NJCAT TECHNOLOGY VERIFICATION

StormScape High Capacity Biofilter

Hydro International

November 2023

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1 Description of Technology

The Hydro StormScape High Capacity Biofilter (StormScape HC Biofilter) is a proprietary stormwater biofilter device that treats polluted stormwater in a downward flow, horizontal media bed system. Each StormScape HC Biofilter consists of a bed of engineered filtration media contained in a box shown in **Figure 1**. The system can be provided with an open bottom allowing for root growth when the media is used as a planter while maximizing contact with native soils, allowing more runoff to be kept onsite. While the open structure of the system is intended to encourage stormwater infiltration and runoff volume reduction, it is also installed with an underdrain comprised of a perforated discharge pipe embedded in coarse stone. The discharge pipe is installed with an unperforated riser that acts as both a bypass and inspection port. These inner components of the StormScape HC Biofilter are shown in **Figure 2**.

As water enters the curb opening, it is distributed by a pad of energy dissipation stones. This forebay slows the water, controlling media scour and encouraging the deposition of trash and coarse sediment. Sediment and particulate pollutants are physically captured in the top layers of the engineered media. Trench grates are provided on the surface to allow for maintenance access to the media.

Figure 1 Rendering of a StormScape High Capacity Biofilter Installed in a Parking Area

Item	Description
1	StormScape Vault
2	Media
3	Tree Grate
4	Curb Opening with Rocky Pad
5	Trench Grate
6	Bypass/Inspection Pipe
7	Gravel Base
8	Mulch
9	Plant (optional)

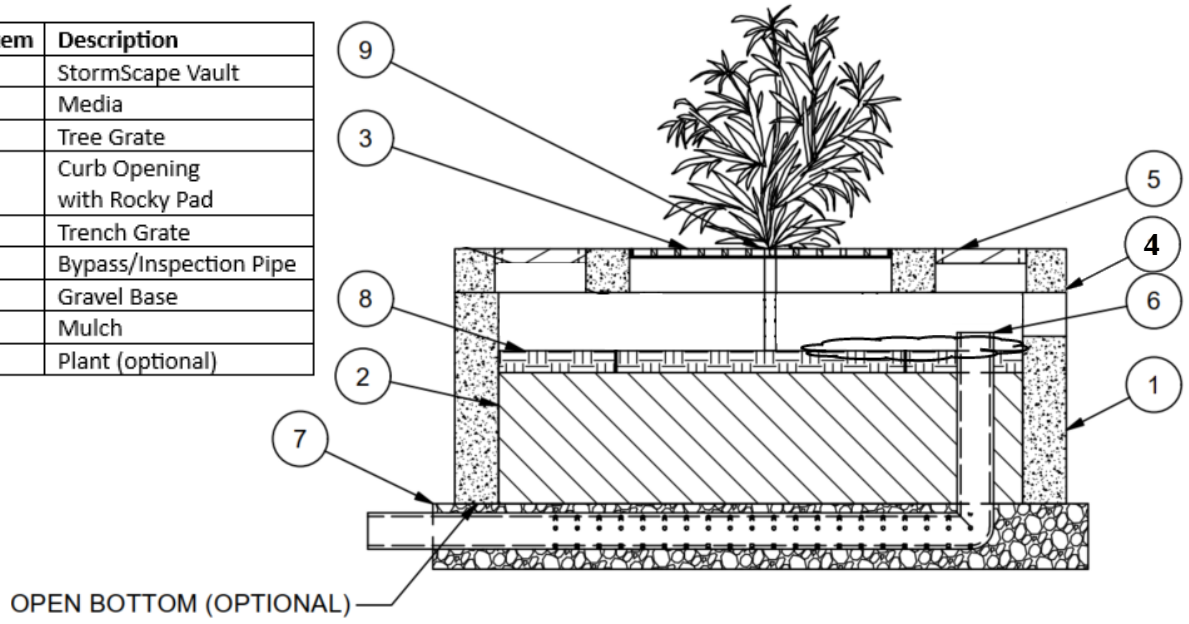


Figure 2 Diagram Showing the Components of a Typical StormScape HC Biofilter System

2 Laboratory Testing

The New Jersey Department of Environmental Protection (NJDEP) maintains a list of certified stormwater manufactured treatment devices (MTDs) that can be installed on newly developed or redeveloped sites to achieve stormwater treatment requirements for Total Suspended Solids (TSS). Manufactured treatment devices are evaluated for certification according to the *New Jersey Department of Environmental Protection Process for Approval of Use for Manufactured Treatment Devices (August 2021*) (hereafter referred to as "NJDEP Approval Process"). The NJDEP Approval Process requires that TSS treatment devices operating on filtration principles be tested according to the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device*, January 2022 (hereafter referred to as "2022 NJDEP Protocol"). In addition, the NJDEP Approval Process requires submittal of a Quality Assurance Project Plan (QAPP) to the New Jersey Corporation for Advanced Technology (NJCAT) for review and approval prior to testing to ensure that all laboratory procedures will be conducted in strict accordance with the NJDEP Protocol. The QAPP was submitted and approved by NJCAT in April 2023 prior to commencement of testing.

Testing was conducted from April through June 2023 by Hydro International ("Hydro") at the company's full-scale hydraulic testing facility in Portland, Maine. Since testing was carried out in-house, Hydro contracted with FB Environmental Associates of Portland, Maine to provide NJDEP Protocol-required third-party oversight. NJCAT reviewed and approved the qualifications of the FB Environmental Associates representatives who were present during all testing procedures. The test program was conducted in accordance with the 2022 NJDEP Protocol in two phases: removal efficiency testing and sediment mass loading capacity testing.

The 3-ft by 3-ft Hydro StormScape HC Biofilter is supplied as a complete system installed in an excavation that may or may not be exactly 36-inches by 36-inches. The single, full-scale test unit described in this verification report measures 35-inches wide by 35-inches long. All performance claims are reported per square foot of filtration surface.

2.1 Test Setup

A schematic drawing of the laboratory setup is shown in **Figure 3**. Clean water from a 2,000-gallon plastic supply tank is recirculated through the system. Opening a flow control valve allows water to flow through a 1 ½-inch pipe with a flow meter and flows upwards into a 6-inch pipe over the top of the StormScape. The influent pipe has an injection port where sediment can be introduced to the influent water before entering the test vessel. After traveling through the filter media, the flow is collected in 6-inch perforated discharge piping embedded in stone at the bottom of the StormScape HC. This discharge falls freely into a 200-gallon catch tank. Once the water elevation in the catch tank reaches a predetermined level, the treated water is pumped through a fine filtration system consisting of three pressurized canisters and returned to the supply tank. This

reduces background concentrations before returning the water to the supply tank. A control loop with a heater and heater pump maintains the water temperature in the supply tank.

Background samples were taken at the background sample port located vertically 44 inches upstream from where the water spills from the influent pipe. Before a sample was taken, the line was flushed to ensure influent background samples were representative. The time of each background and effluent sample was recorded so samples could be time stamped.

Water temperature was measured in the constant head tank with a thermocouple connected to a data acquisition unit. The constant head tank is a representative location to measure water temperature because all test water must pass through this tank immediately before passing through the rest of the test setup. The maximum temperature remained below 80 °F for the duration of testing. Temperature was recorded every 10 seconds. The thermocouple calibration was confirmed by the independent observer prior to testing.

During performance testing, test sediment was injected through an auger at a steady state upstream of the StormScape HC Biofilter Test Unit. The total mass and calibration samples of the injected test sediment were weighed manually. The head level in the Test Unit was measured with a pressure transducer that was threaded into the Test Unit at the top of the mulch layer. A data acquisition unit, the DATAQ DI-245, was connected to a computer system running WINDAQ software. The flow meter, pressure transducer, and thermocouple were connected to the DATAQ unit. Test data was recorded throughout the test, saved, and submitted with the test report.

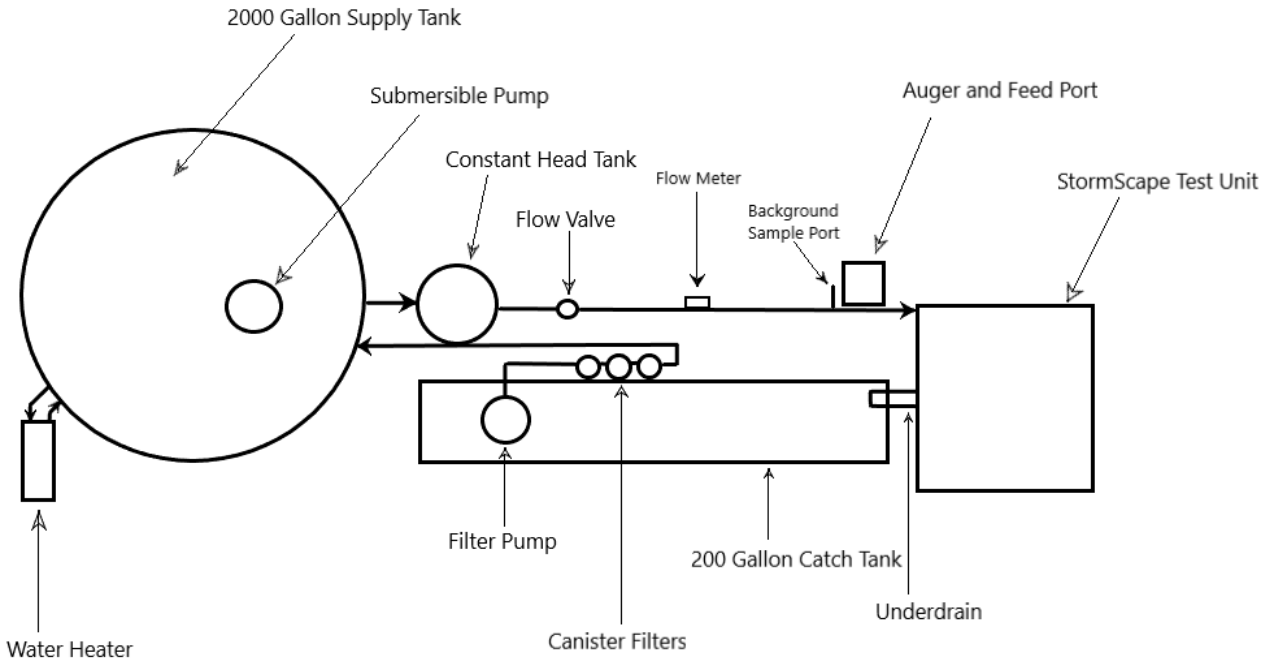


Figure 3 Laboratory Testing Arrangement Diagram

Test Unit Description

The test vessel included one full-scale 3-ft by 3-ft commercially available StormScape HC. The internal dimensions of the test vessel are 35-inches long by 35-inches wide. The 6-inch schedule 40 bypass pipe within the test unit reduces the functional area to 8.26 ft^2. Within the Test Unit, there are three layers of material identical to commercial installations. From bottom to top: 6 inches of stone surrounding the discharge pipe, 18 inches of filter media, and 3 +/- 1/4 inches of shredded hardwood mulch. A 19.5-inch by 19.5-inch rocky pad was positioned at the inlet of the unit to dissipate the entrance velocities. Key dimensions of the unit are shown in **Figure 4** and **Figure 5** and photos of the empty test vessel are shown in **Figure 6.**

Water was pumped from the supply tank through a 1 ½-inch control valve and flow meter up to the unit inlet. The flow meter was installed according to manufacturer's instructions and was in a fully submerged condition. The inlet was piped in and enters the Test Unit through a free discharge positioned above the media surface. The sediment injection port is on the crest of the inlet pipe, 10 ¼-inches from the end of the pipe. The Test Unit discharge port is on the adjacent side and the invert is 1-inch from the Test Unit floor. A background sample port controlled by a 1 ½-inch ball valve on the inlet piping is located 44 inches upstream vertically from the sediment injection port. The water level was monitored with a pressure sensor placed at the top of the mulch layer of filter media, approximately 6 inches from the top of the bypass pipe. The inlet and outlet pipes both had a diameter of 6 inches with a minimum slope of 1%. The Test Unit dimensions were confirmed by the independent observer prior to testing.

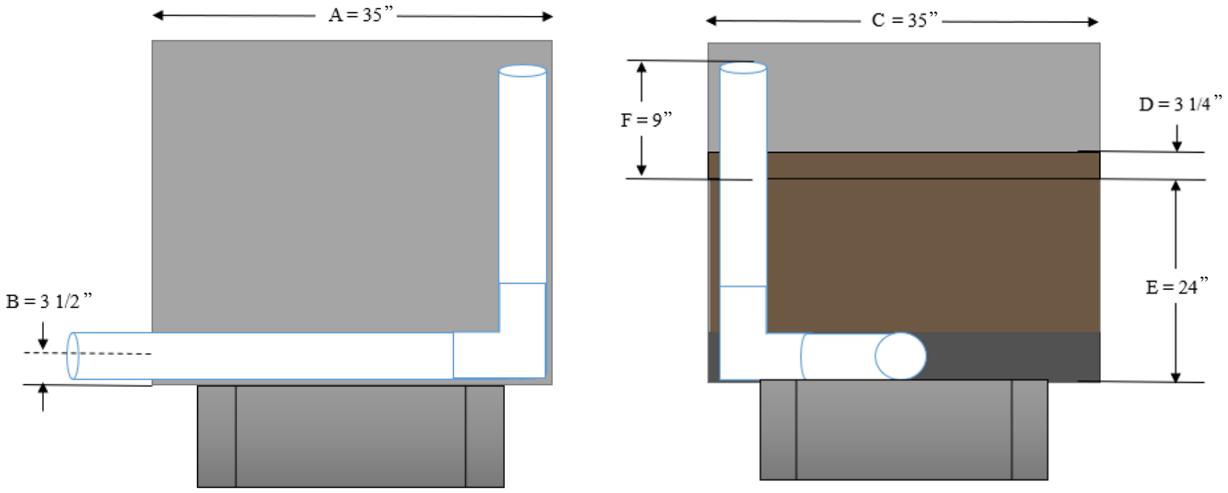
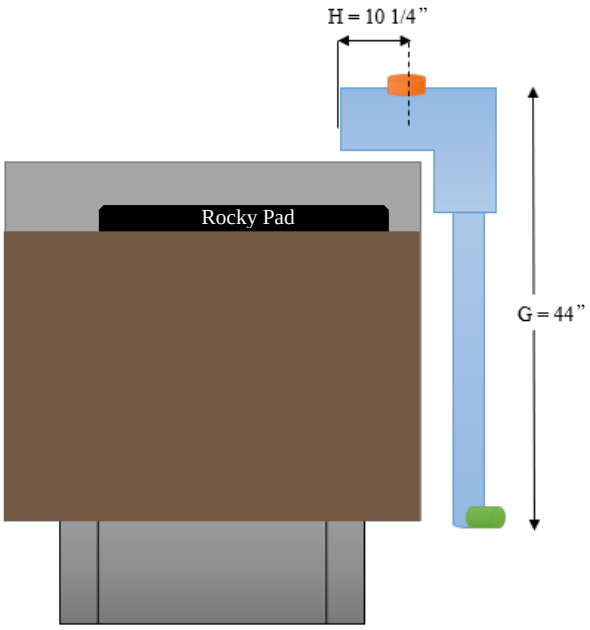


Figure 4 Key Dimensions of Test Vessel



A. Length of test vessel
B. Height of discharge pipe
C. Width of test vessel
D. Depth of mulch
E. Depth of media and coarse stone base
F. Height to bypass pipe from top of engineered media
G. Distance to background port from injection port
H. Distance to injection port from end of pipe

Figure 5 Key Dimensions of Test Vessel Piping

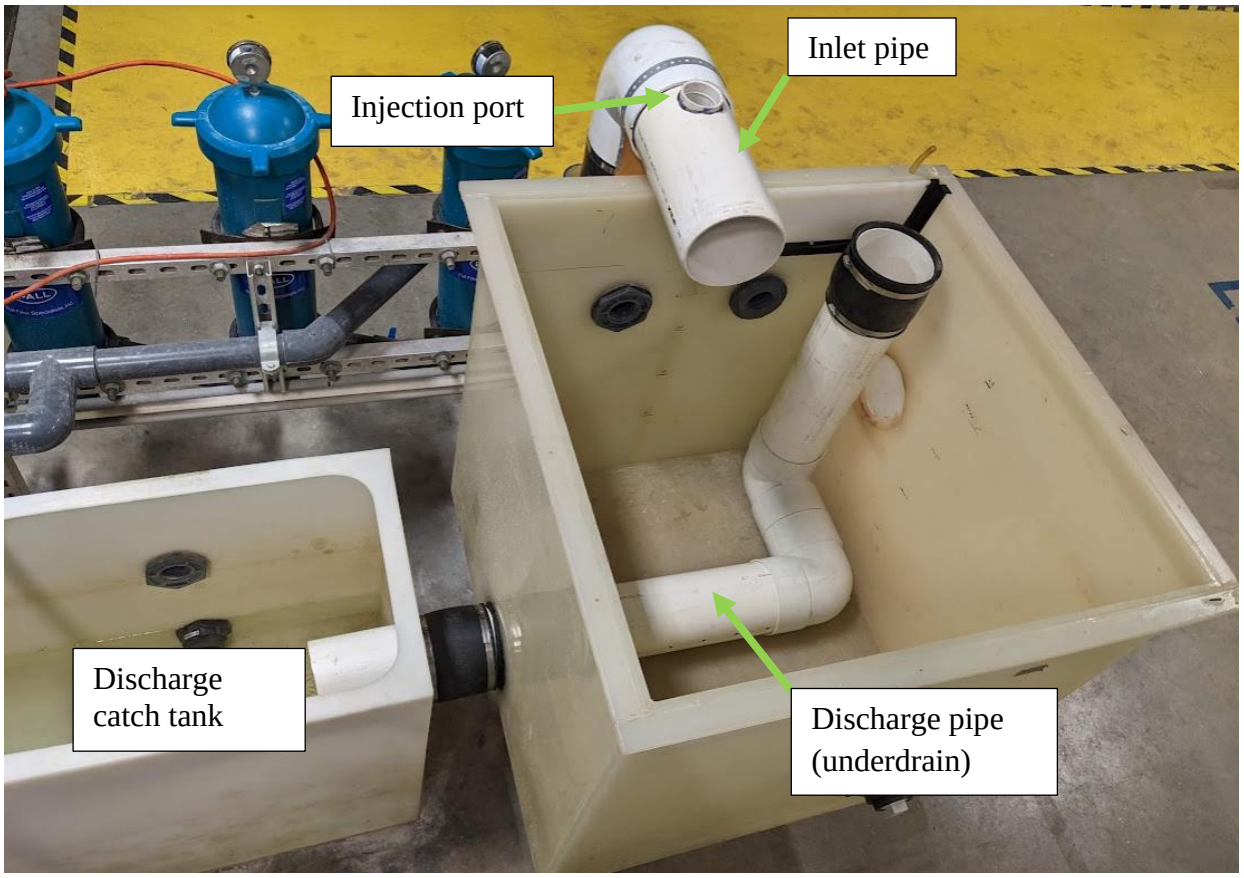


Figure 6 Detail Photo of the Inlet Pipe, Discharge Pipe, and Discharge Catch Tank

2.2 Test Sediment

The test sediment is a blend of commercially available silica sand grades. The particle size distribution was independently verified by GeoTesting Express (A2LA, AASHTO, and USACE Accredited and certified D6913 and D7928 by the state of Massachusetts) to show that the test sediment blend meets the specification as described in Section 4B of the NJDEP Protocol. The sediment blend was mixed by Hydro and stored in five-gallon buckets. The independent observer assisted in collecting three representative samples composited from each of the five-gallon buckets prior to the start of testing. The buckets were sealed by the independent observer until they were used for testing. Results of particle size gradation testing are shown in **Table 1** and **Figure 7** below. The D_{50} of this blend is 72 microns.

Table 1 Particle Size Distribution Results of Test Sediment Samples

Particle Size (µm)	% Finer				Test Sediment Average	Diff. from Protocol	Note
	NJDEP Protocol	Sample 1	Sample 2	Sample 3			
1000	100	100	100	100	100	0	
500	95	99	100	99	99	4	
250	90	94	95	95	95	5	
150	75	77	76	77	77	2	
100[1]	60	57	58	59	58	-2	1
75	50	48	51	52	50	0	
50[1]	45	43	44	44	44	-1	1
20[1]	35	34	34	32	33	-2	1
8[1]	20	22	22	22	22	2	1
5[1]	10	17	17	16	17	7	1
2[1]	5	8	8	8	8	3	1

Note 1: Data for these specific particle sizes were found via linear interpolation of GeoTesting Express' data.

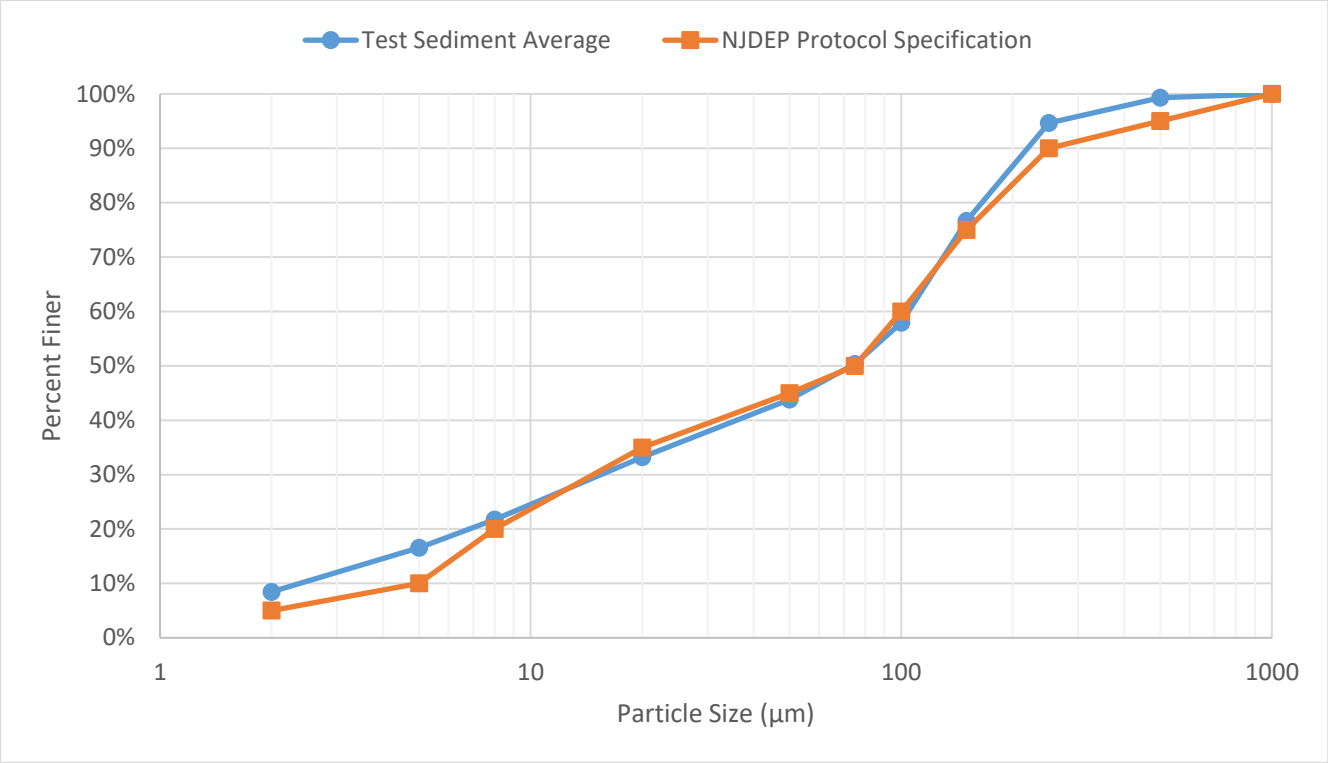


Figure 7 Average PSD of Test Sediment Compared to NJDEP Protocol Specification

2.3 Sediment Removal Efficiency Testing

The StormScape performance was determined by testing its sediment removal efficiency. In accordance with the NJDEP Protocol (Section 4), the sediment removal efficiency was tested in the laboratory by injecting the system with a known test sediment gradation and determining what proportion of the material was retained within the test unit. The removal efficiency testing occurred by repeatedly testing the unit at the maximum treatment flow rate (MTFR) for a minimum of ten repetitions as specified in the NJDEP Protocol.

Background samples were taken at the background sample port located upstream of the sediment injection port. Background samples were taken in correspondence with the odd numbered effluent samples (first, third, and fifth). The collection time was recorded for each background and effluent sample. Effluent sample concentrations were adjusted according to background sample concentration data.

The target influent concentration was 200 mg/L with a 10% tolerance. The test sediment feed rate and total mass of test sediment introduced during each test was a known quantity. Total mass introduced was determined by weighing the mass in the auger hopper at the start and end of the test with an Ohaus Defender 5000 (Model T51P) bench scale to the nearest 0.01 pound. Any sediment remaining in the inlet pipe after the sediment injection point was collected, dried, and

weighed. The mass of the remaining sediment was removed from calculations for final mass and noted in the results.

Three sediment feed calibration samples were taken from the injection port at the start, middle, and just prior to the conclusion of dosing during each test. Samples were taken by interrupting the dry sediment feed from the auger and weighing a one-minute sample with an Ohaus Pioneer (Model PA1602) laboratory balance to the nearest 0.01 gram. The concentration coefficient of variance (COV) of these samples was not to exceed 0.10.

A G2 turbine flow meter is located between the supply tank and the test tank, and the flow rate was recorded every 10 seconds. The average flow rate was maintained within 10% of the target flow and the COV was ≤ 0.03. The flow meter calibration was confirmed by the independent observer using the "time-to-fill" method prior to testing.

The water level in the test tank was measured with an Ashcroft pressure transducer located on the surface of the mulch layer of media. The pressure transducer calibration was confirmed by the independent observer prior to testing.

Water temperature was measured in the supply tank with a thermocouple connected to the data acquisition unit. The temperature was kept below the maximum of 80 °F. The temperature was recorded every 10 seconds via the data acquisition unit.

Once a constant feed of test sediment and flow rate were established, the first effluent sample was collected after a minimum of three MTD detention times had passed. The effluent samples were collected in 1-liter bottles from the underflow discharge pipe exit using the effluent grab sample method (described in Section 4H of the NJDEP Protocol) and time stamped.

The time interval between sequential samples was evenly spaced during the test sediment feed period to achieve six effluent samples. However, when the test sediment feed was interrupted for measurement, the next effluent sample was collected following a minimum of three MTD detention times. An example sampling schedule is given in **Table 2**. Tests were run for the minimum allotted time of 30 minutes.

A "detention time" is defined in Section 2 of the NJDEP Protocol as the operational wet volume divided by the target flow rate. However, it cannot be assumed that the operational wet volume is equivalent to the empty bed volume of the Test Unit. To accurately represent the wet volume, the drain down volume of the unit was calculated by the independent observer by measuring the increase in water level in the catch tank after each test from the time flow was shut off to when the Test Unit was completely drained. This volume was used to calculate the detention time in the Test Unit to ensure that the sampling schedule allowed for three detention times between samples for the following test. The drain down volume was sampled at two equally spaced volumes as the head fell in the Test Unit from the final driving head to the system's static water level.

Table 2 Example Sampling Time for TSS Removal Efficiency Testing

Sampling Schedule 100% MTFR			
Elapsed Time	Dry Feed Sample	Effluent Sample	Background Sample
0:00:00	1		
0:13:30		1	1
0:14:00		2	
0:14:30		3	2
0:15:00	2		
0:28:30		4	
0:29:00		5	3
0:29:30		6	
0:30:00	3		
1/3 Drain Down		7	
2/3 Drain Down		8	

All effluent samples were analyzed for TSS in accordance with ASTM 3977-97 (re-approval 2019) "Standard Test Methods for Determining Sediment Concentrations in Water Samples." Samples were sealed by the independent observer and delivered to Maine Environmental Laboratory (Accredited by the National Environmental Laboratory Accreditation Conference (NELAC) and certified by the states of Maine and New Hampshire) for processing.

In accordance with the January 14, 2022, version of the Filter Test Protocol, two spiked SSC samples were prepared for SSC testing to qualify Maine Environmental Lab for proficiency with ASTM 3977. (This analysis was completed on April 12, 2023, before the April 25 revision of the protocol requiring six proficiency samples.) The results are shown in **Table 3** below.

Table 3 Proficiency Test Results

Spike Conc. (mg/L)	Analyzed Conc. (mg/L)	Variance (mg/L)	Variance (%)	QA/QC (± 15%)
30	27	-3	10%	YES
45	40	-5	11%	YES

Removal efficiency was calculated per **Equation 1**. After the test, drain down water was captured in the catch tank and the volume was calculated using the dimensions of the tank and change in head.

$$\textit{Removal Eff.}(\%) = \frac{\left(\begin{matrix}\textit{Avg. Inf. TSS Conc.}\times\\ \textit{Total Vol. of Water during}\\ \textit{Sediment Addition}\end{matrix}\right) - \left(\begin{matrix}\textit{Avg. Adj. Eff. TSS Conc.}\times\\ \textit{Total Vol. of Effluent}\\ \textit{Water}\end{matrix}\right) - \left(\begin{matrix}\textit{Avg. Drain down TSS Conc.}\times\\ \textit{Total Vol. of Drain Down}\end{matrix}\right)}{\textit{Avg. Inf. TSS Conc.} \times \textit{Total Vol. of Test Water}} \times 100$$

Equation 1 Equation for Calculating Removal Efficiency

2.4 Sediment Mass Loading Capacity Testing

Upon completing the Removal Efficiency Testing, the NJDEP Protocol continued with Sediment Mass Loading Capacity Testing which was used to determine the maximum mass of test sediment that can be captured by the MTD at the MTFR prior to passing the maximum driving head. The influent flow rate was reduced to 90% of the MTFR and testing continued until the maximum driving head was again exceeded.

2.5 Scour Testing

Scour testing was not completed at this time. Currently, the StormScape is being submitted for offline installation approval.

2.6 Quality Objectives and Criteria

Samples sent to the external lab were shipped to the lab for analysis as soon as possible following each test. Auger sample weights analyzed in-house were observed by the third-party witness and were conducted immediately following sample collection.

A Chain of Custody form was used for externally analyzed samples to record sample containers and sampling date and time for each test. Copies of these forms are retained by Hydro. Sample bottles were labeled to identify the test number and sample type (background or effluent) which corresponded to the sample identification on the Chain of Custody form. All sample markings were verified by the third-party witness who also transported all samples to the laboratory.

Data was recorded and retained in accordance with standard laboratory procedures used at Hydro. Hard copies of all original data sets are retained onsite.

The following quality criteria were used to compare to results from individual tests:

- Background TSS concentrations not to exceed 20 mg/L
- Temperature of test water not to exceed 80 °F
- Variation in calculated influent concentration not to exceed 10% of target concentration

- COV of dry calibration samples not to exceed 0.10

The 2022 Protocol to *Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device* (updated 2023) published by the NJDEP specifies that flow rates used must not vary more than 10% from the target flow rate and must maintain a COV of ≤ 0.03. This guidance and prior filtration testing precedent were used as a guideline for the filter test program.

3 Performance Claims

Per the NJDEP Approval Process and based on the laboratory testing conducted for the StormScape, the following are the performance claims made by Hydro.

Total Suspended Solids (TSS) Removal Efficiency

The 8.26 ft^2 StormScape HC Biofilter when operating under a hydraulic loading rate of 30.86 gpm and evaluated in accordance with the NJDEP Protocol achieved a cumulative sediment removal efficiency of the NJDEP specified gradation of silica of 86.0% after the protocol requirement of 10 qualifying sediment removal efficiency test runs and 84.5% at the conclusion of the mass load capacity testing.

Effective Sedimentation Treatment Area

The Effective Sedimentation Treatment Area (ESTA) is the surface area of a 35-inch by 35-inch rectangular tank with a 6-inch schedule 40 bypass pipe occupying an area of 0.24 ft^2. This equates to 8.26 ft^2 feet of functional area.

Effective Filtration Treatment Area

In a horizontal bed filter, the Effective Filtration Treatment Area (EFTA) is equal to the Effective Sedimentation Treatment Area of 8.26 ft^2.

Maximum Treatment Flow Rate (MTFR)

The MTFR for the 8.26 ft^2 StormScape HC system tested equates to 30.86 gpm. For other unit sizes, the loading rate is 3.74 gpm/ft^2 or 360 inches per hour. The MTFR for a system sized at exactly 3-ft by 3-ft is 32.76 gpm.

Sediment Mass Load Capacity

Considering the change in operating head relative to the sediment mass captured, the 8.26 ft^2 StormScape HC has a mass loading capacity of 42.8 lbs (19.4 kg) per unit. For other unit sizes, the loading rate is 5.2 lbs per ft^2 of filtration area. The sediment load for a system sized at exactly 3-ft by 3-ft is 45.6 lbs.

Maximum Allowable Inflow Drainage Area

To ensure the drainage area and expected annual sediment load does not cause higher than intended bypass flows, the sediment mass capture capacity of 42.8 lbs per unit is used to limit the treatable drainage area per unit. Given the NJDEP Protocol requirements for "Maximum Allowable Inflow Drainage Area", the 8.26 ft^2 StormScape can effectively treat 0.071 acres at 600 lbs per acre of drainage area annually. For other unit sizes, the treatment rate is 0.009 acres (378 ft^2 of drainage area) per ft^2 of filtration area.

Wet Volume and Detention Time

The Wet Volume for each test was determined empirically by measuring the volume of water discharged from the unit after the test. This volume ranged from a minimum of 24.36 gallons to 55.67 gallons, generally increasing throughout the test program. Given a flow rate of 30.86 gpm, this equates to a Detention Time ranging from 0.79 minutes to 2.01 minutes.

4 Supporting Documentation

The NJDEP Procedure (NJDEP 2021) for obtaining verification of a stormwater manufactured treatment device (MTD) from the NJCAT requires that "copies of the laboratory test reports, including all collected and measured data; all data from performance evaluation tests; spreadsheets containing original data from all performance tests; all pertinent calculations; etc." be included in this section. This was discussed with NJDEP, and it was agreed that as long as such documentation could be made available by NJCAT upon request, it would not be prudent or necessary to include all this information in this verification report. This information was provided to NJCAT and is available upon request.

4.1 Sediment Removal Efficiency

During initial testing, 10 sediment removal efficiency tests were completed in accordance with the NJDEP Protocol. The target flow rate and influent sediment concentration were 30.86 gpm and 200 mg/L, respectively.

The data logger had a recording frequency of 10 seconds. The flow data has been summarized in **Table 4** and includes the compliance to the QA/QC acceptance criteria. The average flow rate for all removal efficiency tests was 30.77 gpm.

The maximum temperature data are summarized in **Table 5**. Influent sediment concentrations from calibration samples are summarized in **Table 6**, background sediment concentrations are summarized in **Table 7**, and effluent concentrations are summarized in **Table 8**, along with compliance to NJDEP protocol QA/QC criteria.

The remaining tables report all other parameters measured that are required to demonstrate compliance with NJDEP Protocol QA/QC criteria. **Table 9** summarizes the cumulative removal efficiencies for the first ten tests using the total mass added. The cumulative removal efficiency for tests 1-10 was 86.0%. **Table 9** shows the results of the removal drawdown mass escaped calculations.

Table 4 Removal Efficiency Flow Rates

Test #	Target Flow Rate (gpm)	Average Flow Rate (gpm)	QA/QC (± 10%)	COV	QA/QC (COV ≤ 0.03)
1	30.86	30.83	YES	0.003	YES
2	30.86	31.26	YES	0.016	YES
3	30.86	30.62	YES	0.004	YES
4	30.86	30.64	YES	0.003	YES
5	30.86	30.71	YES	0.003	YES
6	30.86	30.86	YES	0.003	YES
7	30.86	30.67	YES	0.003	YES
8	30.86	30.74	YES	0.003	YES
9	30.86	30.64	YES	0.004	YES
10	30.86	30.77	YES	0.004	YES

Table 5 Removal Efficiency Maximum Temperatures

Test #	Maximum Temp (F)	QA/QC (≤ 80F)
1	69.5	YES
2	72.8	YES
3	71.1	YES
4	67.5	YES
5	69.1	YES
6	73.4	YES
7	73.7	YES
8	73.8	YES
9	67.6	YES
10	68.6	YES

Table 6 Removal Efficiency Influent Sediment Concentrations

Test #	Target Conc. (mg/L)	Inf. Conc. (mg/L)	QA/QC (Var.<10%)	Feed Rate Samples (mg/s)			COV	QA/QC (COV<0.1)
1	200	191	YES	359.67	379.83	373.00	0.028	YES
2	200	190	YES	366.33	376.00	378.83	0.018	YES
3	200	191	YES	366.67	349.50	391.83	0.058	YES
4	200	196	YES	379.00	376.17	379.67	0.005	YES
5	200	212	YES	401.00	415.17	417.17	0.021	YES
6	200	199	YES	396.50	393.00	371.67	0.035	YES
7	200	197	YES	390.17	354.50	398.17	0.061	YES
8	200	195	YES	375.67	379.67	377.50	0.005	YES
9	200	197	YES	399.83	368.33	375.67	0.043	YES
10	200	211	YES	429.17	398.00	399.33	0.043	YES

Table 7 Removal Efficiency Background Sediment Concentrations

Test #	Background Samples (mg/L)			Mean (mg/L)	QA/QC (Max = 20 mg/L)
1	1.3	1.3	6.3	3.0	YES
2	6.2	6.2	10	7.5	YES
3	14	15	17	15	YES
4	5.4	5.1	8.1	6.2	YES
5	11	11	15	12	YES
6	5.6	5.6	8.4	6.5	YES
7	12	11	14	12	YES
8	17	17	19	18	YES
9	4.7	5.8	8.5	6.3	YES
10	13	13	14	13	YES

LOQ = 2.5 mg/L (Values below LOQ are designated as half the LOQ value)

Table 8 Removal Efficiency Effluent Concentrations

Test #	Effluent Samples (mg/L)						Mean (mg/L)
1	24	27	25	34	29	28	28
2	27	32	29	32	36	33	32
3	40	38	43	46	45	46	43
4	27	28	28	30	34	35	30
5	38	40	42	42	41	44	41
6	24	26	26	29	28	32	28
7	36	45	39	40	41	42	41
8	40	45	47	45	48	46	45
9	27	28	35	31	33	33	31
10	36	37	41	41	41	43	40

Table 9 Removal Efficiency Results

Test #	Inf. Conc. (mg/L)	Avg. Eff. Conc (mg/L)	Avg. Bkg. Conc (mg/L)	Avg. Adj. Eff. Conc. (mg/L)	Test Vol. (L)	Mass Added (kg)	Test Mass Escaped (kg)	Drawdown Mass Escaped (kg)	Cumulative Mass Captured (kg)	Test Removal Efficiency	Cumulative Removal Efficiency
1	193	28	3.0	25	3268	0.631	0.082	0.004	0.545	86.4%	86.4%
2	192	32	7.5	25	3313	0.636	0.083	0.004	1.094	86.3%	86.3%
3	182	43	15.3	28	3246	0.591	0.091	0.006	1.588	83.6%	85.5%
4	196	30	6.2	24	3248	0.637	0.078	0.004	2.143	87.1%	85.9%
5	220	41	12.3	29	3255	0.716	0.094	0.006	2.759	86.0%	85.9%
6	197	28	6.5	22	3270	0.644	0.072	0.004	3.327	88.2%	86.3%
7	194	41	12.3	29	3251	0.631	0.094	0.005	3.859	84.3%	86.0%
8	196	45	17.7	27	3258	0.639	0.088	0.006	4.404	85.3%	85.9%
9	197	31	6.3	25	3247	0.640	0.081	0.004	4.959	86.7%	86.0%
10	202	40	13	27	3261	0.659	0.088	0.005	5.525	85.9%	86.0%

Table 10 Removal Drawdown Mass Escaped Calculations

Test #	Drawdown Tank Volume (sq. ft.)	Drawdown Depth (in)	Drawdown Volume (cu. ft.)	Drawdown Volume (L)	Drawdown Samples (mg/L)		Avg. Drawdown Conc (mg/L)	Drawdown Mass Escaped (kg)
1	11.16	3.5	3.26	92	30	46	38	0.004
2	11.16	4.0	3.72	105	35	40	38	0.004
3	11.16	3.8	3.49	99	47	79	63	0.006
4	11.16	4.8	4.42	125	36	34	35	0.004
5	11.16	5.0	4.65	132	45	46	46	0.006
6	11.16	4.0	3.72	105	33	45	39	0.004
7	11.16	4.3	3.95	112	41	41	41	0.005
8	11.16	4.3	3.95	112	50	53	52	0.006
9	11.16	4.5	4.19	119	35	35	35	0.004
10	11.16	4.3	3.95	112	44	43	44	0.005

4.2 Sediment Mass Loading Capacity

The Sediment Mass Loading Capacity study was a continuation of the Removal Efficiency study. As required by the NJDEP Protocol, all aspects of the testing remained the same, except for the flow rate which was reduced to 90% of the MTFR after the maximum driving head was exceeded.

A maximum driving head of 6.25-inches was reached at test 31 and the flow rate was reduced to 90% of the MTFR (27.77 gpm) for tests 32-36. During test 36, the maximum driving head was exceeded again, and the test program was completed.

The relationship between removal efficiency and sediment mass loading is illustrated in **Figure 8**. A summary of the Sediment Mass Loading Capacity flow rate is shown in **Table 11**. Also included are recorded maximum temperatures (**Table 12**), influent concentrations (**Table 13**), background concentrations (**Table 14**), effluent concentrations (**Table 15**), removal efficiencies (**Table 16**) and drawdown mass escaped (**Table 17**). **Table 13** uses influent concentrations based on calibration samples and **Table 16** uses the total mass added for its influent concentrations.

Table 11 Mass Load Capacity Flow Rates

Test #	Target Flow Rate (gpm)	Average Flow Rate (gpm)	QA/QC (± 10%)	COV	QA/QC (COV ≤ 0.03)
11	30.86	30.66	YES	0.003	YES
12	30.86	30.43	YES	0.004	YES
13	30.86	30.70	YES	0.008	YES
14	30.86	30.83	YES	0.004	YES
15	30.86	30.60	YES	0.004	YES
16	30.86	30.85	YES	0.005	YES
17	30.86	30.70	YES	0.004	YES
18	30.86	30.81	YES	0.005	YES
19	30.86	30.77	YES	0.004	YES
20	30.86	30.81	YES	0.004	YES
21	30.86	30.74	YES	0.004	YES
22	30.86	30.60	YES	0.004	YES
23	30.86	30.65	YES	0.003	YES
24	30.86	30.73	YES	0.005	YES
25	30.86	30.62	YES	0.003	YES
26	30.86	30.82	YES	0.003	YES
27	30.86	30.84	YES	0.004	YES
28	30.86	30.67	YES	0.004	YES
29	30.86	30.60	YES	0.004	YES
30	30.86	30.55	YES	0.003	YES
31	30.86	30.99	YES	0.003	YES
32	27.77	27.63	YES	0.003	YES
33	27.77	27.74	YES	0.003	YES
34	27.77	27.75	YES	0.004	YES
35	27.77	27.72	YES	0.004	YES
36	27.77	27.66	YES	0.003	YES

Table 12 Mass Load Capacity Maximum Temperatures

Test #	Maximum Temp (F)	QA/QC (≤ 80F)
11	69.1	YES
12	66.1	YES
13	66.7	YES
14	67.8	YES
15	65.7	YES
16	66.7	YES
17	67.1	YES
18	66.3	YES
19	67.5	YES
20	66.1	YES
21	65.1	YES
22	69.9	YES
23	69.0	YES
24	70.7	YES
25	76.3	YES
26	69.0	YES
27	75.3	YES
28	73.2	YES
29	72.8	YES
30	70.7	YES
31	73.0	YES
32	69.4	YES
33	71.1	YES
34	71.9	YES
35	72.5	YES
36	71.6	YES

Table 13 Mass Load Capacity Influent Sediment Concentrations

Test #	Target Inf. (mg/L)	Avg. Inf. (mg/L)	QA/QC Var.<10%	Feed Rate Samples (mg/s)			COV	QA/QC COV<0.1
11	200	208	YES	413.50	393.83	400.50	0.025	YES
12	200	214	YES	413.83	398.83	419.83	0.026	YES
13	200	195	YES	388.17	371.17	374.00	0.024	YES
14	200	190	YES	383.00	366.83	360.67	0.031	YES
15	200	195	YES	378.50	371.00	378.83	0.012	YES
16	200	190	YES	381.83	350.83	376.83	0.045	YES
17	200	196	YES	380.17	368.50	392.33	0.031	YES
18	200	188	YES	370.83	362.83	364.50	0.012	YES
19	200	186	YES	367.17	361.33	352.33	0.021	YES
20	200	181	YES	366.00	352.50	335.17	0.044	YES
21	200	201	YES	394.00	393.17	384.67	0.013	YES
22	200	209	YES	399.50	413.00	397.17	0.021	YES
23	200	206	YES	386.33	419.00	392.33	0.044	YES
24	200	210	YES	395.83	427.17	398.83	0.042	YES
25	200	200	YES	392.50	385.67	378.50	0.018	YES
26	200	199	YES	395.17	386.17	376.67	0.024	YES
27	200	196	YES	384.83	396.17	364.33	0.042	YES
28	200	203	YES	380.33	374.50	420.83	0.064	YES
29	200	192	YES	384.50	367.17	363.17	0.031	YES
30	200	218	YES	413.83	424.17	420.33	0.012	YES
31	200	187	YES	383.83	353.17	360.17	0.044	YES
32	200	205	YES	356.83	355.17	359.17	0.006	YES
33	200	198	YES	350.00	347.67	341.50	0.013	YES
34	200	203	YES	353.50	357.83	356.17	0.006	YES
35	200	202	YES	343.33	357.33	361.17	0.027	YES
36	200	205	YES	366.50	372.67	334.67	0.057	YES

Table 14 Mass Load Capacity Background Sediment Concentrations

Test #	Background Samples (mg/L)			Mean (mg/L)	QA/QC (Max = 20 mg/L)
11	17	18	21	19	NO
12	3.0	3.7	7.5	4.7	YES
13	11	12	14	12	YES
14	18	17	20	18	YES
15	4.8	5.9	8.4	6.4	YES
16	11	11	14	12	YES
17	16	16	18	17	YES
18	3.5	4.5	8.5	5.5	YES
19	7.7	10	11	10	YES
20	12	13	16	14	YES
21	4.5	5.1	7.8	5.8	YES
22	10	7.6	11	10	YES
23	9.3	5.5	16	10	YES
24	4.6	4.3	8.4	5.8	YES
25	7.0	7.1	10.6	8.2	YES
26	8.4	9.6	13	10	YES
27	4.3	5.8	8.1	6.1	YES
28	6.6	8.0	11	8.5	YES
29	9.4	8.9	12	10	YES
30	15	16	22	18	NO
31	24	24	29	26	NO
32	5.4	5.0	7.8	6.1	YES
33	11	12	13	12	YES
34	16	15	17	16	YES
35	11	11	14	12	YES
36	21	19	25	22	NO

Table 15 Mass Load Capacity Effluent Concentrations

Test #	Effluent Samples (mg/L)						Mean (mg/L)
11	44	45	50	48	46	47	47
12	31	29	40	37	41	38	36
13	37	36	39	46	43	43	41
14	45	48	48	51	53	50	49
15	29	31	32	35	36	35	33
16	37	36	39	43	42	44	40
17	42	43	41	45	47	46	44
18	33	37	34	37	38	36	36
19	34	39	43	42	43	42	41
20	28	41	42	47	45	45	41
21	33	36	41	38	38	40	38
22	36	41	41	44	43	45	42
23	43	44	45	50	46	43	45
24	34	36	34	38	41	41	37
25	36	38	36	40	43	42	39
26	41	41	42	43	45	46	43
27	31	33	30	34	34	36	33
28	38	34	36	42	43	42	39
29	37	40	33	41	42	42	39
30	48	51	49	53	59	57	53
31	52	51	50	54	55	57	53
32	32	32	31	40	40	37	35
33	37	39	38	41	41	41	40
34	43	44	43	46	45	44	44
35	41	42	42	45	41	50	44
36	58	51	51	55	57	54	54

Table 16 Mass Load Capacity Removal Efficiency Results

Test #	Inf. Conc. (mg/L)	Avg. Eff. Conc (mg/L)	Avg. Bkg. Conc (mg/L)	Avg. Adj. Eff. Conc (mg/L)	Test Vol. (L)	Mass Added (kg)	Mass Escaped (kg)	Drawdown Mass Escaped (kg)	Cumulative Mass Captured (kg)	Test Eff.	Cumulative Removal Efficiency	Note
1-10						6.424	0.851	0.048	5.525		86.0%	
11	208	47	18.7	28	3250	0.676	0.091	0.006	6.104	85.7%	86.0%	1
12	214	36	4.7	31	3226	0.690	0.100	0.005	6.689	84.8%	85.9%	
13	200	41	12.3	29	3254	0.651	0.094	0.005	7.241	84.8%	85.8%	
14	190	49	18.3	31	3268	0.621	0.101	0.006	7.755	82.8%	85.6%	3
15	192	33	6.4	27	3243	0.623	0.088	0.004	8.286	85.2%	85.5%	
16	181	40	12.0	28	3270	0.592	0.092	0.006	8.780	83.4%	85.4%	
17	191	44	16.7	27	3254	0.622	0.088	0.008	9.306	84.6%	85.4%	
18	190	36	5.5	31	3266	0.621	0.101	0.004	9.822	83.1%	85.4%	
19	189	41	9.6	31	3261	0.616	0.101	0.005	10.332	82.8%	85.1%	
20	179	41	13.7	27	3266	0.585	0.088	0.007	10.822	83.8%	85.1%	2
21	198	38	5.8	32	3258	0.645	0.104	0.005	11.358	83.1%	85.0%	
22	208	42	9.5	33	3244	0.675	0.107	0.007	11.919	83.1%	84.9%	
23	208	45	10.3	35	3249	0.676	0.114	0.007	12.474	82.1%	84.8%	
24	207	37	5.8	31	3257	0.674	0.101	0.006	13.041	84.1%	84.7%	
25	202	39	8.2	31	3246	0.656	0.101	0.008	13.588	83.4%	84.7%	
26	199	43	10.3	33	3266	0.650	0.108	0.007	14.123	82.3%	84.6%	
27	203	33	6.1	27	3269	0.664	0.088	0.007	14.692	85.7%	84.6%	3
28	206	39	8.5	31	3251	0.670	0.101	0.007	15.254	83.9%	84.6%	
29	188	39	10.1	29	3243	0.610	0.094	0.007	15.763	83.4%	84.5%	
30	219	53	17.7	35	3238	0.709	0.113	0.011	16.348	82.5%	84.5%	1

Test #	Inf. Conc. (mg/L)	Avg. Eff. Conc (mg/L)	Avg. Bkg. Conc (mg/L)	Avg. Adj. Eff. Conc (mg/L)	Test Vol. (L)	Mass Added (kg)	Mass Escaped (kg)	Drawdown Mass Escaped (kg)	Cumulative Mass Captured (kg)	Test Eff.	Cumulative Removal Efficiency	Note
31	188	53	25.7	27	3285	0.618	0.089	0.013	16.864	83.5%	84.5%	1
32	205	35	6.1	29	2928	0.600	0.085	0.007	17.372	84.7%	84.5%	
33	201	40	12	28	2940	0.591	0.082	0.007	17.874	84.9%	84.6%	
34	206	44	16	28	2942	0.606	0.082	0.008	18.390	85.1%	84.6%	
35	206	44	12	32	2938	0.605	0.094	0.011	18.890	82.6%	84.5%	
36	209	54	21.7	32	2932	0.613	0.094	0.012	19.397	82.7%	84.5%	1

Note 1: At least one background concentration out of specification.

Note 2: Influent concentration out of specification.

Note 3: Sediment remaining in influent pipe at the conclusion of tests. Mass recorded (1.1 g) and removed from the total mass added when calculated removal efficiency.

Mass counted towards total cumulative mass captured but not used in cumulative removal efficiency calculations.

Table 17 Capacity Drawdown Mass Escaped Calculations

Test #	Drawdown Tank Volume (sq. ft.)	Drawdown Depth (in)	Drawdown Volume (cu. ft.)	Drawdown Volume (L)	Drawdown Samples (mg/L)		Avg. Drawdown Conc (mg/L)	Drawdown Mass Escaped (kg)
11	11.16	4.3	4	112	51	55	53	0.006
12	11.16	4.8	4	125	38	47	43	0.005
13	11.16	4.5	4	119	45	44	45	0.005
14	11.16	4.8	4	125	51	52	52	0.006
15	11.16	4.0	4	105	36	35	36	0.004
16	11.16	5.3	5	138	46	41	44	0.006
17	11.16	6.0	6	158	45	55	50	0.008
18	11.16	4.0	4	105	38	41	40	0.004
19	11.16	4.0	4	105	43	50	47	0.005
20	11.16	5.3	5	138	45	51	48	0.007
21	11.16	4.8	4	125	39	44	42	0.005
22	11.16	5.5	5	145	44	50	47	0.007
23	11.16	5.5	5	145	49	49	49	0.007
24	11.16	5.5	5	145	41	46	44	0.006
25	11.16	4.9	5	129	51	70	61	0.008
26	11.16	5.8	5	151	48	50	49	0.007
27	11.16	6.3	6	165	38	41	40	0.007
28	11.16	6.0	6	158	45	48	47	0.007
29	11.16	6.0	6	158	42	46	44	0.007
30	11.16	7.5	7	198	56	59	58	0.011
31	11.16	7.8	7	204	63	61	62	0.013
32	11.16	4.1	4	109	60	68	64	0.007
33	11.16	5.3	5	140	46	52	49	0.007
34	11.16	5.7	5	150	54	58	56	0.008
35	11.16	7.8	7	204	51	55	53	0.011
36	11.16	8.0	7	211	58	58	58	0.012

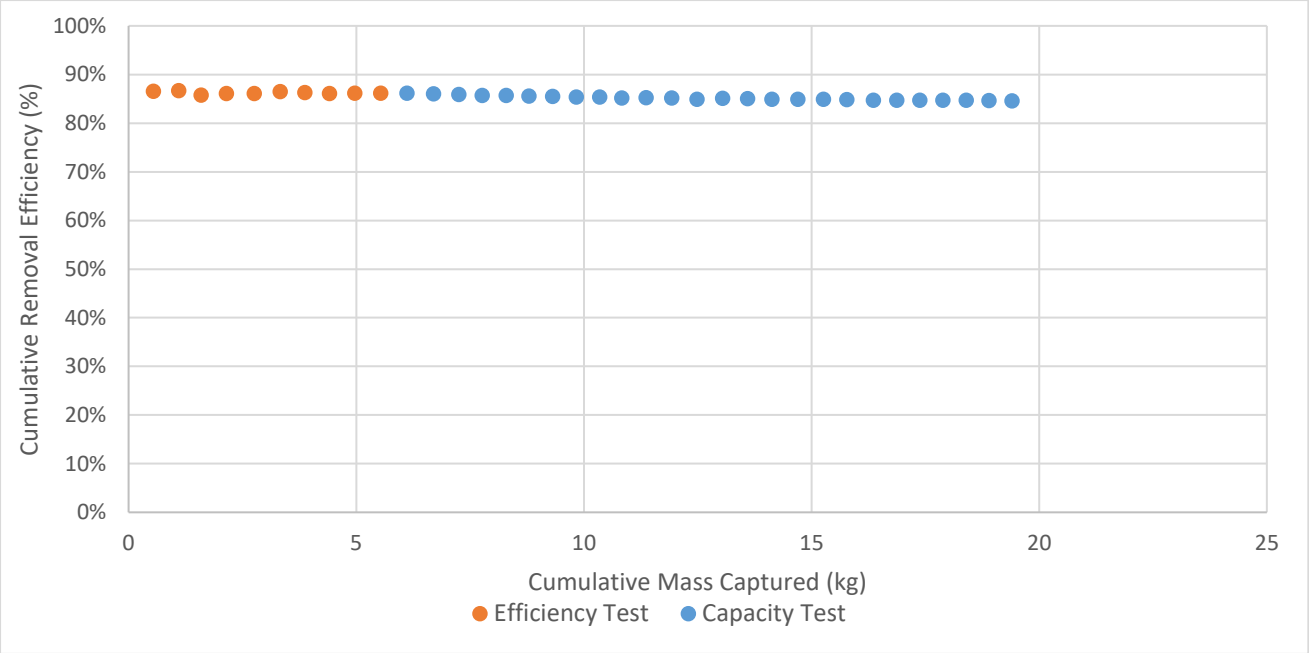


Figure 8 Sediment Mass Load Captured vs Removal Efficiency

4.3 Filter Driving Head

The driving head is defined as the vertical distance between the media level and the water level measured at the end of a test. Thus, the filter driving head was measured from the top of the media and was observed to increase with sediment mass load. This relationship is shown in **Table 18** and **Table 19** and in **Figure 9**.

Table 18 Removal Efficiency Driving Head Summary

Test #	Head Level (in)	Cumulative Mass Captured (kg)
1	0.121	0.545
2	0.016	1.094
3	0.121	1.588
4	0.016	2.143
5	0.016	2.759
6	0.016	3.327
7	0.016	3.859
8	0.225	4.404
9	0.121	4.959
10	0.225	5.525

Table 19 Mass Load Capacity Driving Head Summary

Test #	Head Level (in)	Cumulative Mass Captured (kg)
1-10		5.525
11	0.225	6.104
12	0.016	6.689
13	0.121	7.241
14	0.642	7.755
15	1.164	8.286
16	2.728	8.780
17	3.146	9.306
18	0.851	9.822
19	1.059	10.332
20	2.937	10.822
21	3.354	11.358
22	3.041	11.919
23	3.041	12.474
24	2.937	13.041
25	3.459	13.588
26	3.563	14.123
27	3.771	14.692
28	3.876	15.254
29	3.667	15.763
30	6.066	16.348
31	6.275	16.864
32	3.354	17.372
33	6.066	17.874
34	5.962	18.390
35	5.962	18.890
36	6.484	19.397

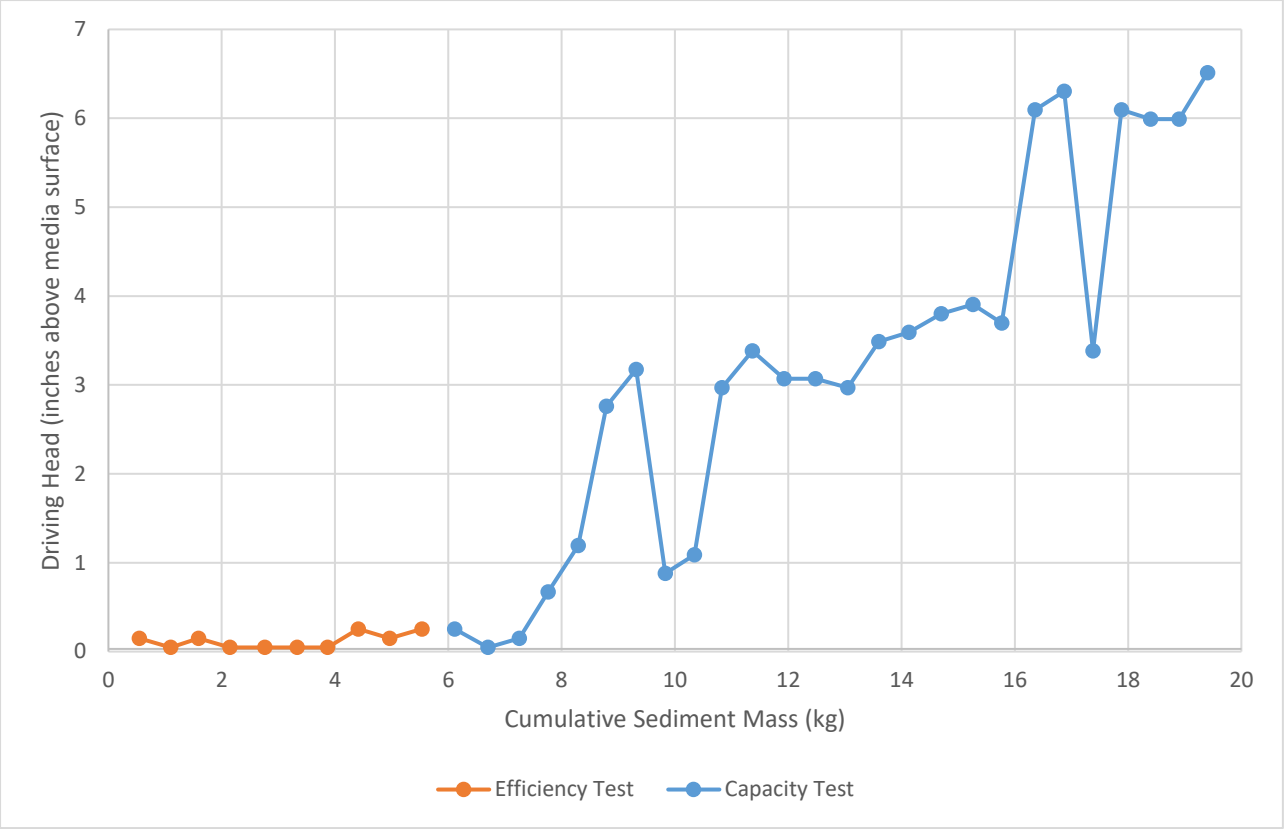


Figure 9 Sediment Mass Load Captured vs Driving Head

5 Design Limitations

If the StormScape HC Biofilter is designed and installed correctly, there is minimal possibility of failure when maintenance is performed at the recommended schedule frequency. The system is designed to convey stormwater up to the maximum flow rate of the contributing surface drainage area. Similar to any other correctly designed treatment technology, a change in the characteristics of the contributing drainage area can lead to poor performance. An increase in imperviousness can result in higher peak flows which can exceed the treatment capacity of the StormScape. A change in land use can result in higher solids loading or a change in the type of stormwater pollutants entering the StormScape. Extraordinarily high solids loading could result in very frequent maintenance intervals. Different stormwater pollutants may not be treatable with the engineered media originally specified. Caution should be used during the design of any stormwater treatment system if changes in the contributing area are expected.

Required Soil Characteristics

All StormScape HC Biofilters are pre-assembled in concrete structures manufactured by ISO certified precast facilities in accordance with all applicable ASTM specifications and regional regulations. Subsequently all systems are designed to accommodate any site-specific limitations or constraints imposed by soil type, conditions or characteristics.

Slope

The StormScape HC Biofilter discharge piping permanently mounts in a fixed horizontal position protruding from the filtration media. In configurations where the pipe stub connects directly to the outlet pipe, slope is restricted to that permitted by the connecting coupling.

Maximum Filtration Rate

The maximum filtration rate of each StormScape HC Biofilter system is contingent on the surface area of the biofilter. Given the test results, the StormScape HC Biofilter will be sized to ensure the maximum filtration rate will be 3.74 gpm per ft^2 of filtration area. This is equal to an infiltration rate of 360 inches per hour.

Maintenance Requirements

StormScape HC Biofilter maintenance requirements vary according to site characteristics such as runoff area, types of surfaces (e.g., paved and/or landscaped), site activities (e.g., short-term or long-term parking), and site maintenance (e.g., sanding and sweeping). At a minimum, Hydro recommends inspection and maintenance should be conducted at intervals of no more than six months during the first year of operation. Observations made during these initial service events may be used to derive a long-term site-specific inspection and maintenance program.

Operating Head

The maximum driving head for the StormScape HC Biofilter is 6.25 inches above the top of the mulch surface. This is the maximum head required to maintain the MTFR and annual sediment load.

Installation Limitations

Hydro provides installation instructions as well as product specific manufacturer specifications with each project submittal. Hydro provides remote technical assistance for contractors as well as offers onsite engineering to facilitate and oversee proper installation.

Configurations

The StormScape HC Biofilter is available in a range of sizes and aspect ratios outlined in the Verification Appendix.

Structural Load Limitations

All StormScape HC Biofilters are pre-assembled in concrete structures manufactured by ISO certified precast facilities in accordance with all applicable ASTM specifications and/or site-specific loading requirements. The precast structures can be provided with a minimum wall thickness sufficient to sustain HS20-44 loading requirements.

Pretreatment Requirements

The StormScape HC Biofilter is designed as a stand-alone device and requires no additional upstream treatment. However, for source control applications with high pollutant loads, inclusion of pretreatment can extend filter media longevity and reduce annual service requirements.

Limitations on Tailwater

Tailwater conditions are carefully evaluated for each application. For the system to operate appropriately, a free discharge is required.

Depth of Seasonal High Water Table

The StormScape HC Biofilter is designed to be connected as part of a surface drainage system. Because the bottom of the unit may be open, the discharge pipe should be installed above any seasonal high water table.

6 Maintenance

Inspection

The frequency of inspection and maintenance can be determined in the field after installation. Based on site characteristics such as contributing area, types of surfaces (e.g., paved and/or landscaped), site activities (e.g., short-term or long-term parking), and site maintenance (e.g., sanding and sweeping), inspection and maintenance should be conducted at intervals of no more than six months during the first year of operation. Typically, maintenance is recommended once per year thereafter.

Site personnel can determine if the Hydro StormScape HC Biofilter media is blinded by removing the trench grate covers and observing if any water is present in the vault. Any observed water pooling in the unit after 24 hours of a storm indicates that StormScape HC Biofilter is not properly draining and the media is clogged. Water pooling in the unit will be present and have an observable elevation above the top of the mulch.

The site-specific solids loading rate accumulating in the mulch and engineered filtration media will be determined during the first year of Hydro StormScape High Capacity Biofilter operation. After completion of the first year of operation, the site-specific inspection and maintenance intervals for replacing the mulch and top surface of media will be established. Removal of floatables should occur at the same frequency unless the first year of operation indicates otherwise. Keeping to the established maintenance intervals is critical for long-term performance of any biofiltration system.

Maintenance Procedures

The removable grates at the top of the StormScape HC Biofilter provide access to the surface of the media for maintenance personnel to access the vessel without any special tools or confined space protocols to replace the mulch and top inch of media, as well as remove any accumulated floatables.

Maintenance activities include inspection, floatables removal, sediment removal, and replacement of the top inch of media and mulch. Depending on the site, some maintenance activities are required at a greater frequency than others. All inspection and maintenance activities should be recorded in an inspection and maintenance log.

Good housekeeping practices upstream of the StormScape HC Biofilter can significantly extend media life. For example, sweeping paved surfaces, collecting leaves and grass trimmings, and employing erosion control practices will reduce loading to the system. Construction stormwater discharge flows should not be directed to the system until all construction activities are complete and site stabilization is ensured to prevent inappropriate clogging of the device.

Solids Disposal

Sediment, floatables, gross debris, and spent media can generally be disposed of at a local landfill in accordance with local regulations. The toxicity of the residues produced will depend on the activities in the contributing drainage area. Testing of the residues may be required if they are considered potentially hazardous.

In all cases, local regulators should be contacted about disposal requirements. The StormScape HC Biofilter O&M manual can be accessed at the link below:
https://hydro-int.com/en/resources/stormscapeHC-installation-maintenance-manual.

7 Statements

The following signed statements from the manufacturer (Hydro International), third-party observer (FB Environmental Associates), and NJCAT are required to complete the NJCAT verification process. In addition, it should be noted that this report has been subjected to public review (e.g., stormwater industry) and all comments and concerns have been satisfactorily addressed.

Stormwater Solutions

Hydro International

Turning Water Around...®

November 20, 2023

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

Re: Manufacturers Statement of Compliance

Dear Dr. Magee:

Hydro International has completed verification testing for the StormScape green infrastructure filter in accordance with the *"New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device"* (January 14, 2022). As required by the *"NJDEP Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology (NJCAT)"*, this letter serves as Hydro International's statement that all procedures and requirements identified in the aforementioned protocol and process document were met or exceeded.

Specifically, a 3x3 StormScape was tested at Hydro International's laboratory in Portland, Maine for efficacy and sediment mass loading. To ensure that all procedures and methods were met, a test plan was completed and submitted to NJCAT for review and approval, all testing and sample collection was conducted under the direct supervision of the independent observer, FB Environmental Associates, and all collected samples were sent to either of two independent and certified laboratories; GeoTesting Express for particle size analysis or Maine Environmental Laboratories for measuring suspended solid concentrations. With this in mind, the preparation of the verification report and the documentation contained therein fulfill the submission requirements of the process document and protocol.

If you have any questions or comments regarding the verification please do not hesitate to contact us.

Sincerely,

Jeremy Fink, PE
Pr. Product Development Engineer

Hydro International (Stormwater), 94 Hutchins Drive, Portland ME 04102
Tel: (207) 756-6200 Fax: (207) 756-6212 Web: www.hydro-int.com

STATEMENT OF DISCLOSURE | THIRD PARTY OBSERVER

TO: Jeremy Fink, Hydro International
FROM: Forrest Bell, FB Environmental Associates (FBE)
SUBJECT: Third Party Observer Statement of Disclosure under New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device
DATE: November 20, 2023
CC: Margaret Mills and Luke Frankel, FB Environmental Associates (FBE)

Statement of Disclosure – Third Party Observer

FB Environmental has no financial conflict of interest regarding the test results of the stormwater device testing outlined in the *NJCAT Technology Verification: StormScape High Capacity* report by Hydro International, dated August 2023 with the July 20, 2023 edits incorporated.

Disclosure Record

FB Environmental has provided the service of third-party observer for tests performed by Hydro International in April through June of 2023. The tests assessed the removal efficiency of the StormScape High Capacity system to prepare for its designated use of capturing particulate pollutants entering the system as part of surface runoff. Beyond this, FB Environmental and Hydro International have no relationships that would constitute a conflict of interest. For example, we have no ownership stake, do not receive commissions, do not have licensing agreements, and do not receive funds or grants beyond those associated with the testing program.

Forrest Bell ~ FB Environmental Associates

11/20/2023
Date

STATEMENT OF WITNESS | THIRD PARTY OBSERVER

TO: Jeremy Fink, Hydro International
FROM: Forrest Bell, FB Environmental Associates (FBE)
SUBJECT: Third Party Witness of Hydro International StormScape High Capacity
DATE: November 20, 2023
CC: Margaret Mills and Luke Frankel, FB Environmental Associates (FBE)

Statement of Third Party Observer

FB Environmental served as the third-party observer for tests performed on the StormScape High Capacity system by Hydro International in April through June of 2023 to achieve certification through the New Jersey Department of Environmental Protection (NJDEP) according to the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January, 2022)*. The test was performed by Hydro International staff at their laboratory located at 94 Hutchinson Drive in Portland, Maine. A member of our staff verified compliance with the laboratory test protocol above, and our staff member was physically present to observe the full duration of all testing procedures including sample and equipment calibrations.

We have also reviewed the data, calculations, and conclusions associated with the removal efficiency testing in the *NJCAT Technology Verification: StormScape High Capacity* report by Hydro International, dated August 2023 with the July 20, 2023 edits incorporated. We state that they conform to what we saw during our supervision as a third-party observer.

Forrest Bell ~ FB Environmental Associates

11/20/2023
Date

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

September 20, 2023

Gabriel Mahon, Chief
NJDEP
Bureau of Non-Point Pollution Control
Division 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 conducted on a 3-ft by 3-ft, commercially available Hydro StormScape High Capacity Biofilter, and observed by FB Environmental Associates, Portland, ME the test protocol requirements contained in the "*New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device*" (NJDEP Filtration Protocol, January 14, 2022) were met or exceeded**.** Specifically:

Test Sediment Feed

The mean PSD of the StormScape HC Biofilter test sediment complied with the PSD criteria established by the NJDEP Filtration protocol. The removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be slightly finer than the sediment blend specified by the protocol (<75µm); the test sediment d_{50} was approximately 72 microns.

Removal Efficiency (RE) Testing

Thirty-six (36) removal efficiency test runs were completed in accordance with the NJDEP test protocol. Ten (10) of the 36 test runs were conducted during removal efficiency testing and 26 tests were conducted during mass loading testing. The target flow rate and influent sediment concentration were 30.86 gpm and 200 mg/L for the removal efficiency testing. The StormScape HC Biofilter achieved a cumulative removal efficiency of 86.0% for runs 1 through 10 at the MTFR of 30.86 gpm.

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted as a continuation of removal efficiency testing. Mass loading test runs were conducted using identical testing procedures and flow rate target as those used in the removal efficiency runs, except that the flow rate was reduced to 90% of the MTFR after the maximum driving head was exceeded. Testing concluded after 26 mass loading test runs. The Hydro StormScape HC Biofilter achieved a cumulative mass removal efficiency of 84.5% over the 36 runs.

The total influent mass loaded through Run 36 was 50.7 lbs (23.0 kg) and the total mass captured by the Hydro StormScape HC Biofilter was 42.8 lbs (19.4 kg). This is equivalent to a sediment mass loading capacity of 5.2 lbs/ft^2 of effective filtration treatment area.

No maintenance was performed on the test system during the testing program.

Scour Testing

Scour testing was not completed at this time. Currently, the Hydro StormScape HC Biofilter is being submitted for offline installation approval.

Sincerely,

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

8 References

ASTM (2017). *Standard Test Methods for Particle-Size Distribution (Gradation of Soils Using Sieve Analysis*, Annual Book of ASTM Standards, D6913/D6913M-17, Vol. 4.09..

ASTM (2019). *Standard Test Methods for Determining Concentrations in Water Samples*, Annual Book of ASTM Standards, D3977-97, Vol. 11.02.

NJDEP (2021). *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology*. Trenton, NJ. August 4, 2021.

NJDEP (2022). *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device.* Trenton, NJ. January 14, 2022 (Updated April 24, 2023).

VERIFICATION APPENDIX

Introduction

- Manufacturer – Hydro International, 94 Hutchins Drive, Portland, ME 04102. *General Phone: (207)756-6200*. *Website:* www.hydro-int.com/us.
- MTD – Typical StormScape HC Biofilter Design Specifications are shown in **Table A-1**.
- TSS Removal Rate – 80%
- Media – Sand/Organics Mix and Mulch
- Offline installation

Detailed Specification

- StormScape HC Biofilter sizes, MTFRs, and maximum inflow drainage areas per NJDEP sizing requirements are attached (**Table A-1**).
- StormScape HC Biofilter O&M Manual can be accessed at: https://hydro-int.com/en/resources/stormscapeHC-installation-maintenance-manual.
- This verification does not extend to the enhanced removal rates under NJAC 7:8-5.5 through the addition of settling chambers (such as hydrodynamic separators) or media filtration practices (such as a sand filter).

Table A-1 StormScape HC Biofilter Design Specifications

Filter Size (ft)	Width (ft)	Length (ft)	Area (sq.ft.)	MTFR (gpm)	Max Drain Area (AC)	EFTA (sq.ft.)	MTFR/ EFTA	ESA (sq.ft.)	ESA/ EFTA	AC/EFTA
Tested	*2.92*	*2.92*	*8.5*	*30.86*	*0.071*	*8.26*	*3.74*	*8.26*	*1*	*0.009*
3x3	3	3	9	32.76	0.075	8.76	3.74	8.76	1	0.009
4x6	4	6	24	88.86	0.204	23.76	3.74	23.76	1	0.009
4x8	4	8	32	118.78	0.273	31.76	3.74	31.76	1	0.009
4x10	4	10	40	148.70	0.342	39.76	3.74	39.76	1	0.009
4x12	4	12	48	178.62	0.411	47.76	3.74	47.76	1	0.009
6x6	6	6	36	133.74	0.307	35.76	3.74	35.76	1	0.009
6x8	6	8	48	178.62	0.411	47.76	3.74	47.76	1	0.009
6x10	6	10	60	223.50	0.514	59.76	3.74	59.76	1	0.009
6x12	6	12	72	268.38	0.617	71.76	3.74	71.76	1	0.009