NJCAT TECHNOLOGY VERIFICATION

StormTrap StormSettler® Hydrodynamic Separator - OK-110 Equivalent PSD

StormTrap LLC

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Introduction

Previous laboratory testing has demonstrated that the StormSettler® manufactured treatment device (MTD) developed by StormTrap, LLC can achieve a weighted TSS removal rate of at least 50% based on the *New Jersey Department of Environmental Protection (NJDEP) hydrodynamic separator MTD 2021 protocol*[1]. The sediment specified by the NJDEP protocol has a particle size range of 1 - 1000 µm and a median particle size (d_{50}) of 75 µm. Many jurisdictions across North America are interested in stormwater MTD removal performance of sediment with an alternative median particle size. Since there are no widely accepted models for predicting capture of sediment of a different particle size distribution, additional testing was undertaken to look at capture of sediment with an alternative particle size distribution.

Testing was done with a coarser test sediment (PSD having a d_{50} of 124 µm rather than 75 µm). While 8 mass capture runs were conducted, only 5 conformed to the flow rates required in the NJDEP test protocol. The other three runs were used to gather additional information: one to determine the 100% capture flow rate and two to confirm the 80% capture flow rate and provide an estimate of run-to-run variability. Since the StormSettler unit tested and the test set up were identical to those used for the recently completed NJDEP certification testing (NJCAT 2022), and the MTFR claimed is lower that the certified MTFR, it was unnecessary to repeat the scour and hydraulic testing.

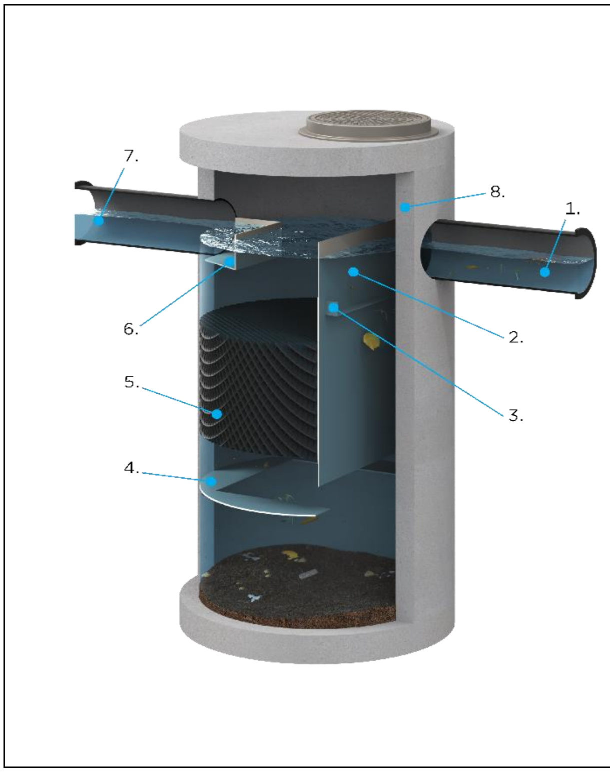
As a result of the use of coarser sediment and the deviation from the flow rate requirements in the NJDEP protocol, these results do not qualify for NJDEP certification. ***Therefore, the performance testing was for NJCAT verification only.***

1. Description of Technology

The StormSettler is a patent pending manufactured treatment device, specifically a hydrodynamic separator (HDS), developed by StormTrap. The StormSettler is designed to remove sediment from runoff using inclined tube settling technology. An inclined tube settler enhances settling by providing many small channels that reduce the settling distance, and therefore the settling time required for a particle to be captured. The settling pack in each StormSettler model occupies 75% of the cross-sectional area of the separator, while the internal dimensions of the settling tubes remain constant. The number of settling tubes and the settling area of the settling pack scales linearly with pack area, ensuring identical settling times in all models. If floatables capture is required, the system can be fitted with a net or basket in consultation with StormTrap. This configuration was not tested; hence, no performance claim is made for that particular application.

In addition to the inclined tube settler, also called an enhanced settling pack, the StormSettler employs several flow modifiers to control the flow and optimize performance. The flow modifiers were designed using computational fluid dynamics (CFD) to create an optimal flow distribution that increases removal while decreasing scour potential. The internal components are typically fabricated using fibreglass parts, however in some applications the components may be plastic or metal. StormSettler internals are typically housed within a concrete structure.

Figure 1 shows the StormSettler in a low flow condition and **Figure 2** shows the StormSettler in a high flow condition (See also **Figure 3**). The view is reversed from **Figure 1** to **Figure 2** to show the internal components more clearly.



1. Inlet
2. Vertical baffle
3. Vortex disruptor
4. Flow modifiers
5. Enhanced Settling pack
6. Outlet control diverter
7. Outlet
8. Tank wall

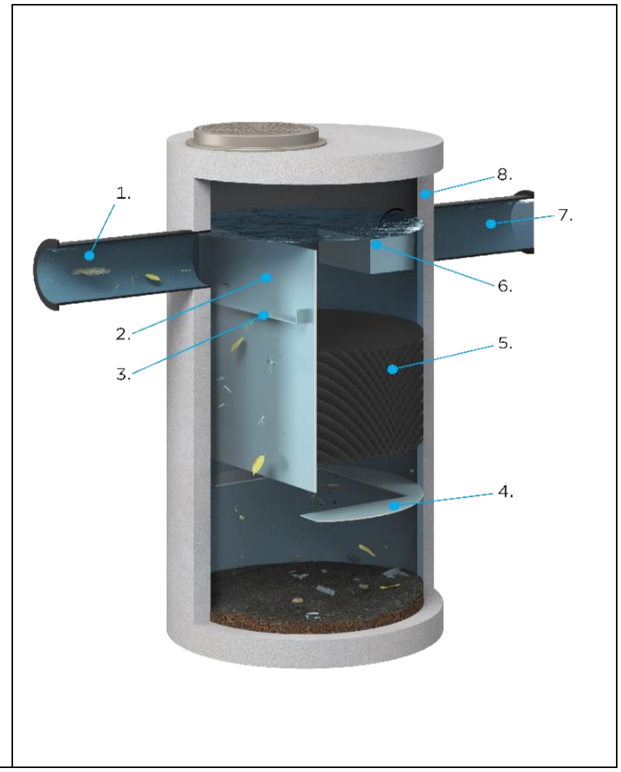


Figure 1 StormSettler Low Flow Operation

Figure 2 StormSettler High Flow Operation

During normal operations, where the vertical baffle forces all the flow under it, stormwater enters the inlet side of the StormSettler HDS through an inlet pipe (1), where it is immediately directed downward by the vertical baffle (2). A vortex disruptor (3) on the baffle helps prevent high velocity vortices on the inlet side. Water then flows under the vertical baffle where additional flow modifiers (4) help distribute the flow more evenly in the outlet chamber prior to the flow entering the enhanced settling pack (5).

The enhanced settling pack (5) consists of a large number of narrow channels which provide an effective settling area much greater than the system footprint. Upon exiting the enhanced settling device, the water is directed through an outlet diverter (6) to prevent any short circuiting and then to the outlet pipe (7).

During high flow events the vertical baffle acts as an internal bypass. All excess flow is directed over the baffle and the top of the outlet diverter. The remaining flow follows the low flow path and is fully treated. The internals are affixed to the tank wall (8). Maintenance is performed by accessing the tank floor from the inlet side.

Figure 3 shows the elevations of the various components in a 4-foot unit, which was the size tested.

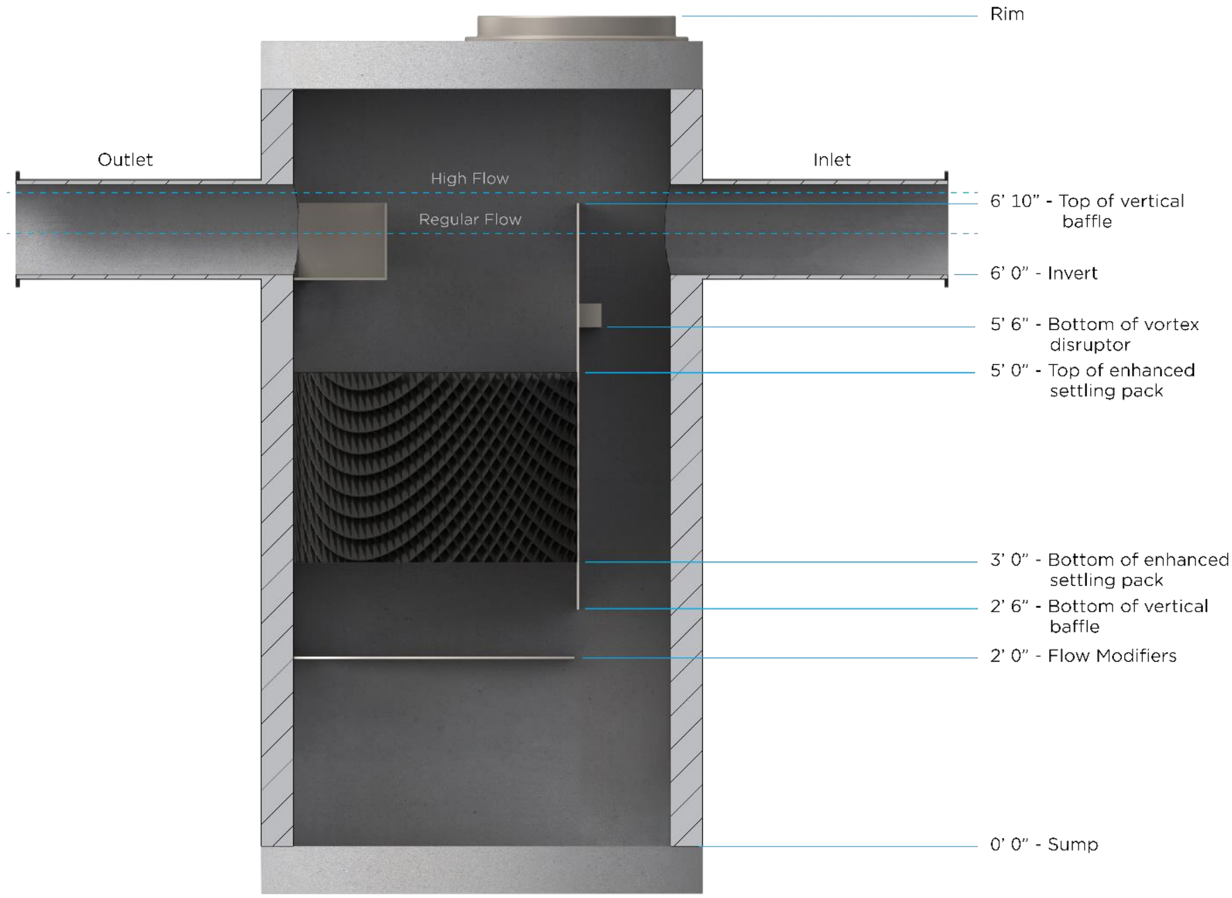


Figure 3 4-Foot System with Component Elevations

2. Laboratory Testing

The test program was conducted by Good Harbour Laboratories (GHL), an independent water technology testing lab, at their site in Mississauga, Ontario, Canada. The test protocol used was a modification of the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2021)*[1]. Prior to starting the performance testing program, a quality assurance project plan (QAPP) detailing these modifications was submitted to and approved by the New Jersey Corporation for Advanced Technology (NJCAT).

The device tested was a prototype of a commercially available 4-foot diameter StormSettler unit consisting of internal components housed in a metal manhole prototype. In commercial systems, the internal components are typically housed in a concrete manhole. The metal prototype of the test unit was equivalent to commercial concrete manholes in all key dimensions. The use of a metal prototype was proposed due to the difficulties associated with transporting and physically supporting the weight of a concrete unit. Using metal in lieu of concrete did not have any impact on system performance. The test unit was equipped with a 24-inch diameter access port with an invert 12 inches above the floor to access the sump to allow for easy recovery of captured sediment. The port contained a plug to maintain a smooth inner wall. The prototype utilized in testing is in conformance with the NJDEP 2021 HDS test protocol. The laboratory test set-up was a water flow loop, capable of moving water at a rate of up to 3 cfs. The test loop, illustrated in **Figure 4**, is comprised of a series of water reservoirs, pumps, sediment filter, receiving tank and flow meters.

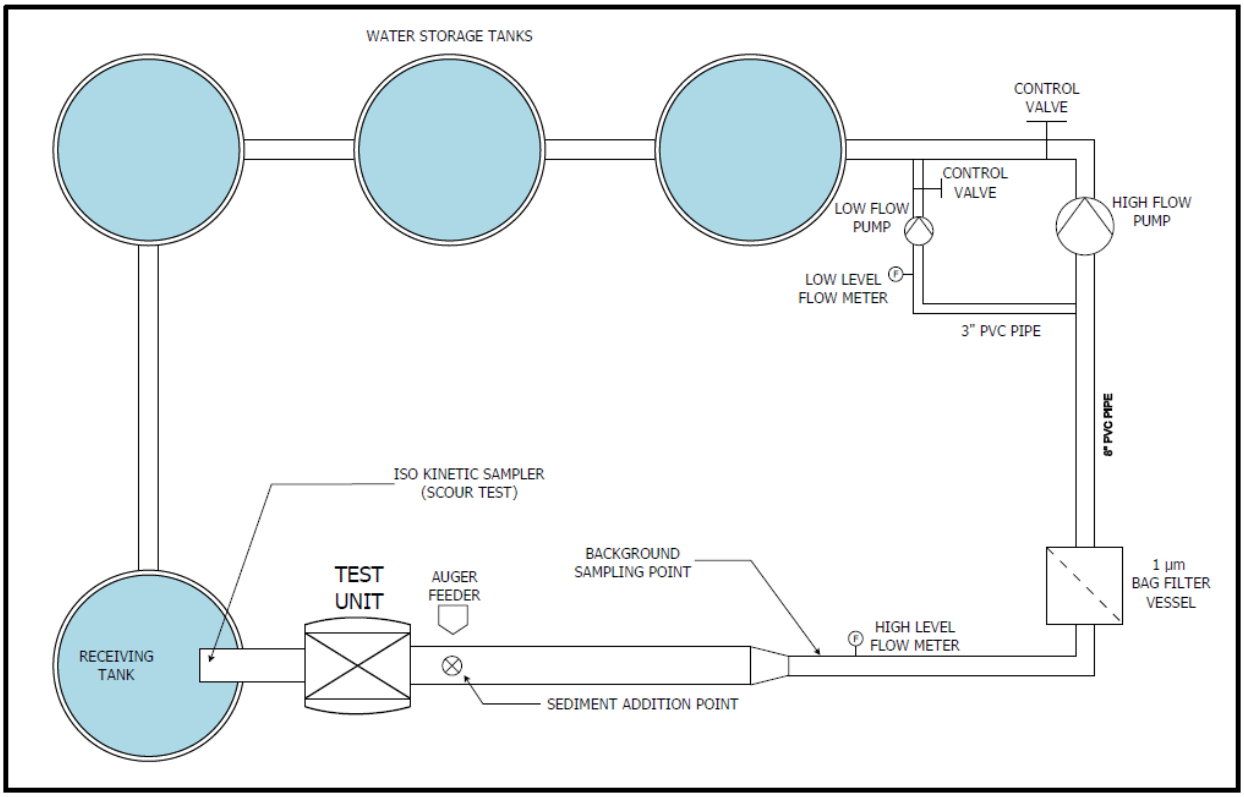


Figure 4 Laboratory Test Setup

2.1 Test Setup

The treatment device tested was a full-scale StormSettler unit (StormSettler-4); dimensional details are provided in **Table 1**. Both the inlet and outlet pipes were 12" in diameter. This unit had a total sump area of 12.6 ft^2 and a ***target*** maximum treatment flow rate (MTFR) of 1.15 cfs (516 gpm). Although the enhanced settling pack provides a very large settling area, for the sake of consistency with other reports the Effective Treatment Area is the cross-sectional area of the system.

Table 1 StormSettler Dimensions

MTFR (target)		Diameter (ft)	Sump Area (ft^2)	Sediment Storage (ft^3)	Maximum Sediment Storage Depth (in)	Effective Treatment Area (ft^2)	Target Loading Rate (gpm/ft^2)
(cfs)	(gpm)						
1.15	516	4	12.6	14.7	14	12.6	40.9

Water Flow and Measurement

From the water supply tanks, water was pumped using either a WEG Model FC00312 (1 - 200 gpm) or an Armstrong Model 8X8X10 4380 (100 - 1000 gpm) centrifugal pump. Flow measurement was done using either a 3″ Toshiba Model GF630 electromagnetic type flow meter with an accuracy of ± 0.2% of reading (1 - 200 gpm) or a MJK Magflux Type 7200 flow meter Model 297237 with an accuracy of ± 0.25% of reading (100 - 1300 gpm). All flow meters were installed away from flow disturbances in accordance with the manufacturer's recommendation. The data logger used was a MadgeTech Process 101A data logger, configured to record a flow measurement once every 30 seconds.

The water in the flow loop was circulated through a filter housing containing high efficiency pleated bag filters with a 1.0 µm absolute rating. The influent pipe was 12 inches in diameter, 84 inches long and installed with a 1% slope. Sediment addition was done through a port on the crown of the influent pipe, 24 inches upstream of the StormSettler. The sediment feeder was an Auger Feeders Model VF-1 volumetric screw feeder with vibratory hopper. The feeder had a 10 gallon hopper above the auger screw to provide a constant supply of sediment.

Water flow exited the StormSettler through an effluent pipe that was 12 inches in diameter, 47-inches long and also installed with a 1% slope and terminated with a free discharge into the receiving tank to complete the flow loop.

Sample Collection

Background water samples were taken by grab sampling. A 1-L, wide-mouth, sample jar was filled using a ¾-inch, full-port (**Figure 5**), sampling ball valve located downstream of the sediment bag filter and upstream of the sediment addition point. The samples were analysed by GHL in accordance with ASTM Method D3977-97(2019) "Standard Test Methods for Determining Sediment Concentrations in Water Samples".

Removal efficiency was determined by mass capture; no effluent samples were collected for removal efficiency analysis. Both the sediment mass captured in the MTD, and the inlet pipe were quantified and reported separately.

For the scour test, effluent samples were taken by hand. The effluent pipe drained freely into the receiving tank. The end of the effluent pipe was fitted with a 3-tube isokinetic sampler (**Figure 6**) and the effluent sample was taken at that point. The sampling technique was to hold a 1 L wide-mouth jar underneath the stream of effluent flow from the isokinetic sampler such that all three tubes drained completely into the jar. Note that the scour testing was not repeated so this information was taken from the previous NJDEP test report.

Duplicate samples were collected for background and scour effluent samples. The primary set was analyzed and reported while the second set was held under refrigerated conditions in case there was a need for investigation of any aberrant results. The duplicate samples were not used.

Figure 5 Background Sampling Point

Figure 6 Scour Effluent Sampling Point

Sediment calibration samples were taken at the end of the auger feeder's spout attachment (**Figure 7**) by holding a 500 mL jar just under the opening. The test sediment was sampled six times per run to confirm the sediment feed rate. Each sediment feed rate sample was collected over an interval timed to the nearest second. Samples were weighed to the nearest 0.01 g.

Figure 7 Sediment Auger Feeder

Other Instrumentation and Measurement

Water temperature was taken using a MadgeTech MicroTemp data logger that was suspended inside the StormSettler next to the inlet pipe. The MicroTemp was configured to take a temperature reading once every minute.

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

The sediment feed samples that were taken during the run were collected in 500 mL jars and weighed on a top loading balance (Mettler Toledo, PB 4002-S/FACT) with a precision of 0.01 g.

The sediment that was added to the auger feeder, and the sediment recovered following each run, were weighed on an industrial balance (Mettler Toledo, BBA 231-3BB35A/S) with a precision of 5 grams.

2.2 Test Sediment

The test sediment used for the study was #110 supplied by AGSCO Corporation as a single, pre-blended batch, lot #102320. The sediment was supplied in 50 lbs bags. Three composite samples were created by sampling all bags used for testing in three locations: top third, middle and bottom third. The three composite samples were sent to GeoTesting Express (Acton, MA) for particle size distribution analysis in accordance with ASTM D6913-17, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis" and ASTM D7928-17 "Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis".

The test results are summarized in **Table 2** and shown graphically in **Figure 8**. The final column in **Table 2** shows the PSD for US Silica OK-110. This material is no longer commercially available but it was widely used in the past, so it is included for comparison.

Table 2 Particle Size Distribution of Test Sediment

Particle Size (µm)	Test Sediment Particle size (%passing) ◊				US Silica
	Sample 1	Sample 2	Sample 3	Average	OK-110
1000	100	100	100	100	100
500	100	100	100	100	100
250	98	98	98	98	100
150	80	77	68	75	98
100	33	28	24	28	26
75	13	9	9	10	3
50	3	3	3	3	0
20	1	0	0	0	0
8	0	0	0	0	0
5	0	0	0	0	0
2	0	0	0	0	0

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

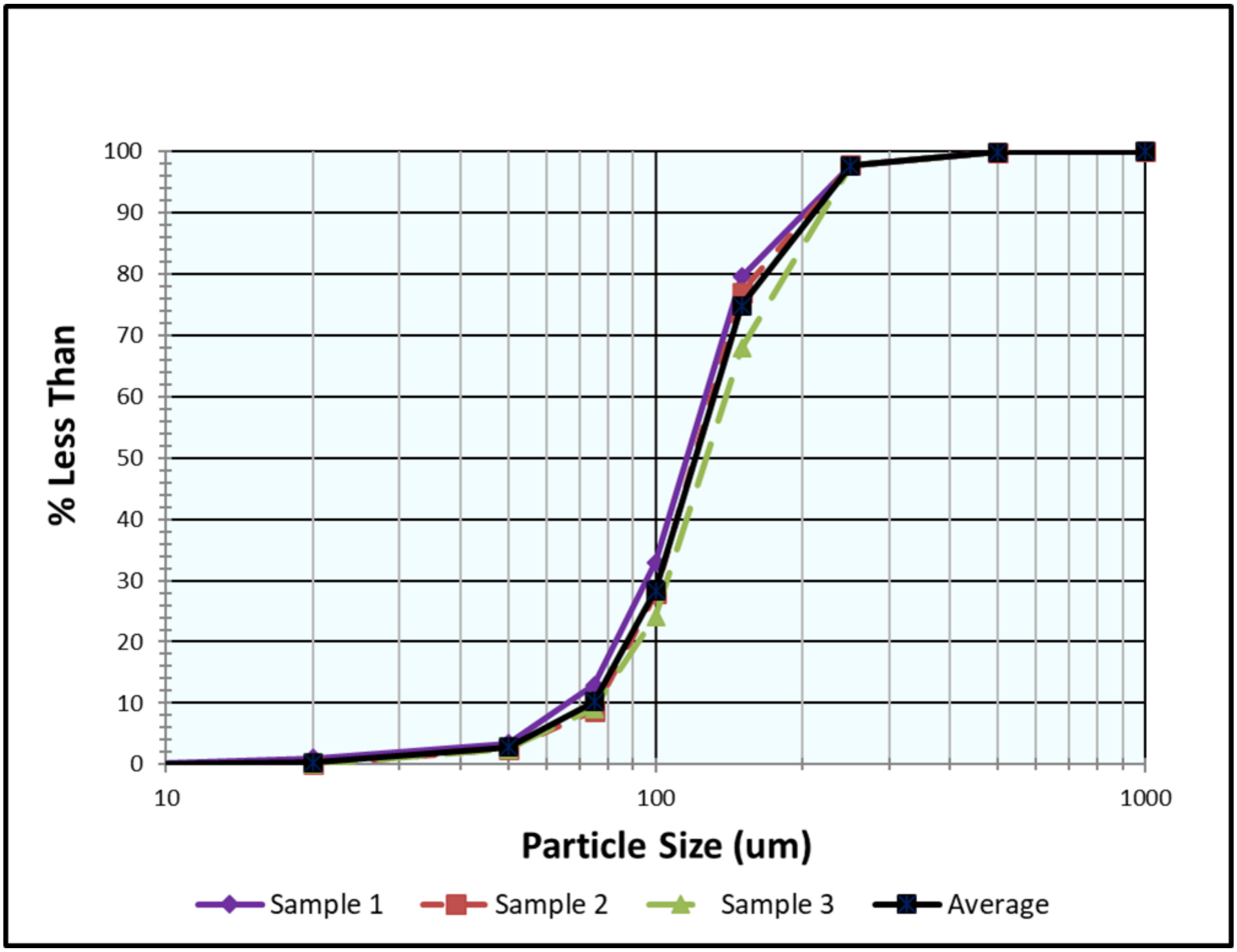


Figure 8 Average Particle Size Distribution of Test Sediment

The average d_{50} of the test sediment was 124 µm, coarser than the sediment required by the NJDEP test protocol and thus not eligible for NJDEP certification.

In addition to particle size distribution, GeoTesting Express also performed a moisture analysis of the test sediment and determined the water content to be <0.05%. This amount of moisture is not considered significant and therefore no correction for the amount of moisture in the sediment mass was made.

Scour Test Sediment

The scour testing was not repeated. This information was taken from the previous NJCAT verification report (NJCAT 2022) and the results included for completeness.

The test sediment used for the scour study was also a custom blend of commercially available silica sediments blended by GHL. This particular batch was GHL lot # A034-081. The blend ratio was determined such that the particle size distribution of the resulting blended sediment would meet the specification for the test protocol. The blended scour test sediment was stored in nine five-gallon buckets. Three separate composite samples were created by sampling all of the five-gallon buckets used to load the StormSettler for the scour test. Each bucket was sampled in three locations: top third, middle third and bottom third. The composite samples were well blended and reduced in size using a sediment riffle splitter.

The three samples were analyzed for PSD by a qualified 3rd party analytical laboratory (GeoTesting Express in Massachusetts) in accordance with ASTM D6913-17, "Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis" and ASTM D7928-17 "Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis". The moisture content of the test sediment was also determined in accordance with ASTM Method D2216-19, "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass." The test results are summarized in **Table 3** and shown graphically in **Figure 9**. The scour test sediment was finer than the sediment required by the NJDEP test protocol and therefore was acceptable for use. The moisture content was reported as 0.0%.

Table 3 Particle Size Distribution of Scour Test Sediment

Particle Size (μm)	Test Sediment Particle size (%passing) ◊				NJDEP Specification (minimum % Passing)*
	Sample 1	Sample 2	Sample 3	Average	
1000	100	100	100	100	100
500	93	94	94	94	90
250	57	61	58	59	55
150	44	48	45	46	40
100	25	29	23	26	25
75	8	11	5	8	10

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

*A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 8% of the particles must be less than 75 microns in size [target is 10%]).

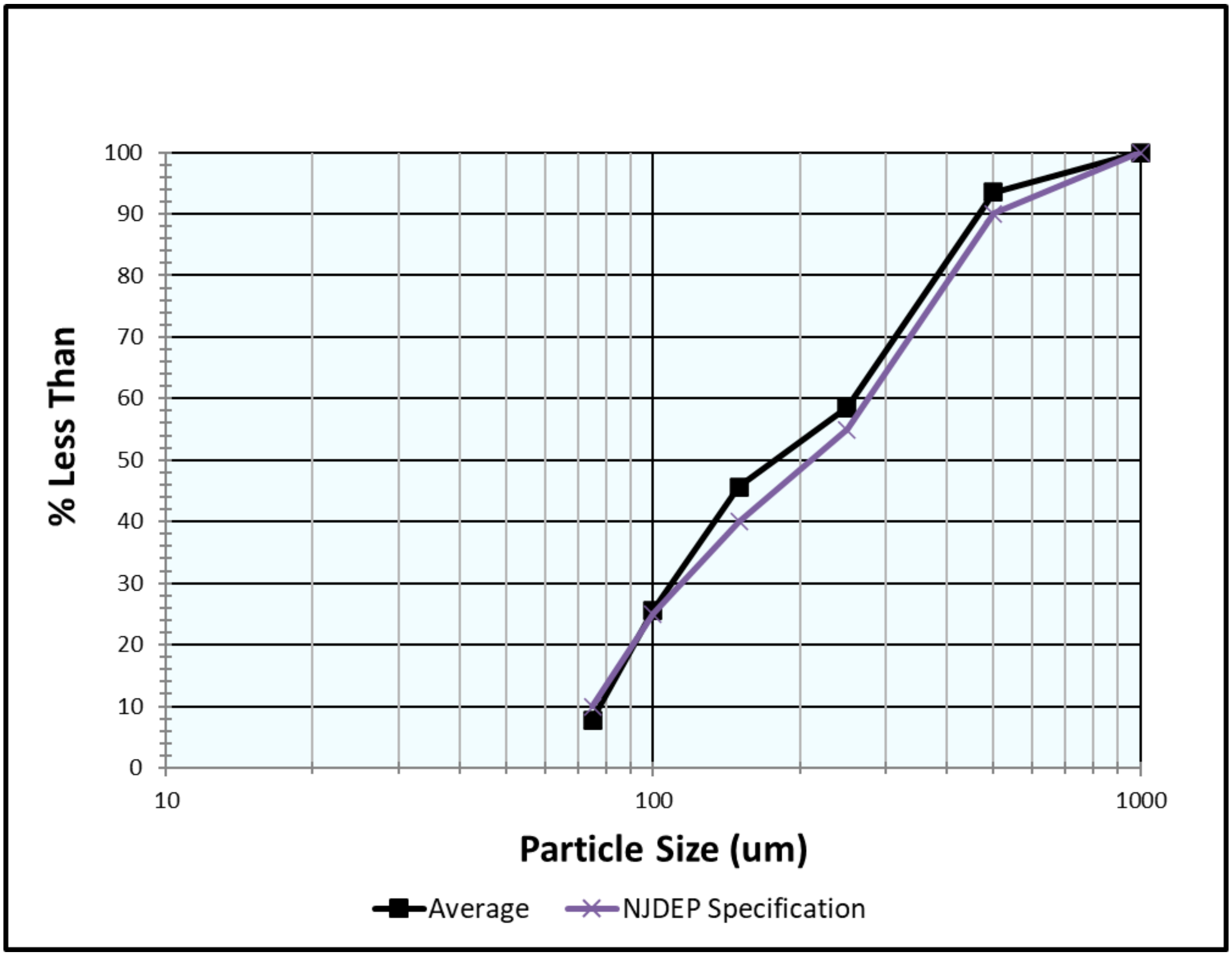


Figure 9 Average Particle Size Distribution of Scour Test Sediment

2.3 Hydraulic Testing

The hydraulic test was not repeated. This information was taken from the previous NJCAT verification report (NJCAT 2022) and the results included for completeness.

Prior to the start of testing with sediment, water flow and the corresponding water levels in the inlet and outlet pipes were measured and recorded to establish the head loss across the device. The head loss measurements were taken approximately one pipe-diameter upstream and downstream of the test unit. The measurements covered the span of 10% to 200% of the target MTFR and included the point when bypass occurred. The false floor was installed at the 50% level for the hydraulic test. Testing results are provided in Section 4.5.

2.4 Removal Efficiency Testing

Removal Efficiency Testing was conducted on a modification of Section 4 of the NJDEP Laboratory Protocol for Hydrodynamic Sedimentation MTDs. Testing was completed at flow rates of 25%, 50%, 75%, 100% and 125% of the target MTFR (0.23 CFS - 1.44 CFS) and at a target influent sediment concentration of 200 mg/L. A false floor was installed at an elevation of 7 inches in the sump.

The test sediment was sampled 6 times per run, using 500 mL jars, to confirm the sediment feed rate. Each sediment feed rate sample was a minimum of 100 mL, or the amount collected over a 1-minute period, whichever came first.

Each run continued until at least 25 lbs of sediment had been added to the MTD. Eight background water samples were taken at evenly-spaced intervals during each test run.

At the end of each run, water flow continued for one detention time after sediment feed was stopped to allow for sediment that would not normally be captured to pass through the MTD. The sediment added during a run was determined by weighing the hopper feed sediment before and after each run and correcting for the six feed sediment calibration samples that were taken.

At the end of the test program the results were fit to a curve, in accordance with the NJDEP HDS protocol, and the resulting performance MTFR determined.

2.5 Additional Testing

Three extra runs were added for information purposes. The flow rates were chosen based on the performance curve. The first was at 20% of the target MTFR, in order to determine the flow rate at which 100% sediment removal occurred. Then two runs at 270 gpm were conducted, which were expected, based on curve fitting the performance test data, to confirm the 80% sediment removal flow rate. The purpose of these runs was to show run-to-run variability and to provide data to compare to the flow rate for 80% removal estimated by the model.

2.6 Scour Testing

The scour test was not repeated since this information was previously obtained during testing for the NJCAT/NJDEP verification/certification report[2]. Scour testing was conducted in accordance with Section 5 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 2.8 cfs (1270 gpm) for the purpose of meeting the requirement for NJDEP certification. Since this flow rate was well above 200% of the target MTFR for this test, the scour test was not repeated. Data for the previous test is included for completeness in Section 4.4.

2.7 Laboratory Proficiency Testing

The performance testing was based on mass recovery. The test loop had already been confirmed to have minimal background level and as no new scour testing was undertaken, there were no samples requiring SSC analysis by an outside laboratory. Therefore, no proficiency testing was required. Background samples were taken and analyzed by GHL in order to confirm there were no system failures or upsets since the previous tests. The results in section 4.1 show that all background samples were non-detect, confirming the earlier testing with the GHL test setup.

3. Performance Claims

As suggested by the NJDEP verification procedure, the following are the performance claims made by StormTrap LLC and/or established via the laboratory testing conducted for the StormSettler Hydrodynamic Separator.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the StormSettler was calculated using the weighted method required by the NJDEP mass capture HDS MTD protocol (**Table 36**). Based on a MTFR of 0.93 cfs (417 gpm), the StormSettler achieved an annualized weighted TSS removal rate of at least 80%.

Maximum Treatment Flow Rate (MTFR).

The tested StormSettler unit had a surface area of 12.6 ft^2 and a MTFR of 0.93 cfs (417 gpm). This equates to a hydraulic loading rate of 33.1 gpm/ft^2.

Maximum Sediment Storage Depth and Volume

The tested sediment storage depth is 14 inches which equates to 14.7 ft^3 of sediment storage volume.

Effective Treatment/Sedimentation Area

The effective treatment area and effective sedimentation area are 12.6 ft^2.

Detention Time and Wet Volume

The detention time at 100% MTFR of the test unit is 92 seconds. The wet volume of the test unit was 86 ft^3, calculated based on the water level at 100% MTFR.

Online Installation

Based on the laboratory scour testing previously conducted, the StormSettler 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 will be provided to NJCAT upon request.

4.1 Removal Efficiency Testing

A total of 5 removal efficiency test runs were completed based on the NJDEP protocol flow rates: 25%, 50%, 75%, 100% and 125% MTFR. Three other test runs were completed at non-NJDEP flow rates. The target influent sediment concentration was 200 mg/L. The results from all runs were used to calculate the overall removal efficiency of the StormSettler. Sediment removal efficiencies were plotted vs. flow rate to generate a removal efficiency curve from which the MTFR was selected, and an annual weighted removal efficiency was calculated. It should be noted that in this case the target net annual removal was 80%, not the 50% used in the NJDEP certified report. It is also noteworthy that the final MTFR of 0.93 cfs was below the target MTFR of 1.15 cfs, so that the removal efficiency flow rates covered the range of flow rates necessary to calculate a weighted annual removal efficiency per the NJDEP protocol without extrapolation.

The total water volume and average flow rate per run were calculated from the data collected by the flow data logger, one reading every 30 seconds. The average influent sediment concentration for each test flow was determined by mass balance. The amount of sediment fed into the auger feeder during dosing, and the amount remaining at the end of a run, was used to determine the amount of sediment fed during a run. The sediment mass was corrected for the mass of the six feed rate samples taken during the run. The mass of the sediment fed was divided by the volume of water that flowed through the MTD during dosing to determine the average influent sediment concentration for each run.

Six feed rate samples were collected at evenly spaced intervals during the run to ensure the rate was stable. The COV of the samples had to be $\leq$ 0.10 per the NJDEP protocol.

Following each run, the captured sediment in the StormSettler was allowed to settle overnight before draining. Once drained, all of the captured sediment was removed from the unit's sump. The sediment that was retained in the inlet pipe was collected separately from the sediment collected in the sump. Any trace amount of sediment that was left behind was flushed with water and suctioned with a wet/dry vacuum. The contents of the vacuum were transferred to a 100 L container and allowed to settle for at least 2 hours before decanting the water. The settled sediment in the container was collected and added to the sediment collected from the sump. All collected sediment was placed in glass trays and dried in a convection oven, that was set to 105 ^{o}C, until a constant weight was obtained when cooled to room temperature, as determined by two successive measurements taken no less than two hours apart which show no more than a 0.1% difference in measured mass weighed to a precision of 10 grams. Any sediment that was recovered from the inlet pipe was dried and weighed separately from the sediment that was recovered from the unit's sump. There was no sediment accumulation in the influent pipe for any of the six runs.

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
0.0	1	1
17.9		2
25.1	2	
35.9		3
50.2	3	
53.8		4
71.7		5
75.3	4	
89.6		6
100.4	5	
107.6		7
125.5	6	8
129.5	End of Testing	
MTD Detention Time = 4.0 minutes Sediment Sampling Time = 1 minute		

Table 5 Water Flow and Temperature - 25% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	129	129.6	0.6%	0.017	62.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

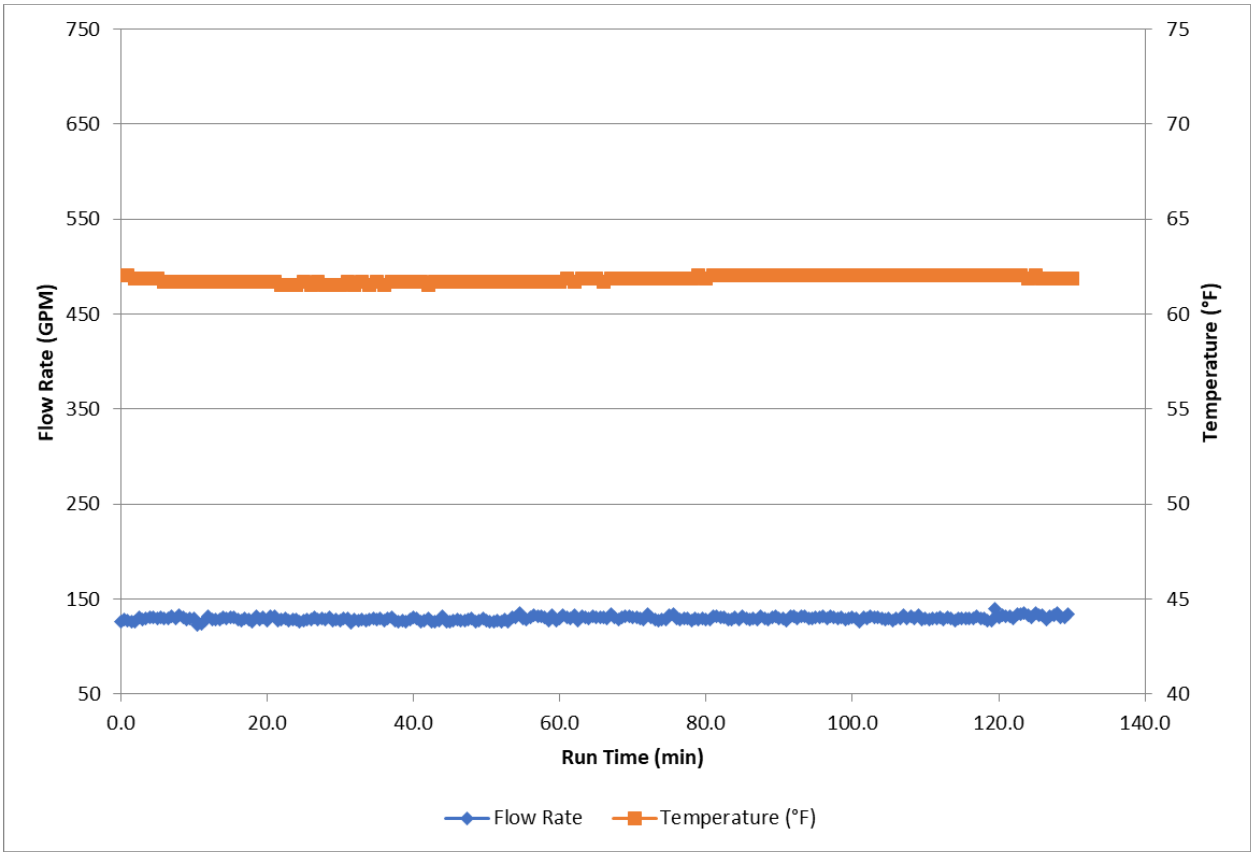


Figure 10 Water Flow and Temperature - 25% MTFR

Table 6 Sediment Feed Rate Summary – 25% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	99.63	Starting Weight of Sediment (lbs.)	69.58
2	102.33		
3	103.44	Recovered Weight of Sediment (lbs.)	40.80
4	104.15		
5	105.64	Mass of Sediment Used (lbs.)	28.78
6	105.23	Volume of Water Through MTD During Dosing (gal)	15,621
Average	103.40		
COV	0.021	Average Influent Sediment Concentration (mg/L)	210.3*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 7 Background SSC - 25% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

50% MTFR

Table 8 Sampling Schedule - 50% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
9.4		2
13.1	2	
18.7		3
26.2	3	
28.1		4
37.4		5
39.3	4	
46.8		6
52.4	5	
56.1		7
65.5	6	8
67.5	End of Testing	
MTD Detention Time = 2.0 minutes Sediment Sampling Time = 1 minute		

Table 9 Water Flow and Temperature - 50% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	258	259.0	0.6%	0.008	60.8
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

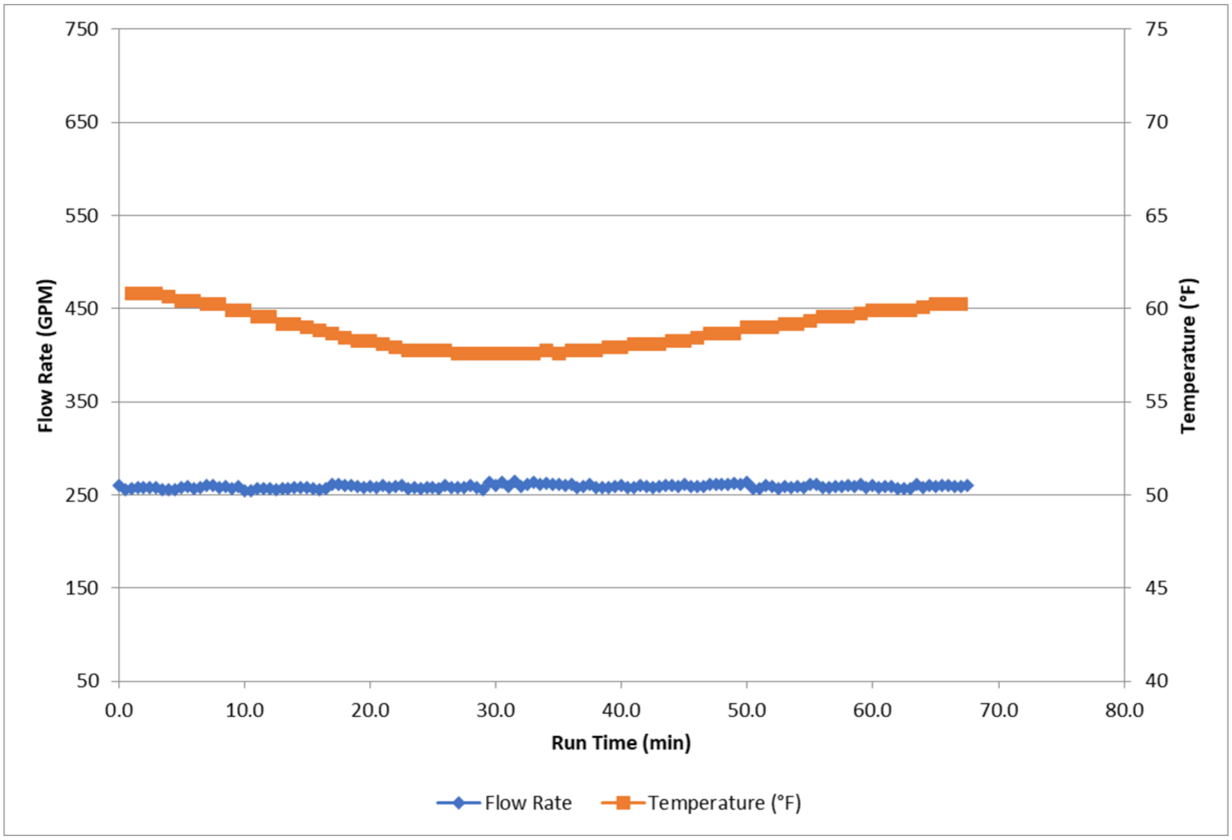


Figure 11 Water Flow and Temperature - 50% MTFR

Table 10 Sediment Feed Rate Summary – 50% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	192.66	Starting Weight of Sediment (lbs.)	76.67
2	196.01		
3	200.13	Recovered Weight of Sediment (lbs.)	47.42
4	205.01		
5	198.23	Mass of Sediment Used (lbs.)	29.25
6	201.65	Volume of Water Through MTD During Dosing (gal)	15,667
Average	198.95		
COV	0.022	Average Influent Sediment Concentration (mg/L)	203.5*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 11 Background SSC - 50% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

75% MTFR

Table 12 Sampling Schedule - 75% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
6.2		2
8.7	2	
12.4		3
17.4	3	
18.6		4
24.9		5
26.1	4	
31.1		6
34.8	5	
37.3		7
43.5	6	8
45.0	End of Testing	
MTD Detention Time = 1.3 minutes Sediment Sampling Time = 30 seconds		

Table 13 Water Flow and Temperature - 75% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	386	385.2	-0.3%	0.005	62.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

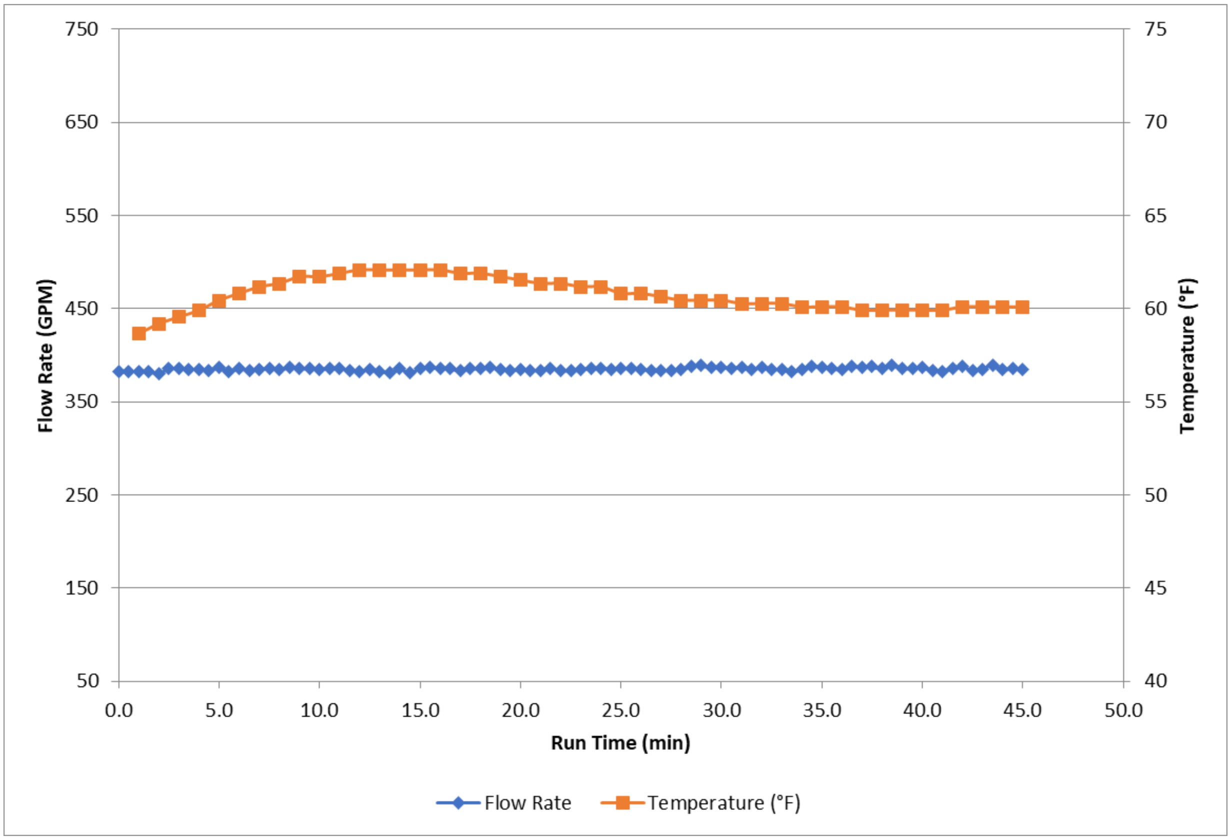


Figure 12 Water Flow and Temperature - 75% MTFR

Table 14 Sediment Feed Rate Summary – 75% MTFR

<table>
<tr><th colspan="2">Sediment Feed Rate (g/min)</th><th colspan="2">Sediment Mass Balance</th></tr>
<tr><td>1</td><td>298.99</td><td rowspan="2">Starting Weight of Sediment (lbs.)</td><td rowspan="2">67.38</td></tr>
<tr><td>2</td><td>301.43</td></tr>
<tr><td>3</td><td>304.75</td><td rowspan="2">Recovered Weight of Sediment (lbs.)</td><td rowspan="2">37.92</td></tr>
<tr><td>4</td><td>303.81</td></tr>
<tr><td>5</td><td>305.76</td><td>Mass of Sediment Used (lbs.)</td><td>29.46</td></tr>
<tr><td>6</td><td>306.89</td><td rowspan="2">Volume of Water Through MTD During Dosing (gal)</td><td rowspan="2">15,800</td></tr>
<tr><td>Average</td><td>303.60</td></tr>
<tr><td>COV</td><td>0.010</td><td>Average Influent Sediment Concentration (mg/L)</td><td>208.3*</td></tr>
<tr><td>QA/QC Limit</td><td>0.10
PASS</td><td>QA/QC Limit</td><td>180 – 220 mg/L
PASS</td></tr>
</table>

*Corrected for sediment feed rate samples

Table 15 Background SSC - 75% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

100% MTFR

Table 16 Sampling Schedule - 100% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
4.7		2
6.6	2	
9.4		3
13.2	3	
14.1		4
18.9		5
19.8	4	
23.6		6
26.4	5	
28.3		7
33.0	6	8
34.0	End of Testing	
MTD Detention Time = 1.0 minutes Sediment Sampling Time = 30 seconds		

Table 17 Water Flow and Temperature - 100% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	515	515.0	0.0	0.004	63.5
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

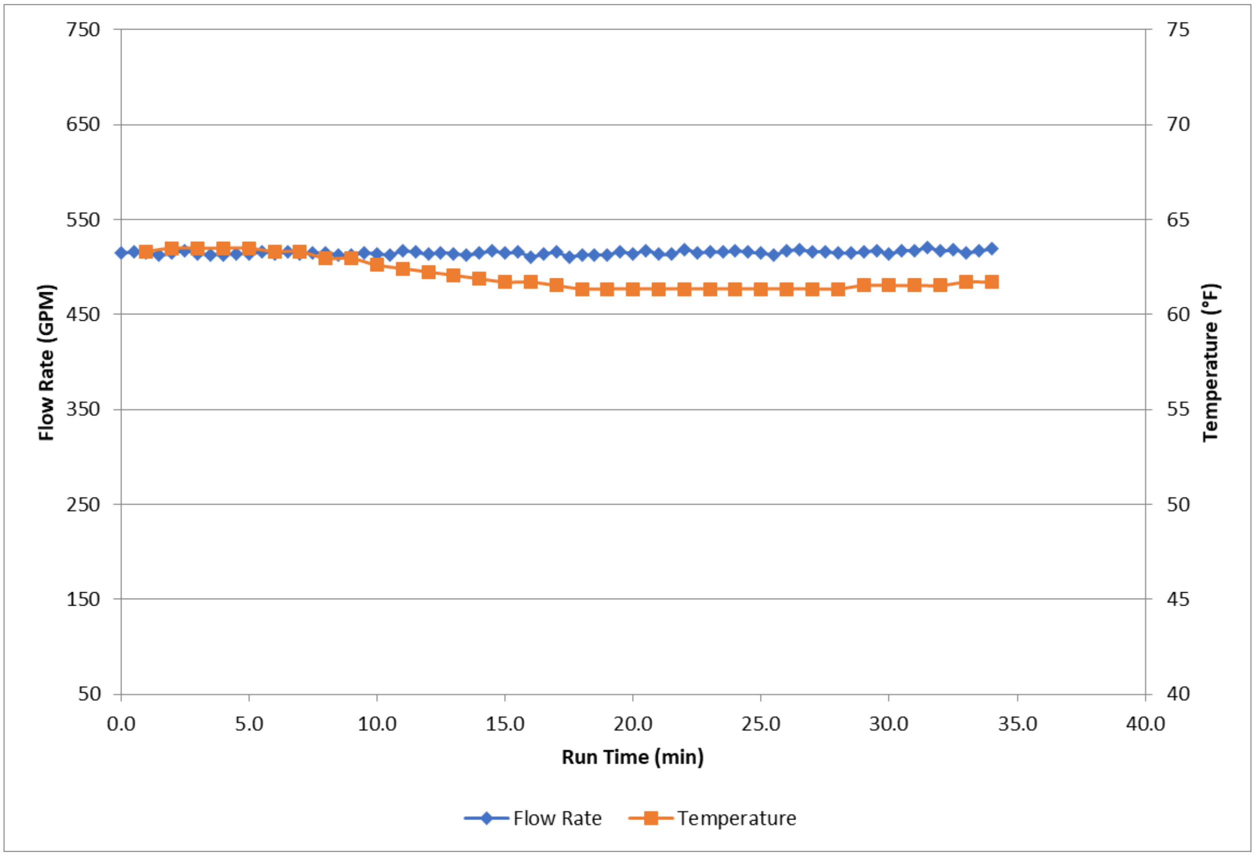


Figure 13 Water Flow and Temperature - 100% MTFR

Table 18 Sediment Feed Rate Summary – 100% MTFR

Sediment Feed Rate (g/min)		**Sediment Mass Balance**	
1	389.22	Starting Weight of Sediment (lbs.)	93.17
2	393.06		
3	391.43	Recovered Weight of Sediment (lbs.)	64.11
4	397.66		
5	398.21	Mass of Sediment Used (lbs.)	29.06
6	400.11	Volume of Water Through MTD During Dosing (gal)	15,712
Average	394.95		
COV	0.011	Average Influent Sediment Concentration (mg/L)	201.7*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 19 Background SSC - 100% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

125% MTFR

Table 20 Sampling Schedule - 125% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
3.7		2
5.2	2	
7.4		3
10.3	3	
11.0		4
14.7		5
15.4	4	
18.4		6
20.6	5	
22.1		7
25.7	6	8
26.5	End of Testing	
MTD Detention Time = 0.8 minutes Sediment Sampling Time = 20 seconds		

Table 21 Water Flow and Temperature - 125% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	644	642.4	-0.2%	0.004	61.3
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

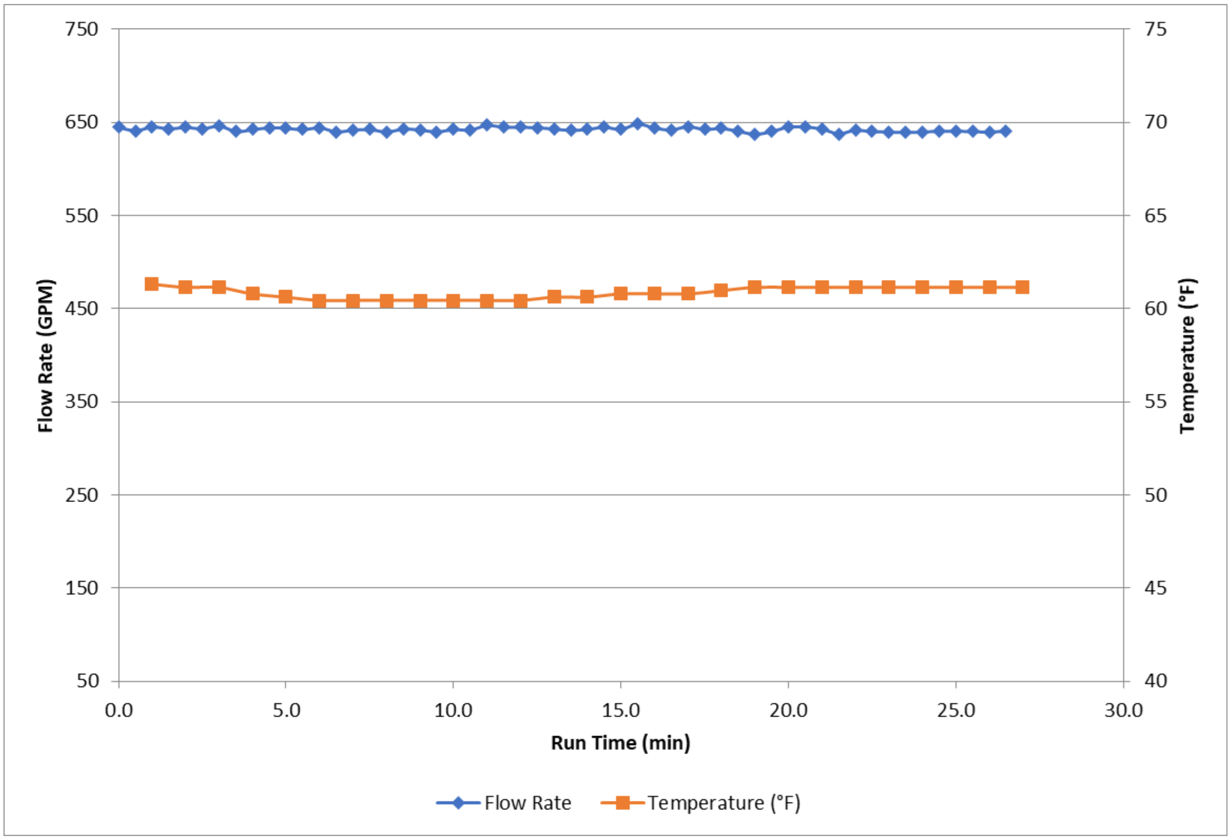


Figure 14 Water Flow and Temperature - 125% MTFR

Table 22 Sediment Feed Rate Summary – 125% MTFR

<table>
<tr><th colspan="2">Sediment Feed Rate (g/min)</th><th colspan="2">Sediment Mass Balance</th></tr>
<tr><td>1</td><td>491.98</td><td rowspan="2">Starting Weight of Sediment (lbs.)</td><td rowspan="2">71.58</td></tr>
<tr><td>2</td><td>495.63</td></tr>
<tr><td>3</td><td>500.22</td><td rowspan="2">Recovered Weight of Sediment (lbs.)</td><td rowspan="2">43.02</td></tr>
<tr><td>4</td><td>499.87</td></tr>
<tr><td>5</td><td>502.83</td><td>Mass of Sediment Used (lbs.)</td><td>28.56</td></tr>
<tr><td>6</td><td>503.96</td><td rowspan="2">Volume of Water Through MTD During Dosing (gal)</td><td rowspan="2">15,469</td></tr>
<tr><td>Average</td><td>499.08</td></tr>
<tr><td>COV</td><td>0.009</td><td>Average Influent Sediment Concentration (mg/L)</td><td>204.3*</td></tr>
<tr><td>QA/QC Limit</td><td>0.10
PASS</td><td>QA/QC Limit</td><td>180 – 220 mg/L
PASS</td></tr>
</table>

*Corrected for sediment feed rate samples

Table 23 Background SSC - 125% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

4.2 Additional Testing

An additional run was done at 20% MTFR in order to determine the flow rate at which 100% sediment removal could be expected. The removal achieved was 99.2%, which was accepted as close enough to 100%. The run details are shown in **Tables 24 - 26** and in **Figure 15**. This result was added to the removal efficiency curve (**Figure 18**).

20% MTFR

Table 24 Sampling Schedule - 20% MTFR

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
23.1		2
32.3	2	
46.1		3
64.6	3	
69.2		4
92.3		5
96.9	4	
115.4		6
129.2	5	
138.4		7
161.5	6	8
167.0	End of Testing	
MTD Detention Time = 5.1 minutes Sediment Sampling Time = 1 minute		

Table 25 Water Flow and Temperature - 20% MTFR

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	100	100.1	0.1%	0.002	62.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

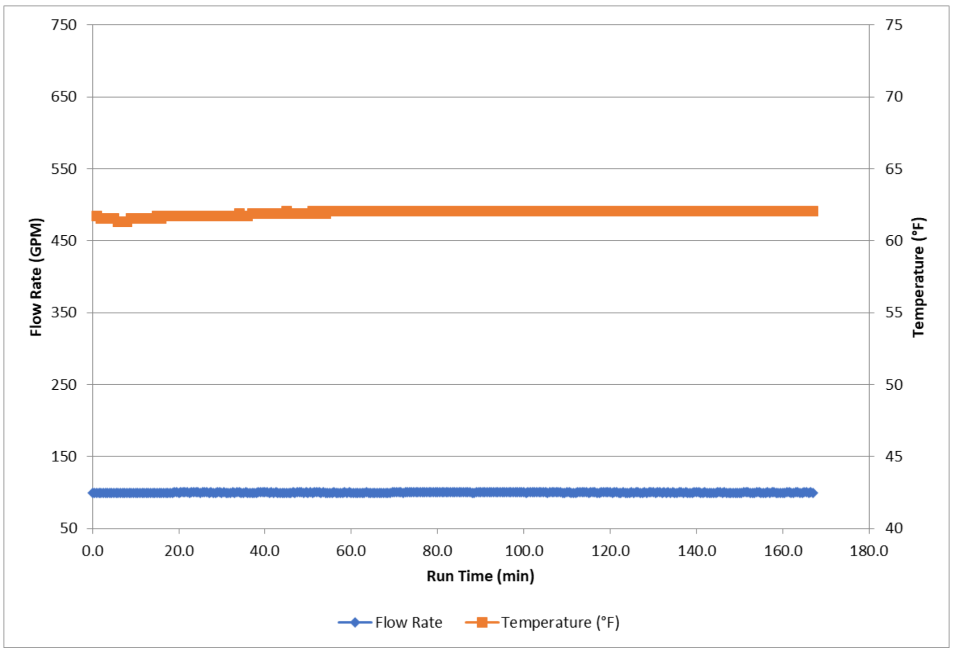


Figure 15 Water Flow and Temperature - 20% MTFR

Table 26 Sediment Feed Rate Summary – 20% MTFR

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	73.47	Starting Weight of Sediment (lbs.)	71.77
2	75.58		
3	76.18	Recovered Weight of Sediment (lbs.)	44.50
4	76.99		
5	77.63	Mass of Sediment Used (lbs.)	27.27
6	77.18	Volume of Water Through MTD During Dosing (gal)	15,663
Average	76.17		
COV	0.020	Average Influent Sediment Concentration (mg/L)	200.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 27 Background SSC - 20% MTFR

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

Flow rate for 80% removal

After completing the primary test runs, two additional runs were conducted for the purpose of statistical evaluation, i.e., run-to-run variability. The flow rate chosen for these runs was 270 gpm since this was the flow rate for 80% sediment removal from the removal efficiency test curve.

The removal efficiencies measured were 80.53 and 81.49%. The removal at 270 gpm calculated from the sediment removal efficiency test curve in Section 4.3 was 80.39. The average of the three numbers is 80.80, with a 95% confidence interval of ± 1.82. This gives confidence that the testing yields a value that is within ~2% of the true value. The results from these test runs were also added to the removal efficiency curve (**Figure 18**). These two additional runs data are presented below.

270 GPM - Run #1

Table 28 Sampling Schedule - *270 GPM*

Runtime (min)	Sampling Schedule	
	Sediment Feed	**Background**
0.0	1	1
8.8		2
12.3	2	
17.6		3
24.7	3	
26.4		4
35.2		5
37.0	4	
44.1		6
49.3	5	
52.9		7
61.7	6	8
63.6	End of Testing	
MTD Detention Time = 1.9 minutes Sediment Sampling Time = 50 seconds		

Table 29 Water Flow and Temperature - *270 GPM - Run #1*

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	270	270.0	0.0	0.006	65.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

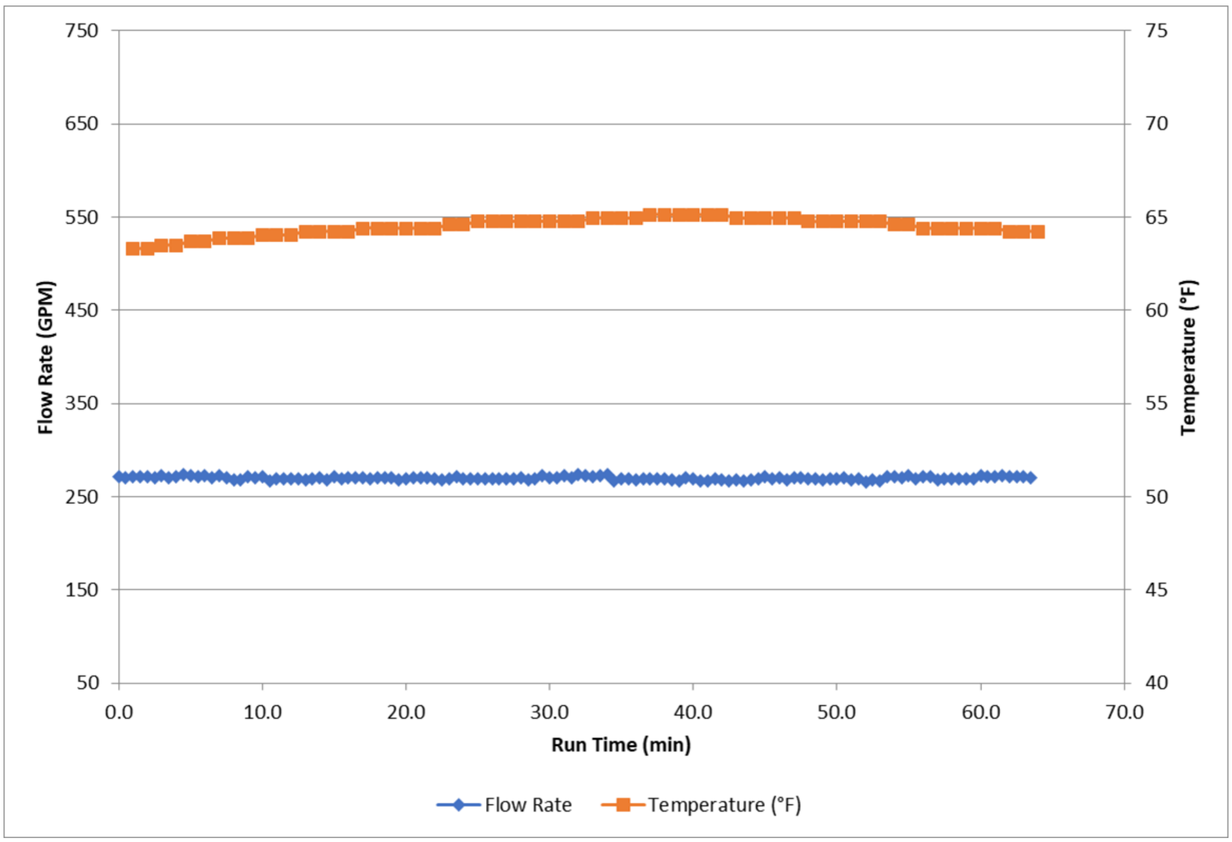


Figure 16 Water Flow and Temperature - *270 GPM - Run #1*

Table 30 Sediment Feed Rate Summary – *270 GPM - Run #1*

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	199.71	Starting Weight of Sediment (lbs.)	68.55
2	202.49		
3	205.92	Recovered Weight of Sediment (lbs.)	40.32
4	207.19		
5	206.76	Mass of Sediment Used (lbs.)	28.23
6	207.33	Volume of Water Through MTD During Dosing (gal)	15,531
Average	204.90		
COV	0.015	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 31 Background SSC - *270 GPM - Run #1*

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

270 GPM - Run #2

Table 32 Water Flow and Temperature - *270 GPM - Run #2*

Run Parameters	Water Flow Rate (GPM)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	270	270.0	0.%	0.007	62.1
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

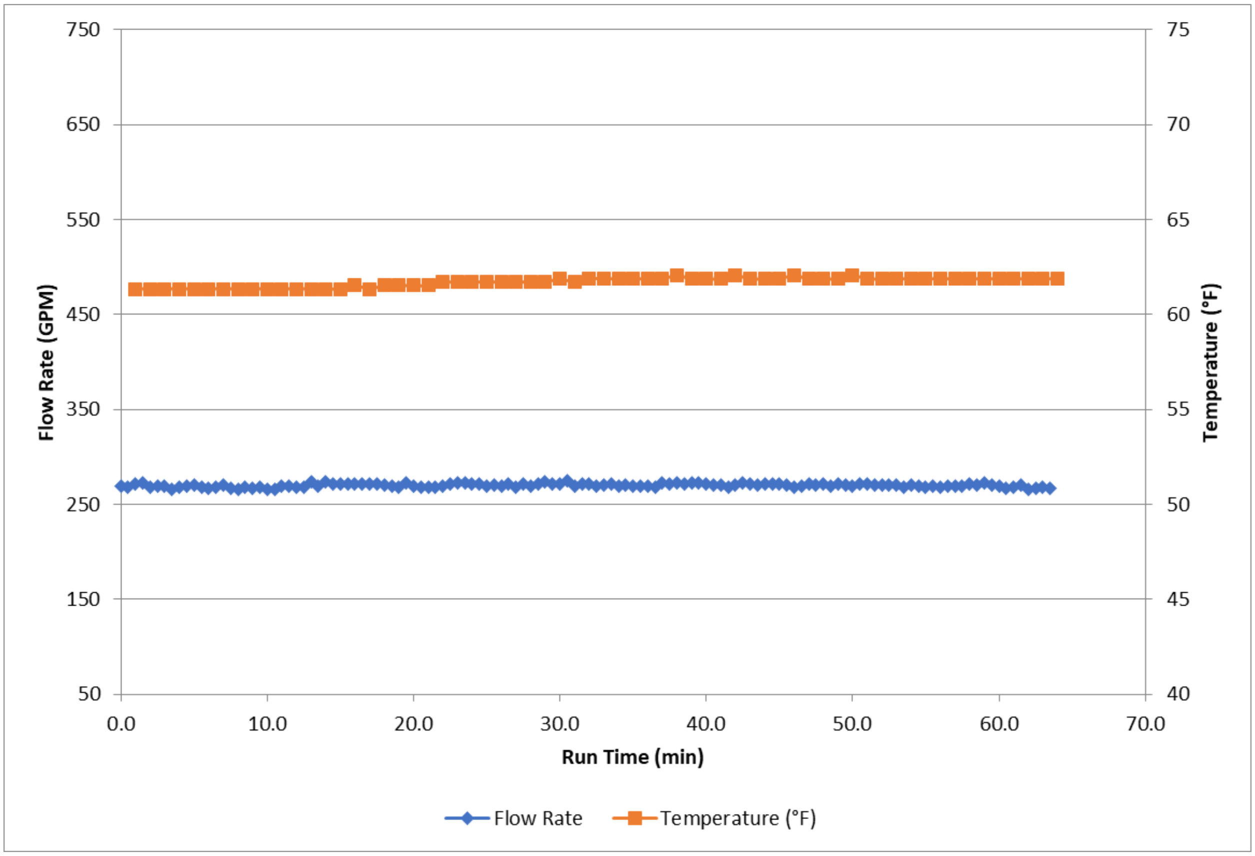


Figure 17 Water Flow and Temperature - *270 GPM - Run #2*

Table 33 Sediment Feed Rate Summary – *270 GPM - Run #2*

Sediment Feed Rate (g/min)		Sediment Mass Balance	
1	200.24	Starting Weight of Sediment (lbs.)	65.32
2	198.76		
3	199.44	Recovered Weight of Sediment (lbs.)	37.72
4	203.14		
5	200.86	Mass of Sediment Used (lbs.)	27.60
6	201.41	Volume of Water Through MTD During Dosing (gal)	15,528
Average	200.64		
COV	0.008	Average Influent Sediment Concentration (mg/L)	195.9*
QA/QC Limit	0.10 PASS	QA/QC Limit	180 – 220 mg/L PASS

*Corrected for sediment feed rate samples

Table 34 Background SSC - *270 GPM - Run #2*

	Suspended Sediment Concentration (mg/L)								
Sample #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**QA/QC Limit**
Background	ND	ND	ND	ND	ND	ND	ND	ND	≤ 20 mg/L PASS

ND = below method quantitation limit of 2.3 mg/L

4.3 Annualized Weighted Removal Efficiency

All the recovered sediment was dried in glass trays using a convection oven. The sediment was dried until a constant weight was achieved. The recovered sediment mass for all runs is summarized below:

Table 35 Sediment Removal Efficiency Based on Retained Sediment

% MTFR	25	50	75	100	125	20	270 GPM #1	270 GPM #2
Total Mass Added (lb)	27.42	26.61	27.47	26.45	26.37	26.27	25.98	25.39
Sediment Captured in MTD (lb)	26.92	21.99	16.98	12.80	8.10	26.11	20.92	20.69
Sediment Captured in Inlet Pipe (lb)	0	0	0	0	0	0	0	0
Total Mass Retained (lb)	26.92	21.99	16.98	12.80	8.10	26.11	20.92	20.69
Removal Efficiency (%)	98.19	82.64	61.80	48.38	30.72	99.42	80.53	81.49

A plot was made of the eight removal efficiency runs (**Figure 18**) and a curve of best fit was obtained using a 2nd order polynomial ($r^2 = 0.995$). All 8 points were used in order to make the removal efficiency curve as accurate as possible. The data was only fit to a second order polynomial instead of a third order polynomial because the r^2 was nearly 1.0 in both cases and the second order equation is stable over a wider range of flows.

The curve was used to determine the StormSettler MTFR that would result in 80% weighted annual removal using the weighting factors provided in the NJDEP laboratory test protocol. The MTFR for 80% annual weighted removal was calculated to be 0.93 cfs (418 gpm), as shown in **Table 36**.

Different geographical locations can use **Figure 18** along with rainfall weighting factors appropriate for that location to calculate a MTFR for a specific location.

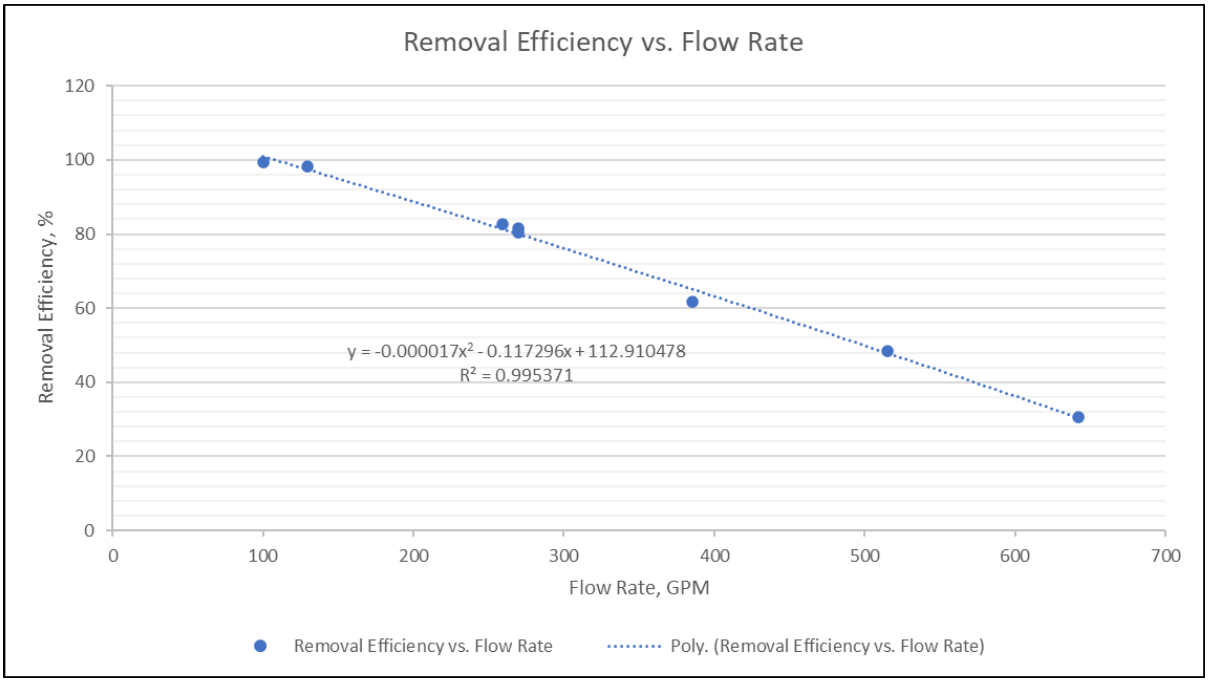


Figure 18 StormSettler Removal Efficiency Curve

Table 36 Annualized Weighted Removal Efficiency for StormSettler

%MTFR	Flow Rate (GPM)	Removal Efficiency (%)	Annual Weighting Fact	Weighted Removal Efficiency (%)
25	105	100	0.25	25.0
50	209	87.6	0.30	26.3
75	314	74.4	0.20	14.9
100	418	60.8	0.15	9.1
125	523	46.9	0.10	4.7
Annualized Weighted Removal Efficiency				**80.0%**

4.4 Scour Testing

Scour testing was not repeated as part of this study using coarse sediment, since scour testing conditions, i.e., flow rate, had already been exceeded in the earlier NJCAT verification testing for NJDEP certification[2] and indicated the StormSettler met the requirements for online installation. These previous results are included here for completeness.

In preparation for the scour test, the false floor inside the unit sump was lowered to 4 inches below the 50% maximum sediment storage volume. The sump was then loaded with scour test sediment. When levelled, the sediment formed a layer 4 inches thick, so the top of the sediment was 7 inches above the sump floor. After sediment loading, the sump was filled with water. The water was added in such a way as to avoid disturbing the sediment bed. The StormSettler was allowed to sit for 95 hours before commencing the scour test.

Scour testing began by gradually increasing the flow rate to the target flow within a 3-minute period. The sampling frequency for background and effluent samples is summarized in **Table 37**. Run time 0 min. is when the pump was started. Water flow and temperature are shown in **Table 38** and plotted on **Figure 19**.

Table 37 Scour Test Sampling Frequency

Sample/ Measurement Taken	Run Time (min.)														
	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29
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

Table 38 Water Flow and Temperature - Scour Test

Run Parameters	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	Actual	Difference	COV	
	1270	1270	-0.001%	0.004	64.6
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

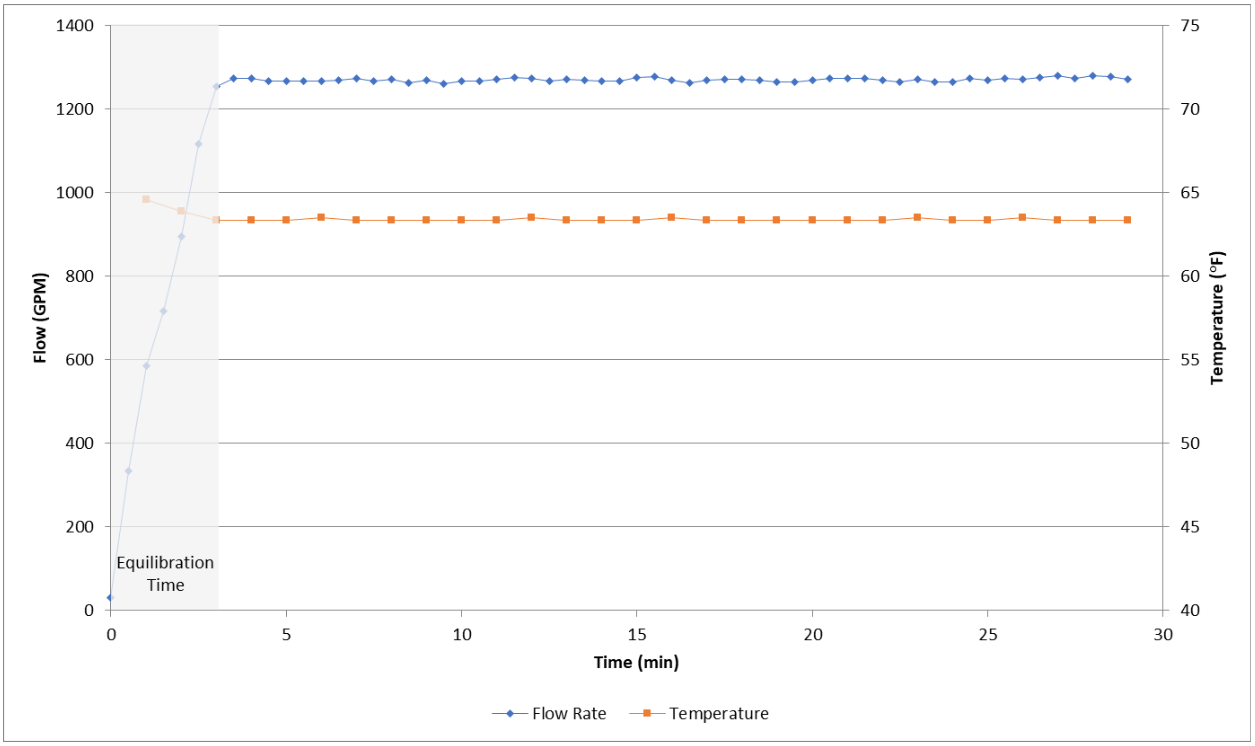


Figure 19 Water Flow and Temperature - Scour Test

The effluent and background SSC results are reported in **Table 39**. For instances where the reported SSC concentration was below 1.0 mg/L, the method detection limit, a value of 0.5 mg/L was used for calculation purposes. The adjusted effluent concentration was calculated as:

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

For effluent samples that did not have a corresponding background sample, the background value was interpolated from the previous and subsequent samples. The average adjusted effluent concentration was 6.8 mg/L at >200% of the MTFR, therefore, the StormSettler meets the criteria for online use.

Table 39 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	0.5	1.3	6.8	8.9	10.2	11.6	8.4	11	11	6.5	8.2	7.9	8.7	6.8	3.7
Background	1.1		0.5		0.5		0.5		1.1		0.5		0.5		0.5
Adjusted Effluent	0	0.5	6.3	8.4	9.7	11.1	7.9	10.2	9.9	5.7	7.7	7.4	8.2	6.3	3.2
Average Adjusted Effluent Concentration							6.8 mg/L								

4.5 Hydraulic Testing

Hydraulic testing was not repeated prior to testing the coarse sediment so this section is the same as the equivalent section in the NJDEP certified report[2]. Prior to performance testing, the head loss across the StormSettler was determined by measuring and comparing the difference between the water level at the influent side of the MTD and the effluent side, defined as the difference in water elevation, or Δh. Measurements were made on a clean unit, without sediment, using a manometer equipped with a meter stick graduated in 1 mm increments.

For the head loss measurements, the false floor was set in the sump at 7", which is 50% of the maximum rated sediment storage depth. Measured flows spanned the range of 10% - 200% MTFR. The head loss data are presented in **Table 40**. Bypass occurred at ~450 gpm, as indicated by the plateau in the headloss curve at that point (**Figure 20**). Using the results in **Table 40**, the head loss coefficient, k, was calculated to be 1.25.

Table 40 StormSettler Head Loss

Flow Rate		Water Elevation (cm)		Δh	
cfs	**gpm**	**Influent**	**Effluent**	**cm**	**inches**
0.03	12.3	2.7	1.4	1.3	0.5
0.06	24.7	3.7	2.0	1.7	0.7
0.11	51.5	6.0	3.1	2.9	1.1
0.14	61.7	6.9	3.5	3.4	1.3
0.27	121	10.4	5.0	5.4	2.1
0.29	129	10.9	5.3	5.6	2.2
0.41	184	13.9	6.9	7.0	2.8
0.55	249	17.6	8.7	8.9	3.5
0.57	258	18.0	9.0	9.0	3.5
0.68	307	20.4	9.8	10.6	4.2

0.86	384	23.9	10.8	13.1	5.2
0.96	431	25.6	11.3	14.3	5.6
1.03	462	27.0	12.9	14.1	5.6
1.15	515	27.7	13.2	14.5	5.7
1.37	617	28.9	13.6	15.3	6.0
1.43	643	29.3	13.9	15.4	6.1
1.72	774	31.5	14.5	17.0	6.7
1.79	803	32.0	14.7	17.3	6.8
2.30	1033	36.2	16.5	19.7	7.8
2.67	1200	40.0	16.7	23.3	9.2
2.85	1278	42.1	16.8	25.3	10.0

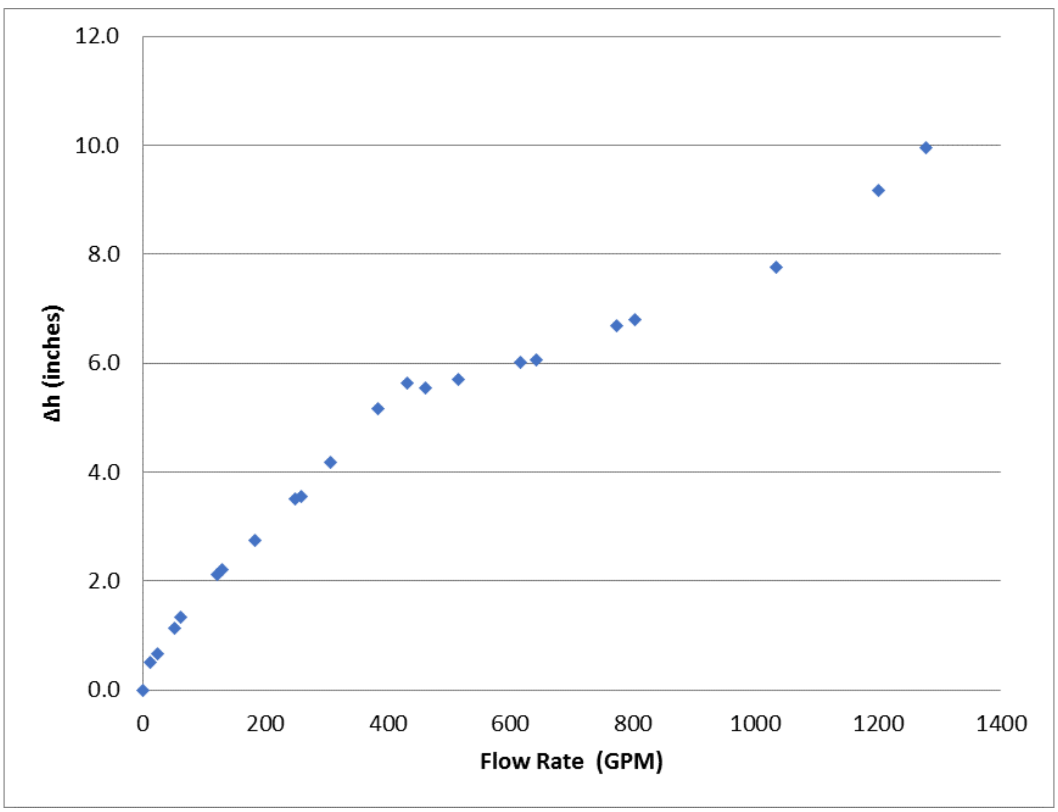


Figure 20 StormSettler Head Loss

5. Design Limitations

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

Soil Characteristics

StormSettler is an enclosed, flow-through system than can be installed and function as intended in all soil types. StormSettler units are installed in accordance with ASTM C-891 "Standard Practice for Installation of Underground Precast Concrete Utility Structures".

Slope of Drainage Pipe

The system was verified with an inlet pipe slope of 1%, as suggested by the NJDEP protocol, but there are no specific drainage pipe slope limitations provided that both the inlet and outlet pipe elevations are identical.

Maximum Treatment Flow Rate

The maximum treatment flow rate (MTFR) for StormTrap StormSettler models is based upon the diameter of the system as shown in **Table A-1**. Systems are sized to a hydraulic loading rate of 33.1 gpm/ft^2 of effective treatment area.

Maintenance Requirements

StormSettler systems should be inspected and maintained following the recommendations and guidelines included in the StormSettler Manufacturer's Instruction Manual available at:

https://stormtrap.com/products/stormsettler/stormsettler-maintenance-manual/

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

Driving Head

StormSettler driving head requirements can be found in **Table 40** and **Figure 20**. The system headloss coefficient, k=1.25.

Installation Limitations

StormTrap provides contractors with detailed installation and assembly instructions as well as specific pick weights prior to delivery.

Configurations

StormSettler has an internal bypass and can be installed online or offline. The verified configuration is a single inlet and outlet at 180 degrees, but other configurations are possible.

Structural Load Limitations

StormSettler modules are typically designed for HS-20 loading. Contact StormTrap if alternate design loadings are anticipated or required for site specific conditions.

Pre-treatment Requirements

The StormSettler has no pre-treatment requirements.

Depth to Seasonal High-Water Table

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

6. Maintenance Plans

The StormSettler treatment device by StormTrap is designed to capture and store pollutants from stormwater. The unit must be inspected and maintained routinely to ensure peak removal efficiency. StormSettler maintenance frequency is site dependent and routine inspections, particularly during the first year after installation, are needed to determine the needed maintenance frequency of the unit.

Inspection

Inspections of the StormSettler are important to ensure peak performance and assess the condition of the system internals. Inspection is simple and can be performed in a short amount of time. Inspections should be performed during dry weather conditions, after the unit has had time to dewater to the usual water level.

Inspection Equipment

- StormSettler Maintenance Manual and Inspection Checklist
- Flashlight
- Manhole cover removal tools
- Proper protective equipment
- Proper traffic control signage
- Sediment probe
- Camera (recommended)

Inspection should begin by removing the manhole cover(s) on the unit and visually inspecting the integrity of the internal components. On larger units where two manhole covers are present, both are recommended to be removed to inspect both the inlet and outlet side of the device as effectively as possible. Visually ensure that the baffle is intact and seated properly, that the vortex disruptor is in place and undamaged, that the enhanced settling pack openings are free from full or partial obstruction, and the outlet diverter is seated properly and in good condition.

Sediment depth should then be determined. NJDEP requires sediment removal when sediment has reached 50% of the unit's storage depth. The 50% sediment storage depth for StormSettler NJDEP models is 7". Sediment depth can be determined either by using a sediment probe or by taking a measurement to the top of the sediment in relation to a fixed object in the system.

Filling in the Inspection Checklist and including photos in the final inspection report is strongly recommended.

Maintenance

StormTrap recommends that a Vactor truck or similar type of equipment be used to remove sediment and floatables from the StormSettler unit. Access to the bottom of the unit is on the inlet side of the baffle. Floatables can alternatively be removed with a pool skimmer or similar netting device.

If a pressure washer is used to assist with dislodging any debris within the system, special care must be taken when spraying the enhanced settling pack. Use a wide spray nozzle on or around the pack to avoid altering the tubes within the enhanced settling pack.

<u>Maintenance Procedure</u>

1. Remove manhole cover(s) to expose the inlet side of the StormSettler.
2. A Vactor truck or similar type of equipment should be used to remove all water, sediment, and floatables from the system. The rodding hose of the Vactor truck should be used to remove any sediment or floatables that are stuck. Maintenance crews should be careful not to damage the internal components.
3. Refill the StormSettler unit to the normal water level.
4. Replace the manhole cover(s).
5. Dispose of any waste according to local regulations.

Dispose of all waste during maintenance per local, state, and federal guidelines and regulations.

If, during maintenance or inspection, any parts of the StormSettler are determined to be damaged, contact StormTrap to order replacements.

7. Statements

The following is a signed statement from the independent test lab (Good Harbour Labs) regarding the impartiality of the test program.

Dr. Richard Magee, Sc.D., P.E., BCEE
Executive Director
New Jersey Corporation for Advance Technology (NJCAT)

Subject: Submission of laboratory verification report for performance of StormSettler with a coarse sediment (OK-110) particle size distribution (PSD)

Dear Dr. Magee,

Previous verified laboratory testing demonstrated that the StormSettler can achieve a weighted annual removal rate of at least 50% based on the New Jersey Department of Environmental Protection (NJDEP) Hydrodynamic Separator MTD Protocol (21021). This protocol specifies testing with a sediment PSD with a median particle size, d_{50}, of ≤ 75 µ. Some authorities having jurisdiction (AHJs) outside of New Jersey are interested in 80% removal of coarser particles, typically US Silica OK-110, even though this material has not been commercially available for several years. Since there are no widely accepted models for translating removal performance with one PSD to removal performance with another PSD, additional testing was undertaken to look at capture of a PSD that is very similar to OK-110.

In order to be as consistent as possible with other testing submitted to NJCAT this second testing program followed the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 1, 2021, with the following exceptions:

1. The Performance testing was done with AGSCO #110 rather than the NJDEP PSD.
2. Scour testing and hydraulic testing were not repeated since the testing was done on the same test unit in the same outside lab.
3. The flow rates tested did not exactly follow the protocol.

StormTrap LLC acknowledges that the above deviations prevent certification of this report, but we request verification by NJCAT. We certify that the requirements of "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (2021) were met or exceeded, with the exceptions outlined above.

Sincerely,

Greg Williams, PhD, PEng

Director of Water Quality

PHONE 815 941 4663 WEB www.stormtrap.com 1287 Windham Parkway
FAX 331 318 5347 EMAIL info@stormtrap.com Romeoville, Illinois 60446

February 3, 2023

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

Re: Performance Verification of the StormTrap StormSettler® System using OK-110 Equivalent PSD

Dear Dr. Magee,

Following the previous laboratory testing, demonstrating that the StormSettler® can achieve a weighted annual removal rate of at least 50% based on the New Jersey Department of Environmental Protection (NJDEP) Hydrodynamic Separator MTD Protocol (2021), Good Harbour Laboratories was contracted by StormTrap LLC to conduct supplementary testing of their StormSettler hydrodynamic separator using a sediment PSD with a median particle size, d_{50}, of > 75 µm.

Once again, this additional test program was conducted in accordance with the NJDEP protocol to assess performance of MTDs, except for the key departures listed in Section 2 of the report. The report is being submitted to you for the purpose of data verification.

Good Harbour Laboratories is an independent hydraulic test facility located in Mississauga, Ontario Canada. I certify that we evaluated the StormSettler according to the aforementioned test protocol, except from the noted departures. The results presented in the NJCAT Verification Report dated February 2023 are accurate and I confirm that all test data that was collected is included or referenced in the report.

GHL provides testing and verification services for numerous water treatment technologies including stormwater treatment devices. GHL has had several different stormwater equipment manufacturers as clients, and we have accumulated considerable experience in testing these devices. In order to be able to make this experience available to as many potential clients as possible, GHL is careful to maintain its position as an independent service provider.

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

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

- that I do not have any conflict of interest in connection to the contracted testing;

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

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

Sincerely,

Date

Roland G. DuBois

February 03, 2023

Roland DuBois, P.Eng.
Managing Director
Good Harbour Laboratories

CC: Greg Williams, StormTrap LLC

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

8. References

1. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device. January 1, 2021.
2. NJCAT Technology Verification Report, "StormTrap StormSettler® Hydrodynamic Separator", December 2022.

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VERIFICATION APPENDIX

Introduction

- Manufacturer – StormTrap LLC, 1287 Windham Parkway, Romeoville, IL 60446
  Website: www.stormtrap.com General Phone: (815) 941-4663

- MTD: StormTrap StormSettler Hydrodynamic Separator. Verified StormSettler models are shown in **Table A-1**.

- TSS Removal Rate: 80% (Coarse sediment OK-110 equivalent PSD)

- Offline or Online Installation

Detailed Specification

- Sizing and dimensional table is attached as **Table A-1**.

- The StormSettler-4 has a maximum treated flow (MTFR) of 0.93 cfs (418 gpm), which corresponds to a hydraulic loading rate of 33.1 gpm/ft^2 of effective treatment area.

- Pick weights and installation procedures vary with model size. StormTrap provides contractors with project-specific unit pick weights and installation instructions prior to delivery.

- Maximum sediment depth for all units is 14 inches.

- An Inspection and Maintenance Manual is provided for each project installation and available at:
  https://stormtrap.com/products/stormsettler/stormsettler-maintenance-manual/

Table A-1 StormSettler MTFRs, Sediment Removal Intervals, and Standard Dimensions								
Model	Manhole Diameter (ft)	OK-110 80% TSS Maximum Treatment Flow Rate (MTFR) (cfs)	Effective Treatment Area (ft^2)	Hydraulic Loading Rate[1] (gpm/ft^2)	Effective Sedimentation Area (ft^2)	Chamber Depth[2] (ft)	Effective Treatment Depth[3] (ft)	Aspect Ratio Treatment Depth:Diameter[4]
StormSettler-3	3	0.52	7.1	33.1	7.1	5	4.42	1.47
StormSettler-4	4	0.93	12.6	33.1	12.6	6	5.42	1.35
StormSettler-5	5	1.45	19.6	33.1	19.6	6	5.42	1.08
StormSettler-6	6	2.09	28.3	33.1	28.3	6	5.42	0.90
StormSettler-7	7	2.84	38.5	33.1	38.5	9	8.42	1.20
StormSettler-8	8	3.71	50.3	33.1	50.3	10	9.42	1.18
StormSettler-10	10	5.79	78.5	33.1	78.5	12.5	11.92	1.19
StormSettler-12	12	8.34	113.1	33.1	113.1	14.5	13.92	1.16

[1]Hydraulic loading rate is defined as the ratio of MTFR to effective treatment area.
[2]Chamber depth is defined as depth from effluent invert to sump floor.
[3]Effective treatment depth is defined as depth from effluent invert to ½ the sediment storage depth.
[4] Aspect ratio is defined as the ratio of effective treatment depth to manhole diameter. The aspect ratio for the tested unit is 1.35. Larger models (>250% MTFR of the unit tested, > 2.3 cfs) must be geometrically proportional to the tested unit within the allowable ±15% tolerance.