NJCAT TECHNOLOGY VERIFICATION

Hydro-Shield™ Advance Plus

Hydro International

May 2024

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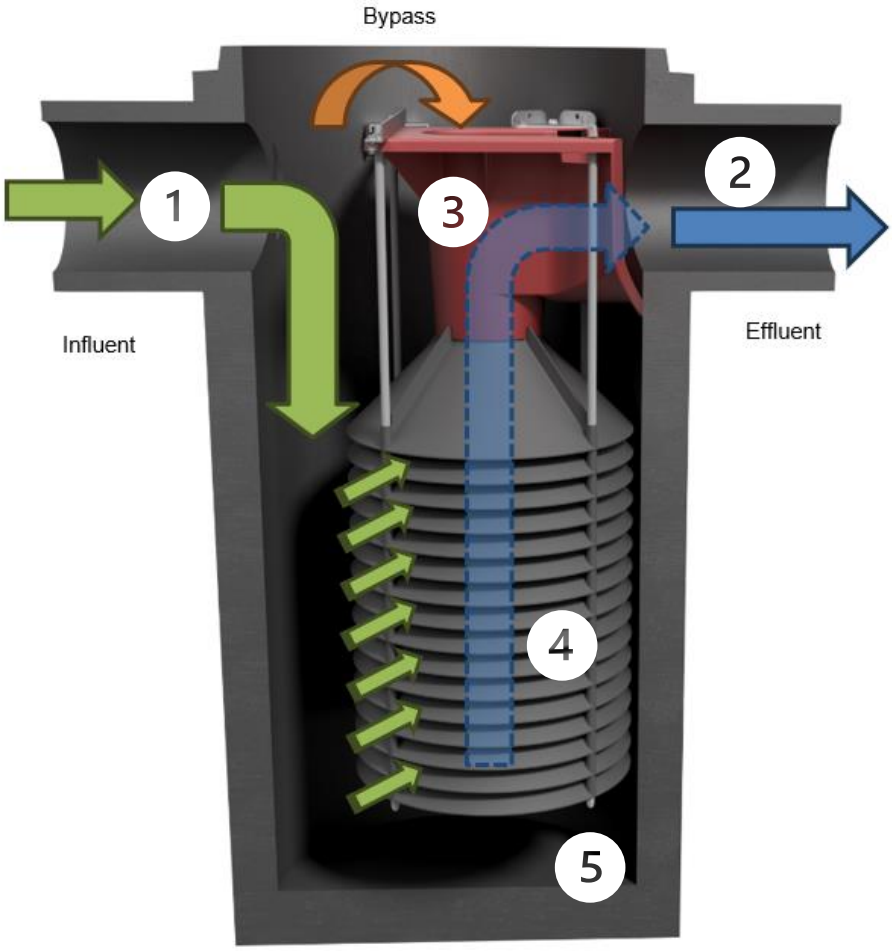
1. Description of Technology

The Hydro-Shield™ Advance Plus separator is a hydrodynamic separator designed and supplied by Hydro International. The Hydro-Shield™ Advance Plus is installed as part of typical drainage network systems to capture particulate pollutants that have entered the system from surface runoff. The Hydro-Shield™ Advance Plus has a stack of inclined plates in which flow is directed upwards. Any solids present fall to the surface of the plates, where they slide by gravity down to the bottom of the separator.

The Hydro-Shield™ Advance Plus chamber is typically a precast concrete manhole. The internal components are injection molded polypropylene. The components include an internal weir to divert higher flow rates over the treatment chamber preventing captured particles from being resuspended and washed out. Stormwater enters the Hydro-Shield™ Advance Plus through an inlet pipe and solids are captured in the sediment storage sump. Treated water exits the treatment chamber via an outlet module and exits the Hydro-Shield™ Advance Plus via an outlet pipe. A drain down component allows for water levels to return to the pipe inverts after each storm. The inner components and flow path of the Hydro-Shield™ Advance Plus are shown below in **Figure 1** and a top down view is shown in **Figure 2.**



1	Inlet Pipe
2	Outlet Pipe
3	Outlet Module
4	Treatment Module
5	Sediment Storage

Figure 1 Diagram Showing the Components of a Typical Hydro-Shield™ Advance Plus

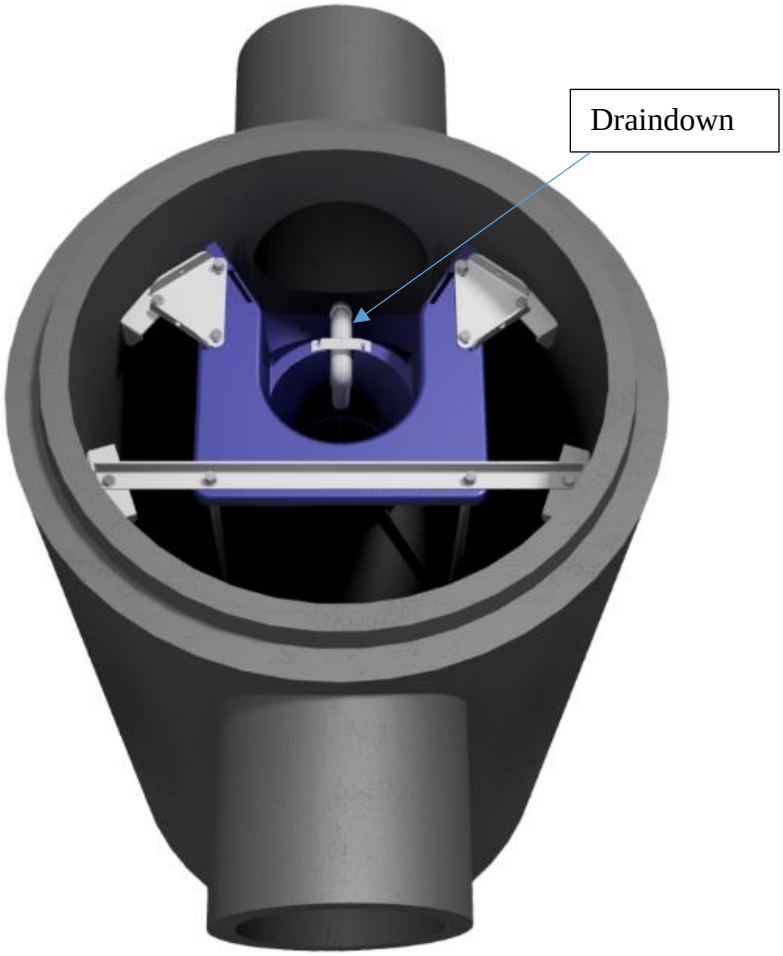


Figure 2 Overhead View of Hydro-Shield™ Advance Plus Noting Draindown Component

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 Procedure for Approval of Use for Manufactured Treatment Devices dated August 4, 2021 (henceforth referred to as "the Procedure"). The Procedure requires that TSS manufactured treatment devices that operate on hydrodynamic principles be tested according to 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 (Last updated April 25, 2023). Henceforth referred to as "the 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 February 2024 prior to commencement of testing.

Testing was conducted in March 2024 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 2023 NJDEP Protocol in two phases: removal efficiency testing and scour testing.

Testing was conducted with a full-scale 4-ft Hydro-Shield™ Advance Plus unit with commercially available internal components installed.

2.1 Test Setup

A schematic drawing of the laboratory setup is shown in **Figure 3**. Operated as a recirculating closed loop system, water from one of two 10,000-gallon supply tanks was pumped to the system through a 10-inch line via a Flygt submersible pump. Flow ran through a filter housing with 1-micron absolute filters before entering an 8-inch line. The effluent discharged freely from the test unit into a 24-inch effluent pipework which flows into the second 10,000-gallon tank further from the test unit. The free discharge flowed through a filter box fitted with 1-micron nominal filter bags to remove fine sediment that remained within the flow. The flow rate of the pump was controlled by a GE Fuji Electric AF300 P11 Adjustable Frequency Drive and measured by an EMCO Flow Systems 4411e Electromagnetic Flow Transmitter. A background sampling port was installed 20 feet upstream of the Hydro-Shield™ Advance Plus.

A three-way valve is located between the Flygt pump and the Hydro-Shield™ Advance Plus which allows flow to enter the Hydro-Shield™ Advance Plus from either the 8-inch pump or a 4-inch Goulds pump. The 4-inch line ran through a similar filter housing with 1-micron absolute filters before entering a Badger Meter M2000 Electromagnetic Flow Meter. The 4-inch flow path was used for flow rates less than 10 l/s.

The water temperature within the tank was regulated by a Hayward 350FD pool heater. Water temperature was measured in the supply tank with a LASCAR EL-USB-TP-LCD sensor and logger. The sensor was placed near the 8-inch pump to provide a representative measurement of the water temperature entering the test system. The sensor was placed near the 4-inch pump when used. Maximum temperature remained below 80˚ F for the duration of all tests. Temperature was recorded every 5 seconds. The original thermocouple calibration was confirmed by the independent observer.

During performance testing, test sediment was injected through an Auger Feeder Model VF-2 volumetric screw feeder upstream of the Hydro-Shield™ Advance Plus. The auger was calibrated prior to each test.

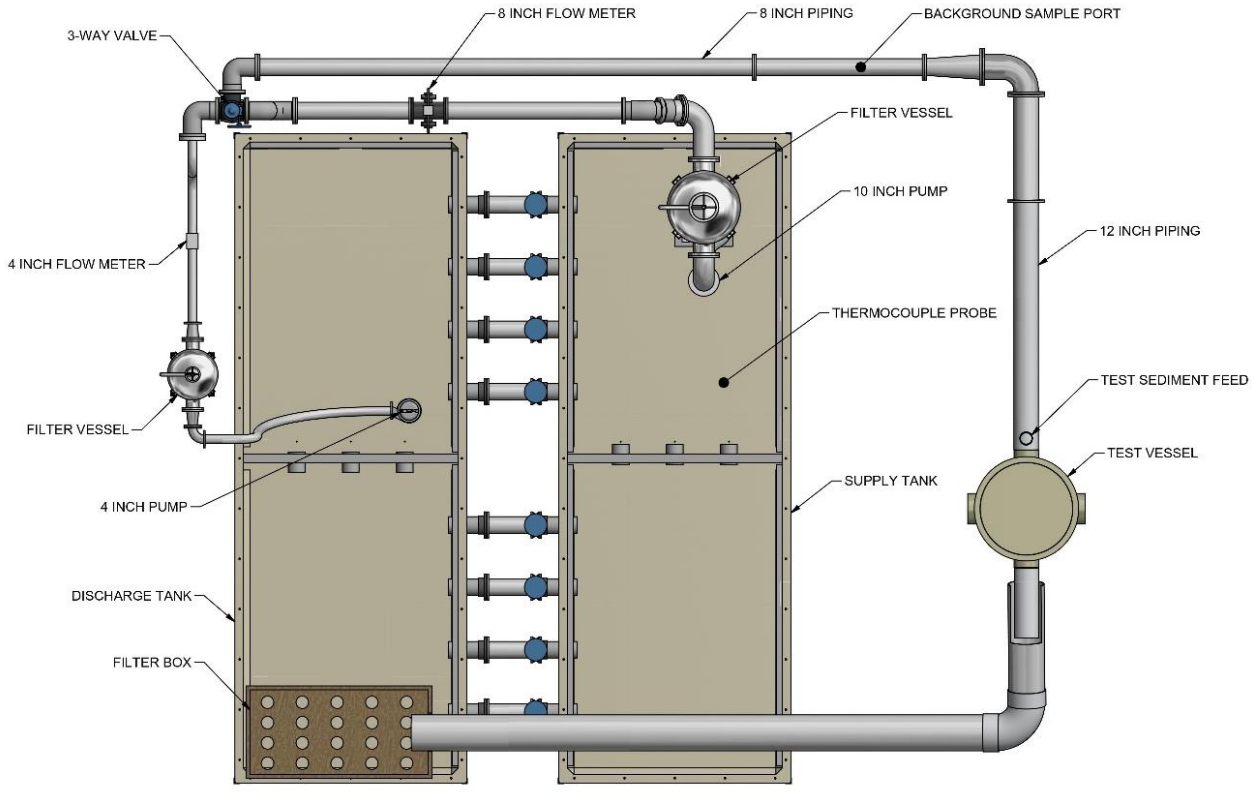


Figure 3 Laboratory Testing Arrangement Diagram

Test Unit Description

The laboratory arrangement was designed for a 4-ft Hydro-Shield™ Advance Plus test unit comprised of full-scale, commercially available internal components installed in a 4-ft round plastic manhole chamber consistent in all key dimensions with the precast chambers used for commercial sales. The plastic chamber, shown below in **Figure 4**, is part of a modular system used to test a variety of different products. Features not applicable for the Hydro-Shield™ Advance Plus have been sealed off to maintain the correct manhole geometry. Both the inlet and outlet pipe diameters of the test model are 12-inch schedule 40 PVC pipe. Both the inlet and outlet pipes are set at 3% slope.

The plastic manhole chamber system can support a false floor at two different positions relative to the treatment module. The upper position allows for the simulation of a 50% full sump condition for use during removal efficiency testing. The lower position allows for 4 inches of sediment to be pre-loaded before scour testing. The test unit dimensions shown in **Figure 5** were confirmed by the independent observer prior to testing.

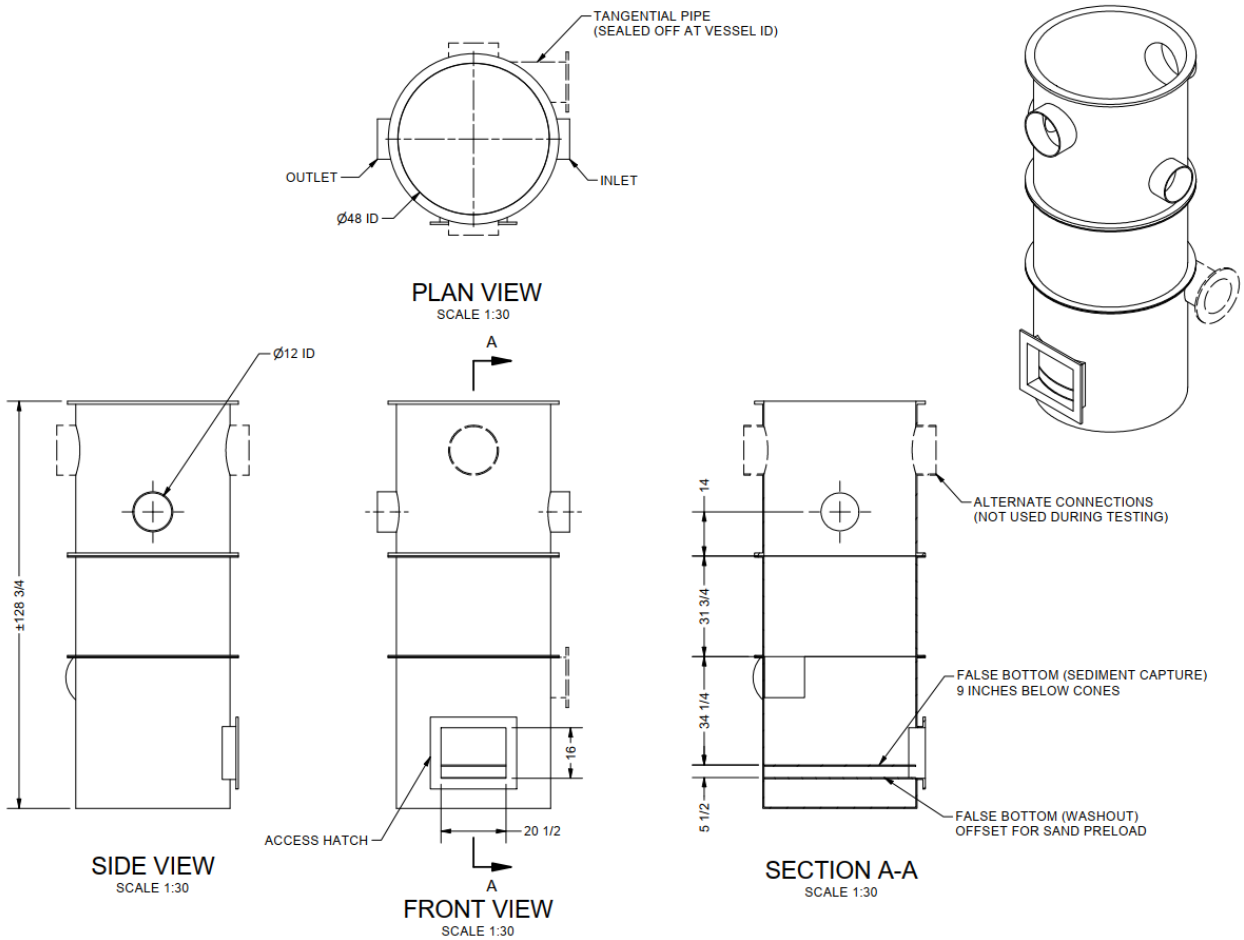


Figure 4 Test Vessel Configuration

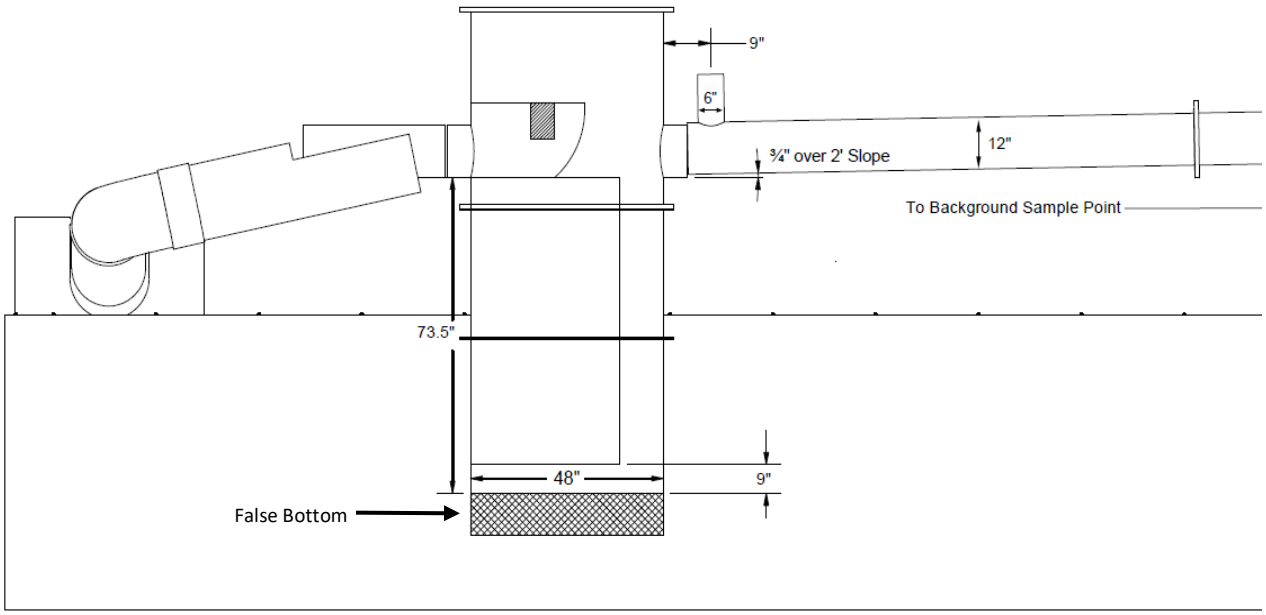


Figure 5 Key Dimensions of Test Vessel

2.2 Test Sediment

The test sediment for removal efficiency testing was a blend of commercially available silica sand grades supplied by AGSCO Corporation and US Silica Company. 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 4A of the 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 6** below. The D_{50} of this blend was 63 microns.

The moisture content of the test sediment was determined referencing ASTM D2216 “Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass”. The moisture content was found to be 0.08%.

Table 1 Particle Size Distribution Results of Removal Efficiency 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	0.0	
500	95	99	100	99	99.3	4.3	
250	90	95	95	94	94.7	4.7	
150	75	78	79	80	79.0	4.0	
100	60	61	62	63	62.0	2.0	1
75	50	53	54	56	54.3	4.3	
50	45	44	46	47	45.4	0.4	1
20	35	32	32	35	33.2	-1.8	1
8	20	21	21	23	21.7	1.7	1
5	10	14	14	16	14.6	4.6	1
2	5	6	6	6	6.3	1.3	1

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

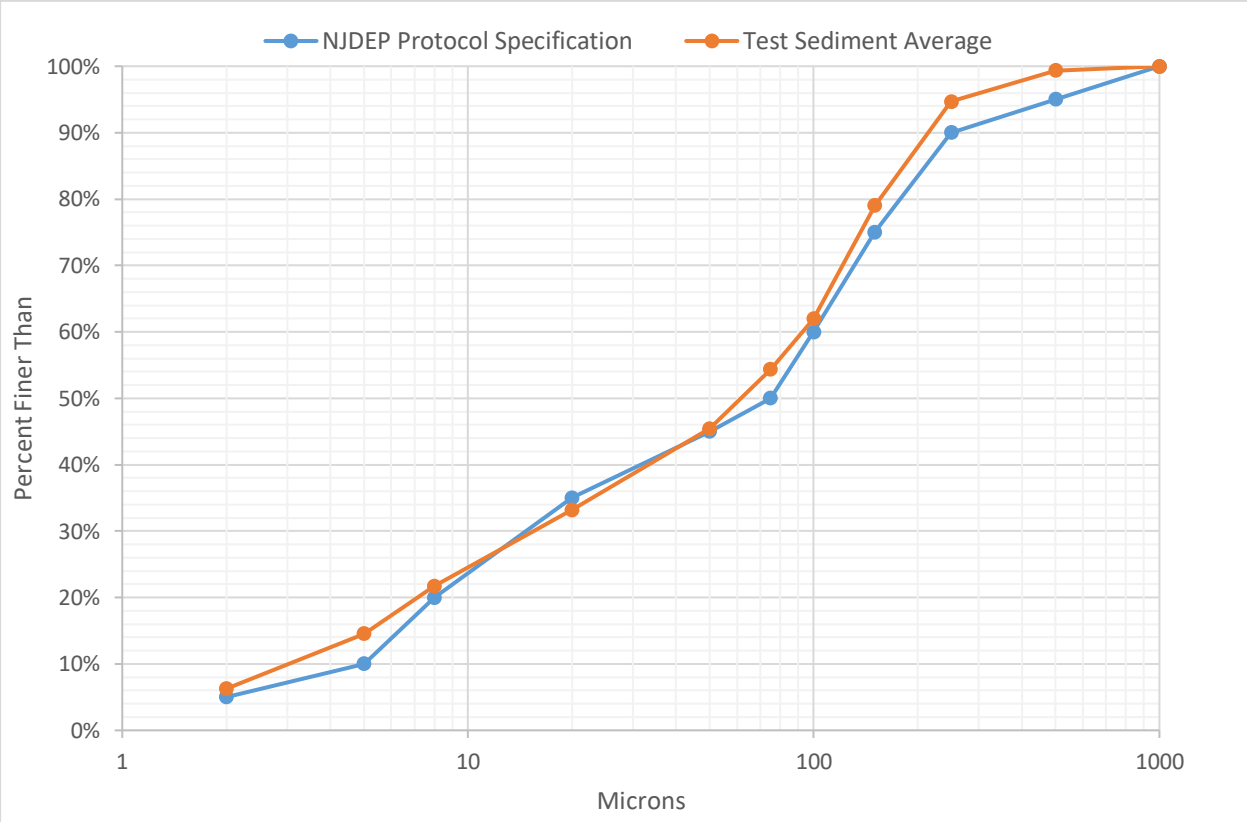


Figure 6 Average PSD of Removal Efficiency Sediment Compared to NJDEP Protocol Specification

The scour sediment was a blend of commercially available silica sand grades supplied by AGSCO Corporation. The sediment was blended by Hydro and the particle size distribution was independently confirmed by GeoTesting Express in Acton, Massachusetts certifying that the supplied silica meets the specification described in Section 4A of the Protocol. Results of particle size gradation testing are shown in **Table 2** and **Figure 7** below.

Table 2 Particle Size Distribution Results of Scour Sediment Samples

Particle Size (µm)	% Finer				Test Sediment Average	Diff. from Protocol	Note
	Protocol	Sample 1	Sample 2	Sample 3			
1000	100	100	100	100	100	0.0	
500	90	100	100	100	100	10.0	
250	55	99	99	100	99.3	44.3	
150	40	79	75	78	77.3	37.3	
100	25	30	24	28	27.2	2.2	1
75	10	16	13	14	14.3	4.3	
50	0	7	6	6	6.0	6.0	1

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

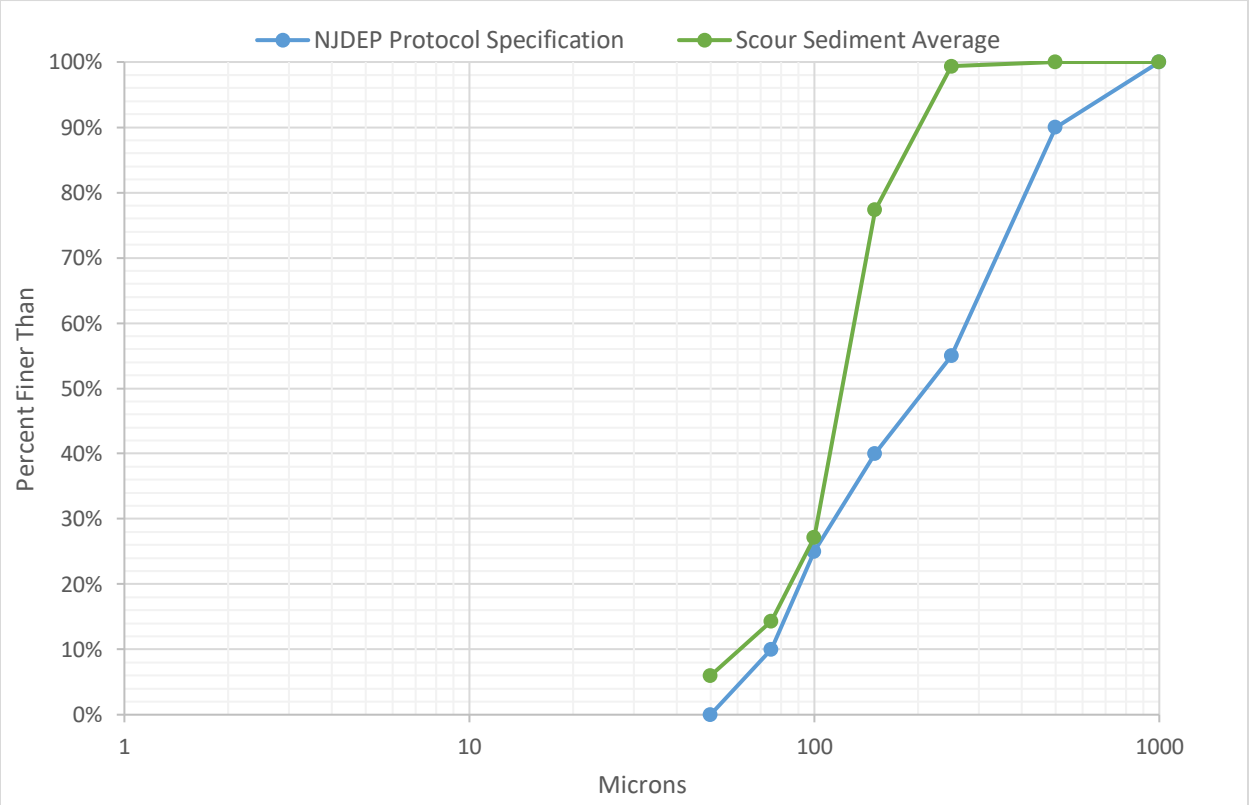


Figure 7 Average PSD of Scour Sediment Compared to NJDEP Protocol Specification

2.3 Sediment Removal Efficiency Testing

Removal efficiency testing was conducted using the Mass Capture Test Method in accordance with Sections 4B and 4C of the Protocol for HDS MTDs. A total of seven flow rates were tested: 10%, 25%, 50%, 75%, 100%, 125%, and 150% of the target Maximum Treatment Flow Rate (MTFR).

The output of the EMCO Electromagnetic Flow Transmitter was logged every 5 seconds with a USB data logger. All flow rates were within 10% of the targeted value and the coefficient of variance (COV) did not exceed 0.03. 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 water temperature was recorded at 5 second intervals to ensure that it did not exceed 80 °F.

Background samples were taken at the background sample port located upstream from the sediment injection point. A minimum of eight influent background samples were taken at evenly spaced intervals during each run. The background samples did not exceed 20.0 mg/L. Each collected sample was time stamped and sealed by Hydro. The independent observer verified the timing and procedures of sample collection and delivered samples to the laboratory for analysis. All samples were analyzed by Maine Environmental Laboratory in accordance with ASTM D3977-97 “Standard Test Methods for Determining Sediment Concentrations in Water Samples.”

The test sediment feed rate and total mass of test sediment introduced during each test run was a known quantity and introduced at a rate within 10% of the targeted value of 200 mg/L influent concentration. A minimum of 25 lbs of sediment was fed into the unit every test. The total sediment introduced to the system was calculated by weighing the sediment in the auger before and after the test run with an Ohaus Defender 5000 bench scale. The times of sediment calibration samples, sediment feed start, feed stop, and flow start/stop were recorded every test run.

Six sediment feed calibration samples were taken from the injection point at evenly spaced intervals during each test. Calibration samples were taken by collecting the sediment at the outlet of the auger. Each sample was collected in a clean container over an interval timed to the nearest second. A minimum sample size of 20 grams was weighed to the nearest 0.1 gram on an Ohaus Pioneer (Model PA1602) laboratory balance observed by the independent observer. The concentration coefficient of variance (COV) did not exceed 0.10.

After each test, the test unit was decanted, and the sediment allowed to settle for a minimum of one hour. The residual mixture of water and test sediment was removed and placed into pre-weighed non-ferrous trays. The sediment was dried in house in a convection oven 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. The sediment was dried overnight, and the oven was sealed by the observer with a tamper-seal tag until ready to be weighed. Any sediment remaining in the inlet pipe was separately cleaned out, dried, and weighed following the same procedure when present.

Removal efficiency was calculated for each MTFR per **Equation 1**.

$$Removal\ Efficiency\ (\%) = \left(\frac{Total\ Mass\ Collected\ in\ MTD}{Total\ Mass\ Input\ During\ Run}\right) * 100 \quad \textbf{Equation 1}$$

2.4 Scour Testing

To simulate a 50% full sump condition, the Hydro-Shield™ Advance Plus sump false bottom is 14.25 inches from the treatment module and was topped with 5.25 inches of scour test sediment. The sediment was levelled and then the test unit was filled with clear water to its normal operating depth. Scour testing began within 24 hours after the sump was pre-loaded with test sediment. All setup, measurements, testing, and sample collection procedures were observed by the independent observer.

Scour testing began by introducing flow and ramping up the flow rate until it reached a minimum of 200% of the MTFR within three minutes of starting. The flow rate remained constant at the target maximum flow rate for the remainder of the test duration. The flow rate was recorded at an interval of 5 seconds.

A total of 15 effluent samples were taken over the duration of the test. Effluent samples were taken at 1, 3, and 5 minutes after the flow of clear water entered the test unit. Effluent samples were then taken every two minutes for an additional 12 samples (i.e., 7, 9, 11…29 minutes). All 15 samples were used to determine average effluent concentration. The effluent samples are collected in glass bottles using the grab sampling method with a minimum volume of 500 milliliters.

Eight background samples were collected at evenly spaced intervals throughout the duration of the test. The background samples were drawn from the background sample port located upstream of the Hydro-Shield™ Advance Plus. At the conclusion of the test, all the collected effluent and background water quality samples were placed into a delivery box and delivered to the laboratory by the independent observer. All samples were analyzed by Maine Environmental Laboratory in accordance with ASTM D3977-97. All adjusted effluent samples were included in the calculation of the average effluent concentration.

2.5 Laboratory Proficiency

Prior to the start of testing, to demonstrate laboratory proficiency in accordance with Section 3B of the Protocol, six spiked Total Suspended Solids (SSC) samples: three at 20 (±5) mg/L and three at 50 (±5) mg/L were prepared by Hydro using the same test sediment as for the removal performance testing. These samples, confirmed by the witness, were sent to Maine Environmental Laboratory, a NELAC Accredited lab, in Yarmouth, Maine. Maine Environmental analyzed these samples in accordance with ASTM D3977-97 “Standard Test Methods for Determining Sediment Concentrations in Water Samples.” Results are shown in **Table 3**.

Table 3 Laboratory Proficiency SSC Results

Sample ID	Measured Concentration (mg/L)	Reported Concentration (mg/L)	% Recovery
2	51.25	48	94
3	53.75	51	95
5	51.25	48	94
		Average	94
1	25.00	24	96
4	21.25	20	94
6	23.75	23	97
		Average	96

The SSC recovery for both concentrations are within the specified ±15% required by the Protocol.

2.6 Quality Objectives and Criteria

Samples sent to the external lab were conveyed 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 witnesses who 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 20.0 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 sediment feed calibration samples not to exceed 0.10
- Variation in flow rate not to exceed 10% of target flow rate
- COV of flow rate not to exceed 0.03

3. Performance Claims

Per the NJDEP Approval Process and based on the laboratory testing conducted for the Hydro-Shield™ Advance Plus, the following are the performance claims made by Hydro.

Total Suspended Solids (TSS) Removal Efficiency

The TSS removal rate of the Hydro-Shield™ Advance Plus is dependent upon flow rate, particle density, and particle size. For the particle size distribution and weighted calculation method required by the NJDEP HDS MTD protocol, the 4-ft Hydro-Shield™ Advance Plus at a MTFR of 1.50 cfs will demonstrate at least 50% annualized weighted TSS removal efficiency.

Effective Treatment and Sedimentation Area

The effective treatment and sedimentation area of the 4-ft Hydro-Shield™ Advance Plus is 12.6 sq. ft.

Maximum Treatment Flow Rate (MTFR)

The MTFR for the 4-ft Hydro-Shield™ Advance Plus was demonstrated to be 42.5 l/s (1.50 cfs) which corresponds to a surface loading rate of 53.4 gpm/sq. ft.

Sediment Storage Depth and Volume

The maximum sediment storage depth of the Hydro-Shield™ Advance Plus is 18 inches. Available sump volume varies with each Hydro-Shield™ Advance Plus model as diameter increases. The available sump volume for a 4-ft Hydro-Shield™ Advance Plus model is 0.70 cubic yards. The operational sediment storage depth is 9 inches, which corresponds to a 50% full sump capacity of 0.35 cubic yards for the standard model (see Appendix **Table A-2**)

Online of Offline Installation

Based on the results of the Scour Test shown in Section 4.2, the 4-ft Hydro-Shield™ Advance Plus qualifies for online installation.

Wet Volume and Detention Time

The detention time of the Hydro-Shield™ Advance Plus depends on flow rate and model size. The detention time is calculated by dividing the treatment volume by the flow rate. The treatment volume is defined as the volume between the pipe invert and the top of the sediment storage zone. For the tested 4-ft Hydro-Shield™ Advance Plus at the MTFR of 1.50 cfs, the detention time is 65 seconds.

4. Supporting Documentation

The NJDEP Process (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 has been provided to NJCAT and retained by Hydro and is available upon request.

4.1 Removal Efficiency

Removal efficiency testing was executed on the 4-ft Hydro-Shield™ Advance Plus unit in order to establish the ability of the Hydro-Shield™ Advance Plus to remove the specified test sediment at 10%, 25%, 50%, 75%, 100%, 125%, and 150% of the target MTFR. The target MTFR was 40 l/s (1.41 cfs).

All results reported in this section were derived from test runs that fully complied with the terms of the Protocol. None of the collection intervals of the calibration samples exceeded one minute in duration for any of the reported tests. The inlet feed concentration coefficient of variance did not exceed 0.10 for any flow rate trials. No background TSS concentrations exceeded the 20.0 mg/L maximum allowed by the protocol. At no point did the water temperature exceed 80 °F. Below in **Table 4** are the removal efficiencies for all of the test runs.

Table 4 Summarized Removal Efficiency from Captured Sediment

% MTFR	10	25	50	75	100	125	150
Total Mass Injected (lb)	30.735	29.595	28.825	27.635	27.705	27.095	27.535
Total Sediment Feed Calibration Samples (lb)	0.697	0.805	1.551	1.142	1.486	1.241	1.484
Sediment Retained in Inlet Pipe (lb)	0.666	0.031	0.000	0.000	0.000	0.000	0.000
Sediment Feed into MTD (lb)	29.372	28.759	27.274	26.493	26.219	25.854	26.051
Sediment Captured in MTD (lb)	19.801	17.012	14.606	12.943	11.312	9.768	8.066
Removal Efficiency (%)	67.4%	59.2%	53.6%	48.9%	43.1%	37.8%	31.0%

The removal efficiency curve, show in **Figure 8** below, and a summary of the removal efficiencies are displayed in **Table 5**. The removal efficiency curve R^2 value of 0.997 exceeded the minimum requirement of 0.97. Using the removal efficiency curve, the 4-ft Hydro-Shield™ Advance Plus achieved a 50.0% annualized weighted TSS removal at an MTFR of 1.50 cfs.

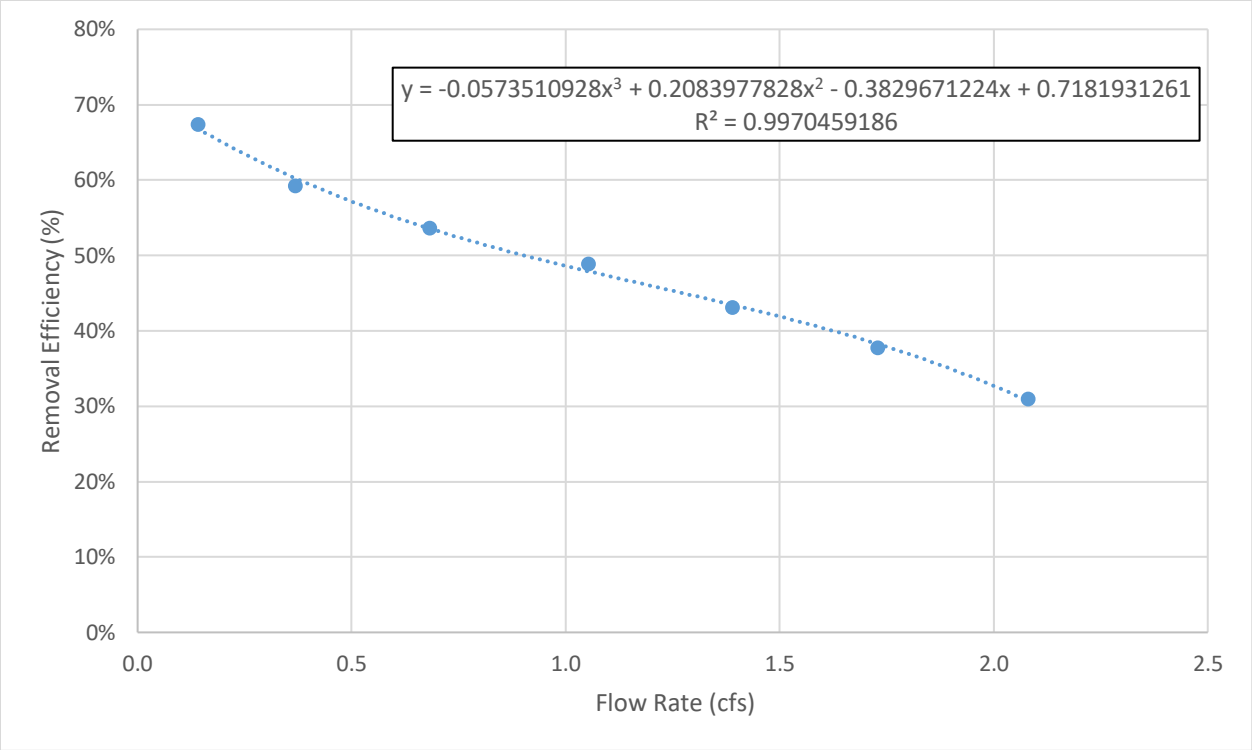


Figure 8 Removal Efficiency vs. Flow Rate

Table 5 Calculated Removal Efficiency Results Summary

% MTFR	Flow Rate (cfs)	Removal Efficiency (%)	Weighting Factor	Weighted Removal (%)
25	0.38	60.1	0.25	15.03
50	0.75	52.4	0.30	15.72
75	1.13	47.0	0.20	9.39
100	1.50	42.0	0.15	6.29
125	1.88	35.6	0.10	3.56
Annualized Weighted Removal Efficiency (%)				50.0

Individualized test results detailing the sampling schedule, flow, temperature, and sediment measurements are available in the sections below.

4.1.1 10% MTFR (0.14 CFS)

Table 6 Sampling Schedule - 10% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:38:06		2
00:53:20	2	
01:16:11		3
01:46:40	3	
01:54:17		4
02:32:23		5
02:40:00	4	
03:10:29		6
03:33:20	5	
03:48:34		7
04:26:40	6	8
MTD Detention Time = 11.3 minutes		

Table 7 Flow - 10% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	0.14	0.14	PASS	0.016	PASS
l/s	4.0	3.99			

Table 8 Temperature - 10% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
75.3	PASS

Table 9 Background SSC - 10% MTFR

Sample ID	Concentration (mg/L)	QA/QC ≤ 20.0 mg/L
1	1.5[1]	PASS
2	1.5[1]	PASS
3	1.5[1]	PASS
4	4	PASS
5	7	PASS
6	9	PASS
7	12	PASS
8	15	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 10 Sediment Feed - 10% MTFR

	Mass (g)
Sample 1	49.74
Sample 2	52.64
Sample 3	53.65
Sample 4	52.69
Sample 5	52.11
Sample 6	55.28
Total	316.11
Average	52.69
QA/QC	
COV	0.035
COV ≤ 0.10	PASS

Table 11 Sediment Mass Balance - 10% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	44.265
Sediment Mass Used (lb)	30.735
Sediment Mass Used Adjusted for Feed Samples (lb)	30.038
Water Volume During Sediment Addition (L)	62,638
Average Sediment Concentration (mg/L)	217.5
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.2 25% MTFR (0.35 CFS)

Table 12 Sampling Schedule - 25% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:15:21		2
00:21:30	2	
00:30:43		3
00:43:00	3	
00:46:04		4
01:01:26		5
01:04:30	4	
01:16:47		6
01:26:00	5	
01:32:09		7
01:47:30	6	8
MTD Detention Time = 4.53 minutes		

Table 13 Flow - 25% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	0.35	0.37	PASS	0.019	PASS
l/s	10.0	10.44			

Table 14 Temperature - 25% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
75.0	PASS

Table 15 Background SSC - 25% MTFR

Sample ID	Concentration (mg/L)	QA/QC
		≤ 20.0 mg/L
1	1.5[1]	PASS
2	1.5[1]	PASS
3	1.5[1]	PASS
4	1.5[1]	PASS
5	1.5[1]	PASS
6	1.5[1]	PASS
7	1.5[1]	PASS
8	1.5[1]	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 16 Sediment Feed - 25% MTFR

	Mass (g)
Sample 1	58.67
Sample 2	60.69
Sample 3	60.32
Sample 4	64.45
Sample 5	60.98
Sample 6	60.19
Total	365.30
Average	60.88
QA/QC	
COV	0.032
COV ≤ 0.10	PASS

Table 17 Sediment Mass Balance - 25% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	45.405
Sediment Mass Used (lb)	29.595
Sediment Mass Used Adjusted for Feed Samples (lb)	28.790
Water Volume During Sediment Addition (L)	65,771
Average Sediment Concentration (mg/L)	198.5
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.3 50% MTFR (0.71 CFS)

Table 18 Sampling Schedule - 50% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:07:56		2
00:11:06	2	
00:15:51		3
00:22:12	3	
00:23:47		4
00:31:43		5
00:33:18	4	
00:39:39		6
00:44:24	5	
00:47:34		7
00:55:30	6	8
MTD Detention Time = 2.27 minutes		

Table 19 Flow - 50% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	0.71	0.68	PASS	0.019	PASS
l/s	20.0	19.32			

Table 20 Temperature - 50% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
73.8	PASS

Table 21 Background SSC - 50% MTFR

Sample ID	Concentration (mg/L)	QA/QC ≤ 20.0 mg/L
1	5	PASS
2	4	PASS
3	5	PASS
4	6	PASS
5	9	PASS
6	12	PASS
7	16	PASS
8	20	PASS

Table 22 Sediment Feed - 50% MTFR

	Mass (g)
Sample 1	120.66
Sample 2	118.93
Sample 3	117.31
Sample 4	114.50
Sample 5	116.19
Sample 6	116.08
Total	703.67
Average	117.28
QA/QC	
COV	0.019
COV ≤ 0.10	PASS

Table 23 Sediment Mass Balance - 50% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	46.175
Sediment Mass Used (lb)	28.825
Sediment Mass Used Adjusted for Feed Samples (lb)	27.274
Water Volume During Sediment Addition (L)	61,483
Average Sediment Concentration (mg/L)	201.2
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.4 75% MTFR (1.06 CFS)

Table 24 Sampling Schedule - 75% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:05:13		2
00:07:18	2	
00:10:26		3
00:14:36	3	
00:15:39		4
00:20:51		5
00:21:54	4	
00:26:04		6
00:29:12	5	
00:31:17		7
00:36:30	6	8
MTD Detention Time = 1.52 minutes		

Table 25 Flow - 75% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	1.06	1.05	PASS	0.006	PASS
l/s	30.0	29.81			

Table 26 Temperature - 75% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
75.2	PASS

Table 27 Background SSC - 75% MTFR

Sample ID	Concentration (mg/L)	QA/QC
		≤ 20.0 mg/L
1	1.5[1]	PASS
2	1.5[1]	PASS
3	1.5[1]	PASS
4	4	PASS
5	7	PASS
6	10	PASS
7	13	PASS
8	16	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 28 Sediment Feed - 75% MTFR

	Mass (g)
Sample 1	87.45
Sample 2	90.24
Sample 3	86.63
Sample 4	85.39
Sample 5	84.42
Sample 6	83.80
Total	517.93
Average	86.32
QA/QC	
COV	0.027
COV ≤ 0.10	PASS

Table 29 Sediment Mass Balance - 75% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	47.365
Sediment Mass Used (lb)	27.635
Sediment Mass Used Adjusted for Feed Samples (lb)	26.493
Water Volume During Sediment Addition (L)	63,129
Average Sediment Concentration (mg/L)	190.4
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.5 100% MTFR (1.41 CFS)

Table 30 Sampling Schedule - 100% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:03:59		2
00:05:34	2	
00:07:57		3
00:11:08	3	
00:11:56		4
00:15:54		5
00:16:42	4	
00:19:53		6
00:22:16	5	
00:23:51		7
00:27:50	6	8
MTD Detention Time = 1.13 minutes		

Table 31 Flow - 100% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	1.41	1.39	PASS	0.019	PASS
l/s	40.0	39.34			

Table 32 Temperature - 100% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
77.8	PASS

Table 33 Background SSC - 100% MTFR

Sample ID	Concentration (mg/L)	QA/QC ≤ 20.0 mg/L
1	1.5[1]	PASS
2	1.5[1]	PASS
3	3	PASS
4	5	PASS
5	7	PASS
6	11	PASS
7	14	PASS
8	17	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 34 Sediment Feed - 100% MTFR

	Mass (g)
Sample 1	114.42
Sample 2	122.04
Sample 3	116.86
Sample 4	109.91
Sample 5	106.98
Sample 6	104.02
Total	674.23
Average	112.37
QA/QC	
COV	0.059
COV ≤ 0.10	PASS

Table 35 Sediment Mass Balance - 100% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	47.295
Sediment Mass Used (lb)	27.705
Sediment Mass Used Adjusted for Feed Samples (lb)	26.219
Water Volume During Sediment Addition (L)	62,870
Average Sediment Concentration (mg/L)	189.2
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.6 125% MTFR (1.77 CFS)

Table 36 Sampling Schedule - 125% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:03:07		2
00:04:22	2	
00:06:14		3
00:08:44	3	
00:09:21		4
00:12:29		5
00:13:06	4	
00:15:36		6
00:17:28	5	
00:18:43		7
00:21:50	6	8
MTD Detention Time = 0.92 minutes		

Table 37 Flow - 125% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	1.77	1.73	PASS	0.007	PASS
l/s	50.0	48.98			

Table 38 Temperature - 125% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
73.8	PASS

Table 39 Background SSC - 125% MTFR

Sample ID	Concentration (mg/L)	QA/QC
		≤ 20.0 mg/L
1	6	PASS
2	1.5[1]	PASS
3	1.5[1]	PASS
4	4	PASS
5	4	PASS
6	6	PASS
7	7	PASS
8	9	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 40 Sediment Feed - 125% MTFR

	Mass (g)
Sample 1	93.77
Sample 2	102.75
Sample 3	98.69
Sample 4	96.33
Sample 5	89.85
Sample 6	81.55
Total	562.94
Average	93.82
QA/QC	
COV	0.079
COV ≤ 0.10	PASS

Table 41 Sediment Mass Balance - 125% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	47.905
Sediment Mass Used (lb)	27.095
Sediment Mass Used Adjusted for Feed Samples (lb)	25.854
Water Volume During Sediment Addition (L)	61,860
Average Sediment Concentration (mg/L)	189.6
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.7 150% MTFR (2.12 CFS)

Table 42 Sampling Schedule - 150% MTFR

Elapsed Time (hh:mm:ss)	Sediment Feed Sample	Background Sample
00:00:00	1	1
00:02:39		2
00:03:42	2	
00:05:17		3
00:07:24	3	
00:07:56		4
00:10:34		5
00:11:06	4	
00:13:13		6
00:14:48	5	
00:15:51		7
00:18:30	6	8
MTD Detention Time = 0.77 minutes		

Table 43 Flow - 150% MTFR

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	2.12	2.08	PASS	0.010	PASS
l/s	60.0	58.90			

Table 44 Temperature - 150% MTFR

Maximum Temperature (°F)	QA/QC
	≤ 80 °F
75.0	PASS

Table 45 Background SSC - 150% MTFR

Sample ID	Concentration (mg/L)	QA/QC ≤ 20.0 mg/L
1	13	PASS
2	1.5[1]	PASS
3	1.5[1]	PASS
4	1.5[1]	PASS
5	1.5[1]	PASS
6	3	PASS
7	4	PASS
8	4	PASS

Note 1: Measurements below the LOQ of 3 mg/L are reported as half of the LOQ

Table 46 Sediment Feed - 150% MTFR

	Mass (g)
Sample 1	107.90
Sample 2	122.43
Sample 3	118.28
Sample 4	116.88
Sample 5	109.49
Sample 6	98.10
Total	673.08
Average	112.2
QA/QC	
COV	0.079
COV ≤ 0.10	PASS

Table 47 Sediment Mass Balance - 150% MTFR

Pre Test Sediment Mass (lb)	75.000
Post Test Sediment Mass (lb)	47.465
Sediment Mass Used (lb)	27.535
Sediment Mass Used Adjusted for Feed Samples (lb)	26.051
Water Volume During Sediment Addition (L)	62,434
Average Sediment Concentration (mg/L)	189.3
QA/QC	
Total Mass Added ≥ 25 lbs	PASS
Average Concentration within ±10% of 200 mg/L	PASS

4.1.8 Performance Verification Data Not Reported

Results from three removal efficiency test runs had to be discarded for failure to meet the protocol requirements. Specifically:

- Run 3502 (3/05/24) at 25% target MTFR. Failed to measure sediment in the inlet pipe.
- Run 3506 (3/12/24) at 75% target MTFR. Flow COV >0.03 (0.033)
- Run 3507 (3/13/24) at 10% target MTFR. One BG sample >20.0 mg/L.

4.2 Scour Testing

Scour testing was performed according to Section 5 of the Protocol at 200% MTFR to verify its suitability for online use. For the 4-ft configuration Hydro-Shield™ Advance Plus with an MTFR of 42.5 l/s (1.50 cfs) the average scour test flow rate had to be at least 84.2 l/s (2.97 cfs). The average flow rate for the scour test was 3.28 cfs which represents 220% of the MTFR. The maximum temperature during the test was 73.2^0 F. The sampling schedule is detailed in **Table 48**. The flow rate and associated quality checks are detailed in **Table 49**.

Table 48 Sampling Schedule - Scour

Elapsed Time (hh:mm:ss)	Effluent Sample	Background Sample
00:00:00		
00:01:00	1	1
00:03:00	2	
00:05:00	3	2
00:07:00	4	
00:09:00	5	3
00:11:00	6	
00:13:00	7	4
00:15:00	8	
00:17:00	9	5
00:19:00	10	
00:21:00	11	6
00:23:00	12	
00:25:00	13	7
00:27:00	14	
00:29:00	15	8

Table 49 Flow - Scour

Units	Target Flow	Actual Flow	QA/ QC		
			±10%	COV	COV ≤ 0.03
cfs	3.18	3.28	PASS	0.003	PASS
l/s	90.0	92.80			

The effluent, background, and adjusted SSC concentrations are reported in **Table 50**. When the reported concentration is below the limit of quantitation, 3 mg/L, half of that value was used for the purpose of calculation. When the background sample concentration needed to be interpolated from the surrounding two samples (i.e. the background samples for even-numbered effluent samples) and one or more of the surrounding samples were below the limit of quantitation, 1.5 mg/L was used for the average.

The adjusted effluent concentration is calculated using **Equation 2** below.

$$Adjusted\ \left(\frac{mg}{L}\right) = Effluent\ \ \left(\frac{mg}{L}\right) - Background\ Concentration\ \left(\frac{mg}{L}\right) \quad \textbf{Equation 2}$$

The maximum adjusted effluent concentration was 4.7 mg/L at >200% of the MTFR, therefore, the Hydro-Shield™ Advance Plus satisfies the criteria for online use.

Table 50 SSC - Scour

Sample ID	Effluent Concentration (mg/L)	Background Concentration (mg/L)	QA/QC ≤ 20.0 mg/L	Adjusted Concentration (mg/L)
1	1.5[1]	3.9	PASS	0
2	3.1	3.6	PASS	0
3	5.2	3.2	PASS	2.0
4	6.1	1.5[1]	PASS	4.6
5	5.6	1.5[1]	PASS	4.1
6	5.4	1.5[1]	PASS	3.9
7	5.3	1.5[1]	PASS	3.8
8	6.1	1.5[1]	PASS	4.6
9	7.5	3.0	PASS	4.5
10	5.6	3.1	PASS	2.5
11	5.5	3.1	PASS	2.4
12	5.6	3.1	PASS	2.5
13	5.7	3.0	PASS	2.7
14	6.2	1.5[1]	PASS	4.7
15	4.6	1.5[1]	PASS	3.1

[1]Measured/calculated value below the limit of quantitation (3.0 mg/L).

4.3 Hydraulics

Prior to testing, the head loss through the Hydro-Shield™ Advance Plus was measured spanning 10% to 200% of the MTFR shown in **Table 51**. Measurements were taken with a clean test vessel, prior to the addition of any sediment, within the inlet pipe, outlet pipe, and the vessel. Measurements were taken to the nearest 1/16-inch using pressure taps and an engineer's scale. Bypass occurred at approximately 1.68 cfs. Head loss vs. flow rate is shown on **Figure 9**.

Table 51 Water Elevation and Head Loss

Flow Rate		Water Elevation (inches)			Loss (inches)
l/s	cfs	Influent	Vessel	Effluent	
4	0.14	10.2	10.3	2.1	8.1
10	0.35	11.3	11.4	3.1	8.2
20	0.71	12.4	12.6	4.7	7.7
30	1.06	13.8	13.9	5.6	8.2
40	1.41	15.4	15.5	6.2	9.2
50	1.77	16.8	16.8	6.8	10.0
60	2.12	18.0	18.0	7.1	10.9
70	2.47	19.5	19.4	6.8	12.7
80	2.83	20.4	20.3	7.3	13.1
90	3.18	20.8	20.8	7.5	13.3
100	3.53	22.3	22.3	7.8	14.5

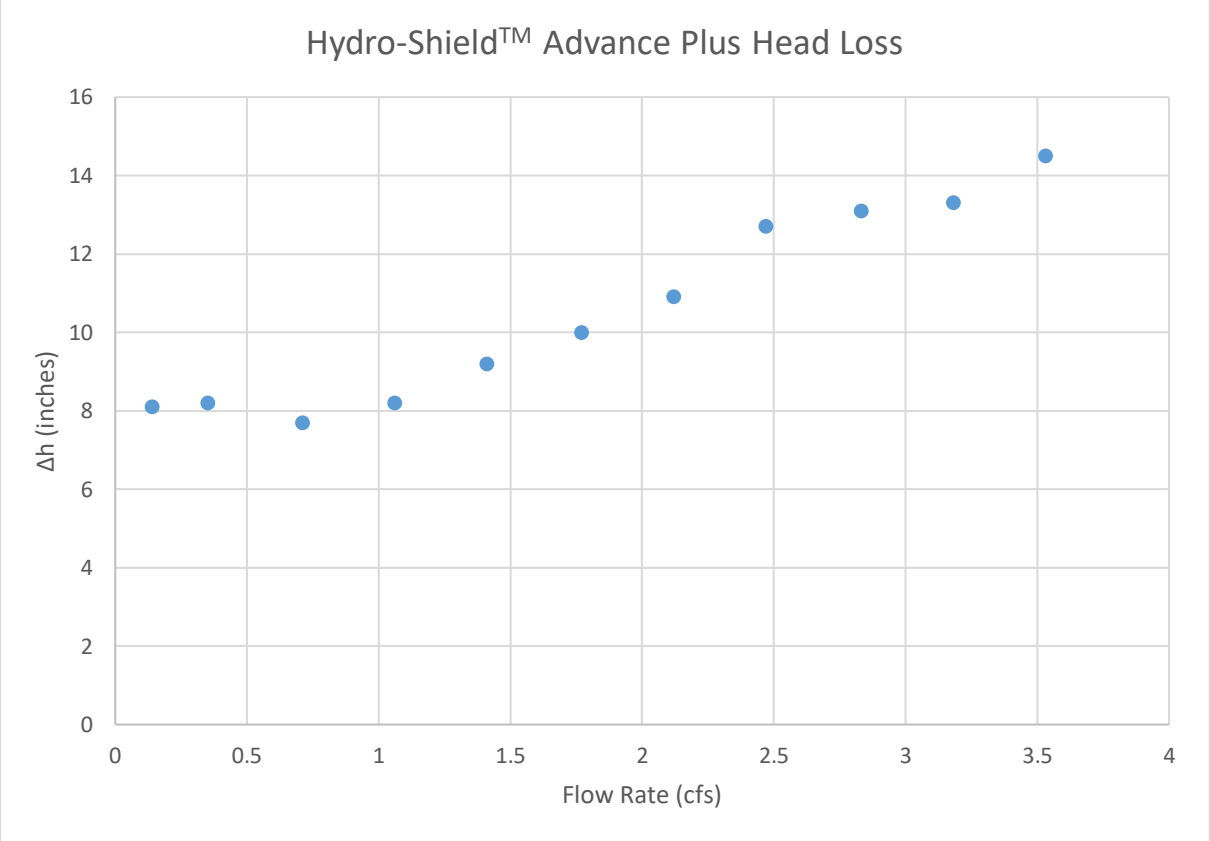


Figure 9 Hydro-Shield™ Advance Plus Head Loss

5. Design Limitations

The Hydro-Shield™ Advance Plus is an engineered system for which Hydro International's engineers work with site designers to generate a detailed engineering submittal package for each installation. As such, design limitations are typically identified and managed during the design process. Design parameters and limitations are discussed in general terms below.

Required Soil Characteristics

The Hydro-Shield™ Advance Plus is a flow-through system contained within a watertight manhole. Therefore, the Hydro-Shield™ Advance Plus can be installed and function as intended in all soil types.

Slope of Drainage Pipe

Hydro International recommends contacting our design engineers when the Hydro-Shield™ Advance Plus is going to be installed on a drainage line with a slope greater than 10%. With steeply sloping pipe, site-specific parameters such as pipe size, online vs. offline arrangement of the Hydro-Shield™ Advance Plus and the frequency of peak flow are taken into consideration by the Hydro International team.

Maximum Treatment Flow Rate

The MTFR of the Hydro-Shield™ Advance Plus is dependent upon model size. The recommended maximum treatment flow rate is dependent on Hydro-Shield™ Advance Plus model size and other design and performance specifications. Hydro International recommends contacting their engineering staff with questions about managing high peak flow rates.

Maintenance Requirements

The Hydro-Shield™ Advance Plus should be inspected and maintained according to recommendations and guidelines set forth in the Operation and Maintenance manual at: https://www.hydro-int.com/en/resources/hydro-shield-advance-operations-and-maintenance-manual

A detailed discussion of inspection and maintenance requirements is discussed later in Section 6.

Operating Head

There is an operational head loss associated with each Hydro-Shield™ Advance Plus unit. Site specifics are evaluated to ensure an appropriate head for the system to function properly.

Installation Limitations

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

Configurations

The Hydro-Shield™ Advance Plus was designed for online applications in which the inlet and outlet are tied directly into the main drainage line.

Structural Load Limitations

Standard Hydro-Shield™ Advance Plus units are designed for HS-20 loading. Contact Hydro International engineering staff when heavier load ratings are required.

Pretreatment Requirements

The Hydro-Shield™ Advance Plus has no pre-treatment requirements.

Limitations on Tailwater

Hydro International recommends working with their engineering team if tailwater is present to increase the available driving head to ensure that the full water quality treatment flow rate is treated consistent with NJDEP protocol requirements.

Depth of Seasonal High Water Table

Although the functionality of the Hydro-Shield™ Advance Plus is not impacted by high groundwater, Hydro International recommends consulting their engineering staff to determine whether the addition of anti-flotation collars to the base of the Hydro-Shield™ Advance Plus chamber are necessary to counterbalance buoyant forces.

6. Maintenance

Inspection and maintenance of the Hydro-Shield™ Advance Plus are simple procedures conducted from the surface. An Operation and Maintenance Manual can be found at: https://www.hydro-int.com/en/resources/hydro-shield-advance-operations-and-maintenance-manual

Neither inspection nor maintenance require the purchasing of spare parts or tools from Hydro International. The Hydro-Shield™ Advance Plus has appropriately located manhole lids to provide inspection and maintenance access to both the internal bypass chamber and vortex treatment chamber.

Inspection

The required frequency of cleanout depends on site use and other site-specific characteristics and should therefore be determined by inspecting the unit after installation. During the first year of operation, the unit should be inspected at least every six months to determine the rate of sediment and floatables accumulation. More frequent inspections are recommended at sites that would generate heavy solids loads, like parking lots with winter sanding or unpaved maintenance lots. A

dipstick can be used to measure accumulated oil; a sediment probe can be used to determine the level of accumulated solids stored in the sump.

Maintenance Procedures

The interval of required clean-out should be determined by post-installation inspection of pollutant accumulation rates. If post-installation inspection cannot be conducted for some reason, Hydro International recommends the Hydro-Shield™ Advance Plus be cleaned out at least once per year. There is no need for man entry into the Hydro-Shield™ Advance Plus during maintenance. However, if man entry does occur then proper confined space entry procedures must be followed.

Floatable trash and debris can be removed by lifting the access covers and using a netted skimming pole or a vactor truck to skim trash from the surface of the standing water. Accumulated oil must be removed from the surface using a vactor truck or sump vac. Accumulated sediment can be removed by lifting the sediment cleanout access cover and dropping a vactor hose down the port to the sump. The entire sump liquid volume does not necessarily need to be removed from the Hydro-Shield™ Advance Plus during maintenance. When all pollutants have been removed from the Hydro-Shield™ Advance Plus, the manhole lids should be put securely back in place.

Sediment, floatables, and gross debris can generally be disposed of at the 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.

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...®

April 16, 2024

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 Hydro-Shield™ Advance Plus in accordance with the *"New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device"* (April 25, 2023). 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 four-foot diameter Hydro-Shield™ Advance Plus was tested at Hydro International's laboratory in Portland, Maine for hydraulic characterization, sediment scour and sediment removal efficiency. 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
Associate Director of Product Development

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

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 Hydro-Shield™ Advance Plus
DATE: April 16, 2024
CC: Luke Frankel, FB Environmental Associates (FBE)

Statement of Third-Party Observer

FB Environmental served as the third-party observer for tests performed on the Hydro-Shield™ Advance Plus system by Hydro International in January through March of 2024 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 Hydrodynamic Sedimentation Manufactured Treatment Device (April 2023).* 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: Hydro-Shield™ Advance Plus* report by Hydro International, dated April 2024 with the April 11, 2024 edits incorporated. We state that they conform to what we saw during our supervision as a third-party observer.

Forrest Bell ~ FB Environmental Associates

4/16/2024
Date

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 Hydrodynamic Sedimentation Manufactured Treatment Device

DATE: April 16, 2024

CC: 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: Hydro-Shield™ Advance Plus* report by Hydro International, dated April 2024 with the April 11, 2024 edits incorporated.

Disclosure Record

FB Environmental has provided the service of third-party observer for tests performed by Hydro International in January through March of 2024. The tests assessed the removal efficiency of the Hydro-Shield™ Advance Plus 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

4/16/2024

Date

Center for Environmental Systems

Stevens Institute of Technology

One Castle Point

Hoboken, NJ 07030-0000

May 16, 2024

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 the Hydro International Hydro-Shield™ Advanced Plus hydrodynamic separator, the test protocol requirements contained in the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device"* (NJDEP HDS Protocol, January 1, 2021- Updated April 25, 2023) were met or exceeded consistent with the NJDEP Approval Process. Specifically:

Test Sediment Feed

The mean PSD of the test sediments comply with the PSD criteria established by the NJDEP HDS 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 (<75µ); the test sediment D_{50} was 63 microns. The scour test sediment PSD analysis was plotted against the NJDEP scour test PSD specification and shown to meet the protocol specifications.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on a 4-ft Hydro-Shield™ Advanced Plus test unit comprised of full-scale, commercially available internal components installed in a 4-ft round plastic manhole, to establish the ability of the Hydro-Shield™ to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. The Hydro-Shield™ demonstrated an annualized weighted solids removal as defined in the NJDEP HDS Protocol of 50.0%. The flow rates, feed rates, and influent concentration all met the NJDEP HDS test protocol's coefficient of variance requirements. Background concentrations never exceeded 20 mg/L.

Scour Testing

The scour testing was conducted at 3.28 cfs (92.80 l/s), which is equal to 220% of the MTFR. The scour test was conducted with the unit preloaded with 5.25" of levelled sediment to the 50% capacity level, prior to conducting the test. A total of 15 effluent samples were collected throughout the test. The calculated concentrations, adjusted for background, ranged from 0 to 4.7 mg/L, qualifying the Hydro-Shield™ Advanced Plus for online installation.

Maintenance Frequency

The predicted maintenance frequency for all Hydro-Shield™ Advanced Plus models is 45 months.

Sincerely,

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

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 (2021). *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device. Trenton, NJ. January 1, 2021 (updated April 25, 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 Hydro-Shield™ Advance Plus Design Specifications are shown in **Table A-1**.
- TSS Removal Rate – 50%
- Online and offline installation

Detailed Specification

- Hydro-Shield™ Advance Plus maximum treatment flow rates (MTFRs), sediment storage amounts and sediment removal intervals per NJDEP sizing requirements are attached as **Table A-1**.
- Standard Hydro-Shield™ Advance Plus dimensions are attached as **Table A-2**.
- Pick weights and installation procedures vary with model size. Hydro International provides contractors with project-specific unit pick weights and installation instructions prior to delivery.
- Maximum recommended sediment depth prior to cleanout is 9 inches for all model sizes.
- For a reference maintenance plan, download the Hydro-Shield™ Advance Plus Operation & Maintenance Manual at: https://www.hydro-int.com/en/resources/hydro-shield-advance-operations-and-maintenance-manual
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the Hydro-Shield™ Advance Plus to be used in series with another hydrodynamic separator to achieve an enhanced total suspended solids (TSS) removal rate.

Table A-1 MTFRs and Sediment Removal Intervals for HSA Plus Models

HSA Plus Model	Manhole Diameter (ft)	NJDEP 50% TSS Maximum Treatment Flow Rate (cfs)	Treatment Area (ft^2)	Hydraulic Loading Rate (gpm/ft^2)	50% Max Sediment Storage Volume (ft^3)	Required Sediment Removal Interval[1] (months)
4-ft	4	1.50	12.6	53.4	9.4	45
6-ft	6	3.38	28.3	53.4	21.2	45
8-ft	8	6.00	50.3	53.4	37.7	45

[1]Required sediment removal interval was calculated using the equation specified in Appendix B Part B of the NJDEP Laboratory Protocol for HDS MTDs:

$$\text{Sediment Removal Interval (months)} = \frac{(\text{50\% HDS MTD Max Sediment Storage Volume} * 3.57)}{(\text{MTFR} * \text{TSS Removal Efficiency})}$$

Table A-2 Standard Dimensions for HSA Plus Models

HSA Plus Model	Maximum Treatment Flow Rate (cfs)	50% Max Sediment Storage Volume (ft^3)	Chamber Depth (ft)	Treated Chamber Depth[1] (ft)	Sediment Sump Depth (ft)	Aspect Ratio Treatment Depth: Diameter	Ratio Total Plate Area: Vessel Area	Maximum Pipe Diameter (inch)
4-ft	1.50	9.5	6.88	6.13	1.5	1.53	8	24
6-ft	3.38	21.2	7.67	6.92	1.5	n/a	8	36
8-ft	6.00	37.7	11.17	10.42	1.5	1.30	8	48

[1]Treated Chamber Depth is the chamber depth minus 1/2 the sediment sump depth. Larger models (>250% MTFR of the tested unit) must be geometrically proportionate to the tested unit (4-ft model). A variance of 15% is allowable. For units <250% MTFR (6-ft model) the depth must be equal or greater than the depth of the unit treated.