9	116.0	112.0	115.0

Average Adjusted Effluent Concentration	113.3 mg/L	Removal Efficiency	41.8 %

125% MTFR

Table 20 Sampling Schedule - 125% MTFR

Runtime (min)	Sampling Schedule		
	Sediment Feed	**Background**	**Effluent**
0	1		
1.71		1	1
2.21			2
2.71	2	2	3
4.43			4
4.93		3	5
5.43	3		6
7.14		4	7
7.64			8
8.14	4	5	9
9.85			10
10.35		6	11
10.85	5		12
12.57		7	13
13.07			14
13.57	6	8	15
13.92	End of Testing		
MTD Detention Time = 0.455 minutes Target Sediment Sampling Time = 21 seconds			

Table 21 Water Flow and Temperature - 125% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	617.1	613.4	-0.597%	0.004	69.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

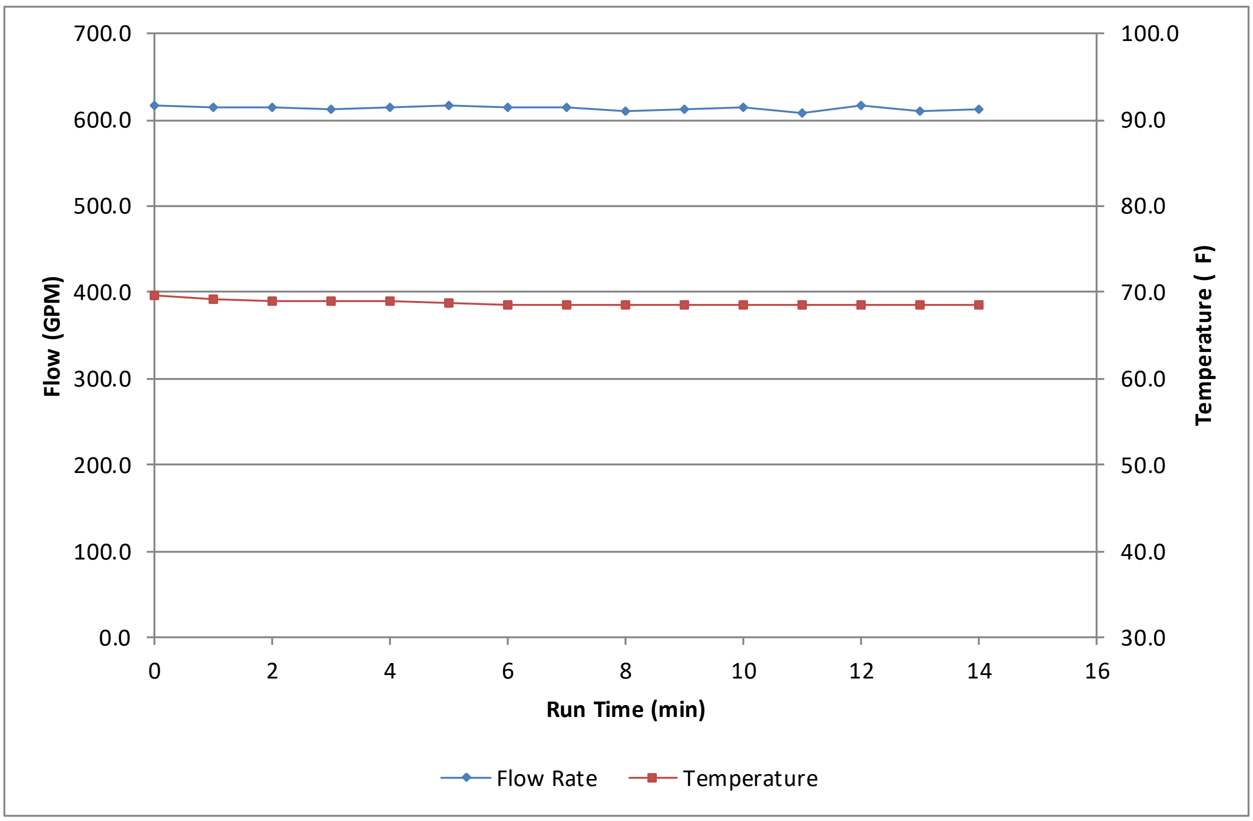

Figure 18 Water Flow and Temperature - 125% MTFR

Table 22 Sediment Feed Rate Summary – 125% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	441.740	Starting Weight of Sediment (lbs.)	64.188
2	461.940		
3	482.677	Recovered Weight of Sediment (lbs.)	49.902
4	461.016		
5	477.493	Mass of Sediment Used (lbs.)	14.286
6	473.290	Volume of Water Through MTD During Dosing (gal)	7261
Average	466.359		
COV	0.032	Average Influent Sediment Concentration (mg/L)	200.4*
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	124.7	134.7	134.0	128.9	133.7	140.6	134.0	142.5	144.5	114.0	121.0	132.0	132.0	128.0	137.3
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	122.7	132.7	132.0	126.9	131.7	138.6	132.0	140.5	142.5	112.0	119.0	130.0	130.0	126.0	135.3

Average Adjusted Effluent Concentration	130.1 mg/L	Removal Efficiency	35.1 %

Excluded Data

After the scour test at 2.4 cfs some removal efficiency runs were conducted using 1.2 cfs as the MTFR. The projected weighted removal was just under 50.0% so the runs were repeated with 1.1 cfs as the MTFR and only those results are presented in this report.

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 DSBB annual weighted removal for a MTFR of 1.1 cfs (494 gpm) is 51.8%, as shown in **Table 24**

Table 24 Annualized Weighted Removal Efficiency for DSBB

%MTFR	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	62.3	0.25	15.6
50	56.0	0.30	16.8
75	47.9	0.20	9.6
100	41.8	0.15	6.3
125	35.1	0.10	3.5
Annualized Weighted Removal Efficiency			**51.8%**

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 2.4 cfs (1,077 gpm), more than 200% of the maximum treatment flow rate (MTFR).

Table 25 PSD of Scour Test Sediment (GHL Lot #A022-20)

Particle Size (µm)	Test Sediment PSD (% Passing)	NJDEP Scour Test Sediment Specification* (minimum % Less Than)
1000	100	100
500	100	90
250	97	55
150	73	40
100	26	25
75	9	10
d_{50} (µm)	126	N/A

*A measured value may be lower than a target minimum % Less Than value by up to two percentage points

In preparation for the scour test, the sump of the DSBB was fitted with a false floor, 4 inches below the depth of the 50% maximum sediment storage height. The sump was then loaded with 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 90 hours.

Effluent sampling began 2 minutes after achieving the target flow rate and background samples were taken with odd-numbered effluent samples. The sampling frequency for the test is summarized in **Table 26**. Water flow and temperature are summarized in **Table 27** and shown on **Figure 19**.

Table 26 Scour Test Sampling Frequency

Sample/ Measurement Taken	Run Time (min.)														
	7	**9**	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**
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 at which flow to the system began.

Table 27 Water Flow and Temperature - Scour Test

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	1077	1072.2	-0.46 %	0.003	61.0
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

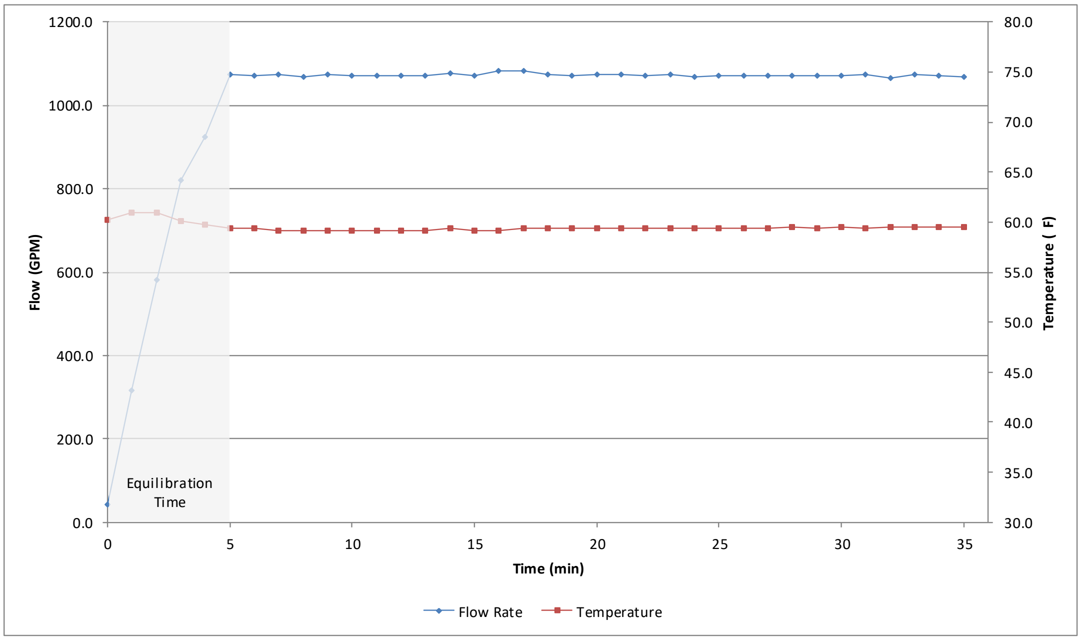

Figure 19 Water Flow and Temperature - Scour Test

The effluent and background SSC results are reported in **Table 28**.

The adjusted effluent concentration was calculated as:

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

All the background sediment concentrations were found to be below the method reporting limit (MDL) of 2.3 mg/L, therefore a background correction value of 2.0 mg/L was used for calculation purposes. For effluent concentrations below the MDL, 2.0 mg/L was used for calculation purposes. The average adjusted effluent concentration was 0.12 mg/L. Therefore, when operated at 200% of the MTFR, the DSBB 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	2.0	2.0	2.0	2.0	2.0	2.0	3.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Background	2.0		2.0		2.0		2.0		2.0		2.0		2.0		2.0
Adjusted Effluent	0	0	0	0	0	0	1.8	0	0	0	0	0	0	0	0
Average Adjusted Effluent Concentration							0.12 mg/L								

5. Design Limitations

Bio Clean Environmental Services Inc. provides engineering support to clients on all projects. Each system prior to submittal is evaluated and properly designed/sized to meet site specific conditions including treatment and bypass flow rates, load rating requirements, and pipe depth. All site and design constraints will be addressed during the design and manufacturing process.

Required Soil Characteristics

The DSBB is delivered to the job site as a complete pre-assembled unit housed in a concrete structure designed to meet site specific soil conditions, corrosiveness, top and lateral loading, and ground water. The system can be used in all soil types. A copy of the geotechnical report along with surface loading requirements are reviewed and verified for each project.

Slope

The DSBB is most commonly used in a piped-in configuration in which one pipe enters the side of the system subsurface. This was the configuration tested. In general, it is not recommended that the pipe slope into the system exceed 10% nor be less than 0.5%. Slopes higher than 10% will cause increased velocities which could affect the performance. Slopes less than 0.5% could cause sediment to accumulate in the bottom of the inflow pipe and affect its hydraulic capacity.

The DSBB is usually not affected by variations in slope of the finish surface as the unit is buried underground. Risers of various heights can be used to bring access to the system up to finish surface. In these configurations finish surface slope is more constrained and will require design review to ensure appropriate configuration.

Maximum Flow Rate

Maximum treatment flow rate is dependent on model size. The DSBB will be sized based upon the NJCAT tested hydraulic loading rate of 39.5 gallons per minute per square foot of settling surface area. Section 6 includes details pertaining to inspection and maintenance of the DSBB.

Maintenance Requirements

Requirements pertaining to maintenance of the DSBB will vary depending on pollutant loading and individual site conditions. It is recommended that the system be inspected at least twice during the first year to determine loading conditions for each site. These first-year inspections can be used to establish inspection and maintenance frequency for subsequent years.

Driving Head

Driving head will vary for a given DSBB model based on the site-specific configuration. Design support is provided for all projects including site-specific drawings/cut sheets which show elevations of pipes and finish surface. Peak and treatment flow rates will also be evaluated to ensure the system is properly designed from a hydraulic standpoint.

Installation Limitations

With each installation Bio Clean Environmental provides contractors with instructions prior to delivery. Contractors can request onsite assistance from an installation technician during delivery and installation. Pick weights and lifting details are also provided prior to delivery so the contractor can prepare appropriate equipment onsite to set the unit.

Configurations

The DSBB is available in various configurations. The units can be installed online or offline. The DSBB has an internal bypass, which allows for it to be installed online without the need for any external high flow diversion structure.

Structural Load Limitations

The DSBB is generally housed in a pre-cast concrete structure. Most standard structures are designed to handle indirect traffic loads with minimal cover. For deeper installation, or installation requiring direct traffic rating or higher, the structure will be designed and modified with potentially thicker tops, bottoms and/or walls to handle the additional loading. Various access hatch options are available for parkway, indirect traffic, direct traffic and other higher loading requirements such as airports or loading docks.

Pre-treatment Requirements

The DSBB has no pre-treatment requirements.

Limitations in Tailwater

Site specific tailwater conditions must be assessed on each individual project. Tailwater conditions increase the amount of driving head required for optimal system operation. The manufacturer's internal protocols require that these conditions are discussed with the engineer of record and that a solution be implemented to adjust for any design variations caused by tailwater conditions at both treatment and bypass flow rates.

Depth to Seasonal High-Water Table

High groundwater conditions will not affect the operation of the DSBB as it is a closed system. In conditions where high groundwater is present, various measures will be employed by Bio Clean Environmental's engineering department to ensure that there are no negative consequences caused by the high groundwater. Various measures can be employed such as waterproofing the inside and outside of the structure with an approved coating. A footing can also be added to the bottom of the structure to increase its footprint and offset any buoyancy concerns.

6. Maintenance Plans

The DSBB, a stormwater dual-stage Hydrodynamic Separator, is designed to remove high levels of trash, debris, sediments and hydrocarbons. The innovative screening system directs floatable trash, debris, and organics onto raised debris separation screens for dry state storage, allowing for easy removal. The raised screens are assisted by a self-cleaning inlet splitting screen which directs flows to the screens while maintaining high treatment flow rates. The DSBB can effectively capture and store sediment with no maintenance or loss of treatment capacity for several years based on annual average loading in most regions.

As with all stormwater BMPs, inspection and maintenance on the DSBB Hydrodynamic Separator is necessary. Stormwater BMP practices recommend that all devices 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. Additional inspection and maintenance instructions, including visual enhancements and inspection and maintenance forms, are available in the Bio Clean DSBB Separator Operations and Maintenance Manual at: https://biocleanenvironmental.com/wp-content/uploads/2019/02/Operations-Maintenance-DSBB-NJDEP-PSD.pdf

Inspection Equipment

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

- Bio Clean Environmental Inspection Form (contained within the O&M manual).
- Flashlight.
- Manhole hook or appropriate tools to remove 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. Entering is generally not required for routine inspections or maintenance of the system.

Inspection Steps

The core to any successful stormwater BMP maintenance program is routine inspections. The inspection steps required on the DSBB 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 DSBB 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 nearby 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 and 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, sediment chambers, debris separation screens, splitter screen, or outflow pipe. Write down any observations on the inspection form.
- Inspect the divergence and convergence structures for offline units.
- Through observation and/or digital photographs estimate the amount of floatable debris accumulated inside the debris separation screens. Record this information on the inspection form. Check both the right and left screens.
- Utilizing a tape measure or measuring stick estimate the amount of sediment accumulated in each of the three sediment chambers. Record this depth on the inspection form.
- Observe the condition and color of the hydrocarbon booms and any floating oils in front of the boom cage. Record this information on the inspection form.
- Finalize the 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 trash, debris and foliage on the screens in which the length and width of the chambers screens is more than half full and/or flow into the screens is fully impeded by debris. Large items blocking the entrance.
- Excessive accumulation of sediment in any of the three separation chambers, such as when more than half-full (6”). See **Table A-1**.

Maintenance Equipment

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

- Bio Clean Environmental Maintenance Form (contained in the 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. Exception is deeper units where entry may be required to open filtration screen lids and replace hydrocarbon booms.
- 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 from any associated upstream detention systems. Maintaining the system while flows are still entering it will increase the time and complexity required for maintenance. Debris captured on the debris separation screens requires time to dry out which decreases time to remove and associated weight. Cleaning of the screens and sediment chambers can be performed from finish surface without entry into the vault utilizing a vacuum truck on most installations. Depth and configuration of the installation may create conditions which would require entry for some or all of the maintenance procedures. Configuration and size of access hatches also affects the conditions in which entry may be required. Once all safety measures have been set up cleaning of the screens, hydrocarbon boom(s) and/or sediment chambers can proceed as follows:

- Remove all access hatches (requires traffic control and safety measures to be completed prior).
- Locate the right and left debris separation screens. Manhole or hatch access will be provided to each of these screens. As highlighted below, depending on the configuration of the DSBB the screens may or may not have hinged lids depending on factors such as online or offline bypass, water level at peak flow, back flow conditions amongst other site-specific variables. Units that have lids are designed with hinges and locking mechanisms along the sidewall of the structure that can be unlocked from finish surface with an extension rod. The length of this rod is limited and for deeper installations entry may be required to unlock and open the lids.
- Once the screens lids are opened (if applicable) the vacuum hose extension is inserted down into the screens for removal of debris. The width of the screen of the smallest model is 9” therefore allowing a standard 8” vacuum hose to be used for all models and sizes. All debris should be removed with the vacuum hose and the pressure washer should be used to spray down and remove all debris on the bottom, side and top screens. Ensure that all holes within the screen are cleared of debris. This is critical to restoring the full hydraulic capacity of the filtration screens. Once completed close and lock lids (if applicable).
- Using an extension on a vacuum truck position the hose over the opened access hatch or hatches leading to the first sediment chamber adjacent to the pipe inlet that includes the splitter screen. Lower vacuum hose into the sediment chamber on the left and right side of the splitter screen. This is where a majority of the larger sediments and heavy debris will accumulate. Remove all floating debris, standing water and sediment from this sediment chamber. Vertical access to the bottom of the sediment 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. The power washer should also be used to spray the splitter screen clean of any accumulated debris. The vacuum hose can also be inserted on the outlet side of the splitter screen (inside the V) to remove any remaining accumulated sediment.
- Repeat the same procedure in the second and third sediment chambers. Access to these two chambers is in the center of the system unlike the first sediment chamber. The screens cover the sediment chamber along the sides yet allow for unimpeded access in the middle without requirement to open filtration chamber tops or go through the screens (hinged floor) as found with other baffle box systems. Hatch or manhole size, quantity and location vary based on model size and site-specific project constraints. Various access hatch sizes and configurations are available to meet individual project requirements. Larger hatches, open assisted hatches and/or taller ID dimensions to increase headroom are available by request.
- Based on the color of the hydrocarbon booms replacement may be necessary. The booms are housed inside the boom cage which is attached to the influent side of the oil skimmer wall. The cage has a hinged top that can be opened from the finish surface using a hook,

allowing access to the hydrocarbon booms. Once old booms are removed new booms can be dropped in and the top closed.

- NOTE: Debris separation screens can be cleaned before or after cleaning and removal of sediment from the sediment chambers. Cleaning them before is preferred before removing sediment and standing water from the second and third chamber as debris and water will be deposited on the sediment chamber floors in the process of cleaning the screens over the second and third chamber. Cleaning the first sediment chamber before the debris separation screens allows the splitter screen to be fully exposed. Thus, the pressure washing of all screens (splitter and debris separation) can be done at the same time if needed.
- 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 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, unless it is installed in association with an industrial NPDES permit.
- In the case of damaged components, replacement parts can be ordered from the manufacturer. Hydrocarbon booms can also be ordered directly from the manufacturer.

7. Statements

The following attached pages are signed statements from the manufacturer (Bio Clean Environmental Inc.), the testing lab (Good Harbour Labs), and NJCAT.

Bio Clean
A Forterra Company

Date: 1/31/2019

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 followed.

We confirm that all requirements and criteria were met and/or exceeded during testing of the Debris Separating Baffle Box 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: 1-31-2019

P O Box 869 Oceanside CA 92049
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March 06, 2019

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

Re: Performance Verification of the Debris Separating Baffle Box® Hydrodynamic Separator (HDS)

Dear Dr. Magee,

Good Harbour Laboratories (GHL) was contracted by BioClean Environmental Services Inc., a Forterra Company, to conduct a performance verification of their Debris Separating Baffle Box® 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).

GHL is an independent hydraulic test facility located in Mississauga, Ontario, Canada. I certify that we evaluated the Debris Separating Baffle Box®, model 2.5-5, in January 2019 according to the aforementioned test protocol. The results presented in the NJCAT Verification Report dated February 2019 are accurate and all procedures and requirements stated in the test protocol were met or exceeded.

In addition I confirm, on behalf of GHL and Monteco:

-that we 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 we 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.

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

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

Sincerely,

Date

Greg Williams

March 6, 2019

Greg Williams, Ph.D., P.Eng.
Managing Director
Good Harbour Laboratories

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Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

February 20, 2019

Gabriel Mahon, Chief
NJDEP
Bureau of Non-Point Pollution Control
Bureau of Water Quality
401 E. State Street
Mail Code 401-02B, PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing on the Bio Clean Debris Separating Baffle Box (DSBB™) stormwater treatment system conducted by Good Harbour Laboratories, Ltd., Mississauga, Ontario, Canada, the test protocol requirements contained in the *"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) were met or exceeded consistent with the NJDEP Approval Process. Specifically:

Test Sediment Feed - The test sediment used for the removal efficiency study was custom blended by GHL using various commercially available silica sands; this particular batch was GHL lot # A020-054. Three samples of sediment were sent out for particle size analysis using the methodology of ASTM method D422-63 (reapproved 2007). The samples were composite samples created by taking samples throughout the blending process and in various positions within the blending drum. The testing lab was Maxxam Analytics, an independent test lab also located in Ontario Canada. The sediment met the NJDEP specification (minimum % less than) and the $d_{50} <$ 75µm.

Removal Efficiency Testing – Removal efficiency testing followed the effluent grab sampling test method outlined in Section 5 of the NJDEP Protocol. The Bio Clean DSBB Model 2.5-5 achieved an annual weighted removal efficiency of 51.8% of the test sediment (d_{50} of 73 μm) for a MTFR of 494 gpm (1.1 cfs).

Scour Test Sediment - The test sediment used for the scour test was commercially available silica sediment supplied by AGSCO Corporation, generally referred to as #110 but labeled #140-200. This particular batch was composed of five separate sediment lots that were blended by GHL; the GHL internal lot number for the blend was A022-020. During blending, three representative sediment samples were taken of the batch and analysed for particle size distribution using the methodology of ASTM method D422-63 (reapproved 2007). The PSD testing was conducted by GHL. The sediment met the NJDEP Protocol specifications.

Scour Testing – The DSBB-2.5-5 model exhibited very low scour at 200% MTFR (0.12 mg/L) qualifying it for online use.

All other criteria and requirements of the NJDEP HDS 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; and water temperature <80 ºF.

Sincerely,

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

8. References

1. 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.

2. GHL Laboratory Notebook: A023, pp. 130- 160.

3. GHL Laboratory Notebook: A024, pp. 1 – 36; pp. 80 - 95

VERIFICATION APPENDIX

Introduction

- Manufacturer – Bio Clean Environmental Inc., 398 Via El Centro, Oceanside, CA 92058. Website: http://www.biocleanenvironmental.com Phone: 760-433-7640.
- DSBB MTD – Bio Clean DSBB verified models are shown in **Table A-1** and **Table A-2**.
- The Bio Clean DSBB Separator demonstrated a TSS removal rate of 50%.
- The Bio Clean DSBB Separator qualifies for online installation for the New Jersey Water Quality Design Storm (NJWQDS).

Detailed Specification

- NJDEP sizing tables and physical dimensions of the Bio Clean DSBB Separator verified models are attached (**Table A-1**, **Table A-2** and **Table A-3**).
- New Jersey requires that the peak flow rate of the NJWQ Design Storm event of 1.25 inch in 2 hours shall be used to determine the appropriate size for the MTD. The Debris Separating Baffle Box model DSBB-2.5-5 has a maximum treatment flow rate (MTFR) of 1.1 cfs (494 gpm), which corresponds to a surface loading rate of 39.5 gpm/ft^2 of sedimentation area.
- Pick weights and installation procedures vary slightly with model size. Design support is given by Bio Clean for each project and pick weights and installation procedures will be provided prior to delivery.
- NJDEP maximum recommended sediment depth prior to cleanout is 6 inches for all model sizes.
- The Bio Clean Operations and Maintenance Guide is at: https://biocleanenvironmental.com/wp-content/uploads/2019/02/Operations-Maintenance-DSBB-NJDEP-PSD.pdf
- Maintenance frequency for all the DSBB models is 38-40 months (**Table A-1**).
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the DSBB to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

Table A-1 MTFRs, Dimensions, and Required Sediment Removal Intervals for DSBB Models

DSBB Model #	Inside Length (L), ft	Inside Width (W), ft	Below Invert (DBI)[1], ft.	Treatment Flow Rate (MTFR)[2], cfs	Tested Loading Rate (gpm/sq ft)	Partition Height (PH)[3], ft	Partition Thickness (PT), ft	Floor Area (FA)[4], ft^2	50% Maximum Sediment Storage Area Volume, ft^3	Sediment Removal Interval (SRI)[5], months
2-4	4.00	2.00	2.50	0.70	39.5	2.50	0.06	7.75	3.88	39
2.5-5	5.00	2.50	2.50	1.10	39.5	2.50	0.06	12.19	6.09	40
3-6	6.00	3.00	2.50	1.59	39.5	2.50	0.06	17.63	8.81	40
4-6	6.00	4.00	2.50	2.11	39.5	2.50	0.06	23.50	11.75	40
4-8	8.00	4.00	3.25	2.82	39.5	3.25	0.06	31.50	15.75	40
5-10	10.00	5.00	4.00	4.40	39.5	4.00	0.33	46.67	23.34	38
6-12	12.00	6.00	4.75	6.34	39.5	4.75	0.33	68.00	34.00	38
7-14	14.00	7.00	5.25	8.63	39.5	5.25	0.33	93.34	46.67	39
8-14	14.00	8.00	6.00	9.86	39.5	6.00	0.33	106.67	53.34	39
8-16	16.00	8.00	6.00	11.27	39.5	6.00	0.33	122.67	61.34	39
9-18	18.00	9.00	6.75	14.27	39.5	6.75	0.50	153.00	76.50	38
10-18	18.00	10.00	7.50	15.85	39.5	7.50	0.50	170.00	85.00	38
10-20	20.00	10.00	7.50	17.61	39.5	7.50	0.50	190.00	95.00	39
10-22	22.00	10.00	8.00	19.37	39.5	8.00	0.50	210.00	105.00	39
11-22	22.00	11.00	8.00	21.31	39.5	8.00	0.50	231.00	115.50	39
11-24	24.00	11.00	8.75	23.25	39.5	8.75	0.50	253.00	126.50	39
12-24	24.00	12.00	8.75	25.36	39.5	8.75	0.50	276.00	138.00	39

NOTES:

[1]DBI = depth from invert of inlet pipe to bottom of unit

[2]MTFR scaling based on 1.1/12.5 = 0.088 cfs/ft2

[3]PH = DBI

[4]FA = W x (L-2xPT)

[5]SRI Calculated from NJDEP HSD Protocol 2013 (Appendix A) 50% TSS Removal Efficiency

Table A-2 DSBB Model Scaling Ratios

				SD/SD		L/W		SD/L		SD/W	
DSBB Model #	Inside Length (L), ft	Inside Width (W), ft	Scaling Depth (SD)[1], ft	SD/SD[2]	SD within 15% of DSBB 2.5-5?	L/W	L/W within 15% of DSBB 2.5-5?	SD/L	SD/L within 15% of DSBB 2.5-5?	SD/W	SD/W within 15% of DSBB 2.5-5?
Test Unit											
2.5-5	5.00	2.50	2.00			2.00		0.40		0.80	
MTFR < 250% of Test Unit											
2-4	4.00	2.00	2.00	1.00	Yes						
3-6	6.00	3.00	2.00	1.00	Yes						
4-6	6.00	4.00	2.00	1.00	Yes						
MTFR > 250% of Test Unit											
4-8	8.00	4.00	2.75			2.00	Yes	0.34	Yes	0.69	Yes
5-10	10.00	5.00	3.50			2.00	Yes	0.35	Yes	0.70	Yes
6-12	12.00	6.00	4.25			2.00	Yes	0.35	Yes	0.71	Yes
7-14	14.00	7.00	4.75			2.00	Yes	0.34	Yes	0.68	Yes
8-14	14.00	8.00	5.50			1.75	Yes	0.39	Yes	0.69	Yes
8-16	16.00	8.00	5.50			2.00	Yes	0.34	Yes	0.69	Yes
9-18	18.00	9.00	6.25			2.00	Yes	0.35	Yes	0.69	Yes
10-18	18.00	10.00	7.00			1.80	Yes	0.39	Yes	0.70	Yes
10-20	20.00	10.00	7.00			2.00	Yes	0.35	Yes	0.70	Yes
10-22	22.00	10.00	7.50			2.20	Yes	0.34	Yes	0.75	Yes
11-22	22.00	11.00	7.50			2.00	Yes	0.34	Yes	0.68	Yes
11-24	24.00	11.00	8.25			2.18	Yes	0.34	Yes	0.75	Yes
12-24	24.00	12.00	8.25			2.00	Yes	0.34	Yes	0.69	Yes

NOTES:

[1]SD = Depth of invert of inlet pipe to bottom of unit (DBI) minus 0.5 ft (location of false floor for tested unit).

[2]SD/SD = Ratio of scaling depth of the DSBB model to the test unit scaling depth.

Table A-3 DSBB Model Flow Control Weir Scaling Ratios

DSBB Model #	Inside Length (L), ft	Inside Width (W), ft	Weir Width, ft	Ratio: Weir Width to Inside Width	Max Pipe Size Diameter, in[1]	Ratio: Pipe Diameter to Inside Width
2-4	4.00	2.00	1.26	63%	14.40	60%
2.5-5	5.00	2.50	1.58	63%	18.00	60%
3-6	6.00	3.00	1.89	63%	21.60	60%
4-6	6.00	4.00	2.52	63%	28.80	60%
4-8	8.00	4.00	2.52	63%	28.80	60%
5-10	10.00	5.00	3.15	63%	36.00	60%
6-12	12.00	6.00	3.78	63%	43.20	60%
7-14	14.00	7.00	4.41	63%	50.40	60%
8-14	14.00	8.00	5.04	63%	57.60	60%
8-16	16.00	8.00	5.04	63%	57.60	60%
9-18	18.00	9.00	5.67	63%	64.80	60%
10-18	18.00	10.00	6.30	63%	72.00	60%
10-20	20.00	10.00	6.30	63%	72.00	60%
10-22	22.00	10.00	6.30	63%	72.00	60%
11-22	22.00	11.00	6.93	63%	79.20	60%
11-24	24.00	11.00	6.93	63%	79.20	60%
12-24	24.00	12.00	7.56	63%	86.40	60%

[1]Available pipe sizes do not match precisely based on ratio. For example, where it says 14.4-inch diameter pipe the biggest standard available pipe diameter will be 12 inches.