NJCAT TECHNOLOGY VERIFICATION

HydroChain™ Prime Separator (HCPS) System

Xerxes Corporation

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1. Description of Technology

The HydroChain™ Prime Separator (HCPS) is a hydrodynamic vortex separator (HDS) that is supplied by Xerxes. It is intended to remove pollutants of concern that settle or float from stormwater runoff. **Figure 1** depicts the Prime Separator internal components fitted into a manhole that is typically made from precast concrete. The patented internal components modify the flow regime to increase pollutant removal efficiency and maximize captured pollutants retention over a wide range of hydraulic and pollutant loading rates. HCPS internal components are assembled from high-density polyethylene (HDPE) plastic at a manufacturing facility and then installed into a standard size manhole. Site specific needs determine the appropriate standard model or size selected and installed into the drainage system; or alternatively, a non-standard unit scaled according to the verified scaling ratios is provided.

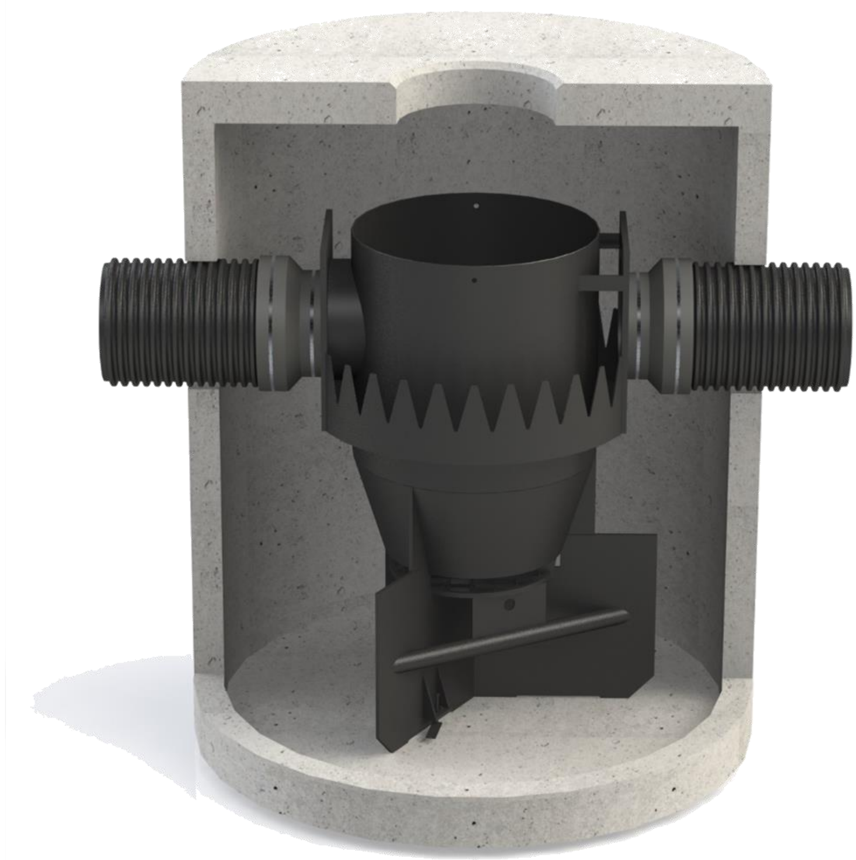

Figure 1 HCPS in a Manhole with HDPE Inlet/Outlet Pipes

The Prime Separator internal components are shown in **Figure 2** and listed in **Table 1**, which also includes a description of the function for each part. All components are constructed from the same HDPE material except for hardware used to attach the HDPE components to the manhole, which are stainless steel.

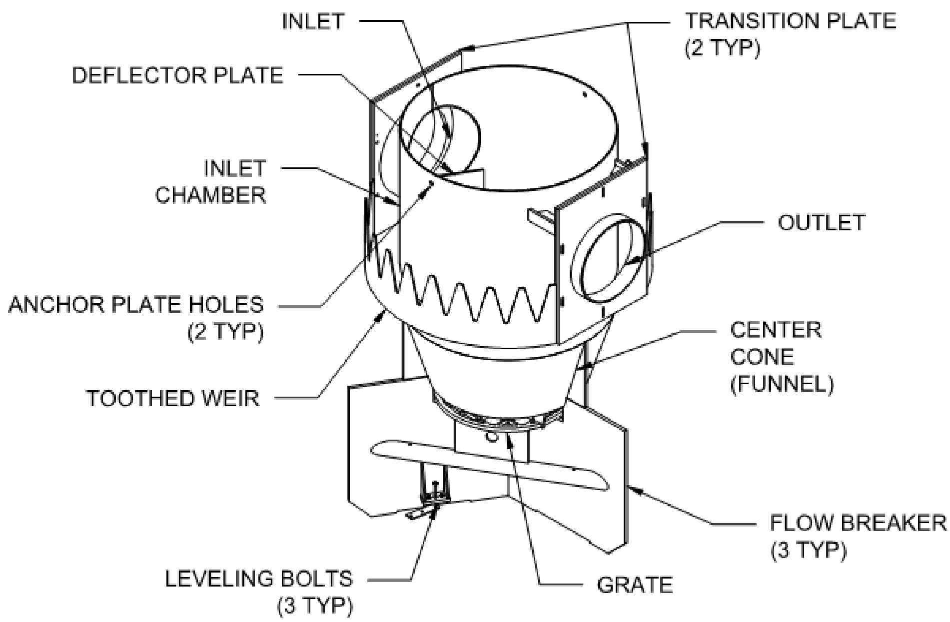

Figure 2 Prime Separator Components

Table 1 Prime Separator Component Purpose

Component	Purpose
Inlet	Brings untreated water into the separator
Transition Plate	Connects exterior inlet and outlet pipes to the Prime Separator (PS) unit
Deflector Plate	Inlet baffles to convert linear flow into vortex flow for hydrodynamic separation
Inlet Chamber	Passes flow from the deflector plate to the center cone
Center Cone (funnel)	Removes suspended solids via hydrodynamic separation
Flow Breaker	Baffles in the sump designed to reduce re-suspension of sediments
Toothed Weir	Controls water elevations entering the outlet "tray"
Outlet	Discharges treated water from the separator
Grate	Captures large settling debris
Anchor Plate Holes	To anchor the PS body to the manhole structure
Leveling Bolts	Allows for minor adjustment to align the components with the inlet and outlet pipes and manhole floor

A generalized flow diagram is shown in **Figure 3**. The following steps explain how the HCPS operates:

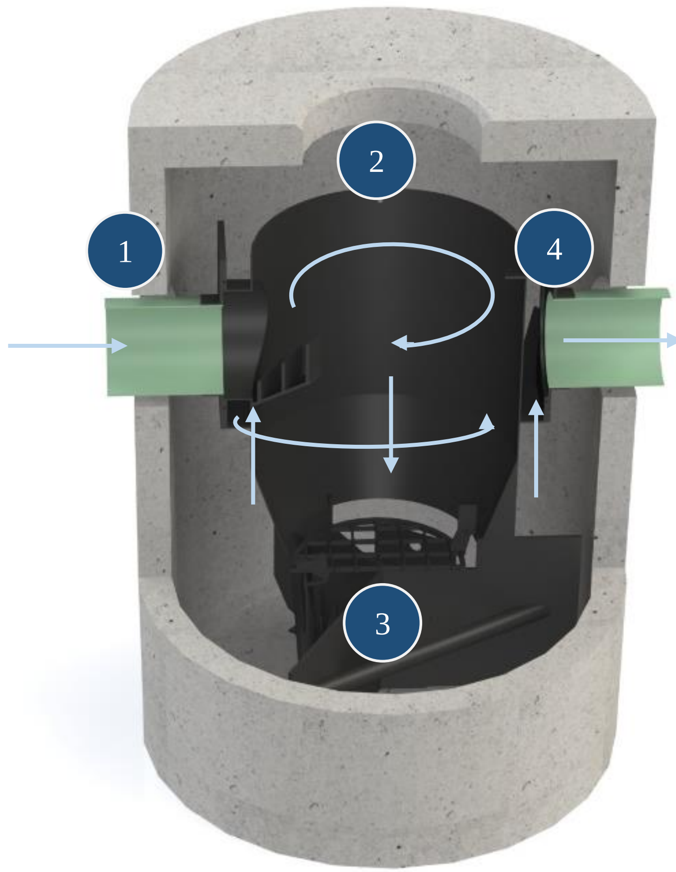

Figure 3 Prime Separator Flow Path

1. An **inlet pipe** conveys stormwater into the inlet chamber that includes a deflector plate (**Figure 4**) to initiate a circular, rotational flow.
2. As hydraulic head pressure increases, the rotating flow column and settling pollutants within the **funnel** (vortex chamber) are forced to travel downward towards the sediment sump. The funnel also creates a trap that is designed to capture pollutants that float and rise to the surface.
3. Pollutants that are settled collect in the **sediment sump** as the flow transitions from a rotating downward flow within the funnel to an upward rotating flow around the outside of the funnel between the funnel and vessel wall.
4. With pollutants that settle, and float separated from the incoming flow, treated flow is directed up and around the outside of the center funnel, through the circular toothed weir (**Figure 5**) and into the **outlet pipe**. Hydraulically, the system is designed so that water elevations do not exceed the elevation of the funnel. This prevents pollutants that float and are retained in the funnel from escaping.

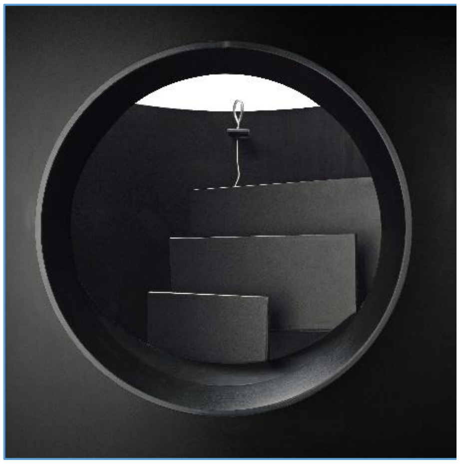

Figure 4 Inlet Deflector Plate Baffles

Figure 5 Outlet Tray with Toothed Weir

2. Laboratory Testing

The New Jersey Department of Environmental Protection (NJDEP) maintains a list of certified stormwater hydrodynamic separator devices (HDS) that can be installed on newly developed or redeveloped sites to achieve stormwater treatment requirements for Total Suspended Solids (TSS). Hydrodynamic separators are evaluated for certification according to the *New Jersey Department of Environmental Protection Process for Approval of Use for Manufactured Treatment Devices* (NJDEP August 4, 2021). The NJDEP Approval Process requires that TSS treatment devices operating 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* (NJDEP January 1, 2021*)* (hereafter referred to as "NJDEP HDS 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 NJDEP HDS Protocol. The QAPP was submitted and approved by NJCAT prior to commencement of testing.

Laboratory testing was performed by 3P staff at their manufacturing and test facility in Germany. The Institut für Unterirdische Infrastruktur gGmbH (Exterbruch 1, 45886 Gelsenkirchen, Germany), or IKT, under the direction of Marcel Goerke, M.Sc., provided services as the third-party observer. IKT is an independent third-party testing organization that specializes in testing and verifying underground infrastructure for the Deutsches Institut für Bautechnik (DIBt). The DIBt is a technical authority based in Berlin authorized to provide numerous public tasks in the field of construction on behalf of the 16 federal states and the Federation in Germany. DIBt is known in the industry as the German technical approval body and a leading European Assessment Body.

Analytical sample analyses required by the NJDEP HDS Protocol were conducted by certified laboratories. Particle size distribution (PSD) samples were analyzed by RMB Environmental Laboratories, Hibbing, MN 55746, and TSS samples were analyzed by Fredericktowne Environmental Testing Labs, Inc., Myersville, MD 21773. The manufacturers' calibration documents for scales and flow meters were provided to NJCAT. Lab proficiency test results are provided in Section 2.6.

2.1 Test Setup

The test unit included full-scale commercially supplied HCPS-5 internal components housed in a 1500 mm (59.1 inch) diameter plastic tank. Dimensional units are provided in **Table 2** and shown in **Figure 6**. The test unit had a target MTFR of 45 l/s or 1.6 cfs.

Table 2 HCPS-5 Test Unit Dimensions

Target MTFR		Diameter			Effective Treatment Area	Chamber Depth	50% Sediment Storage Capacity Depth	Effective Treatment Depth
(l/s)	(cfs)	(m)	(inches)	(feet)	(ft^2)	(inches)	(inches)	(inches)
45.0	1.6	1.5	59.1	4.92	19.02	55.9	12.2	43.7

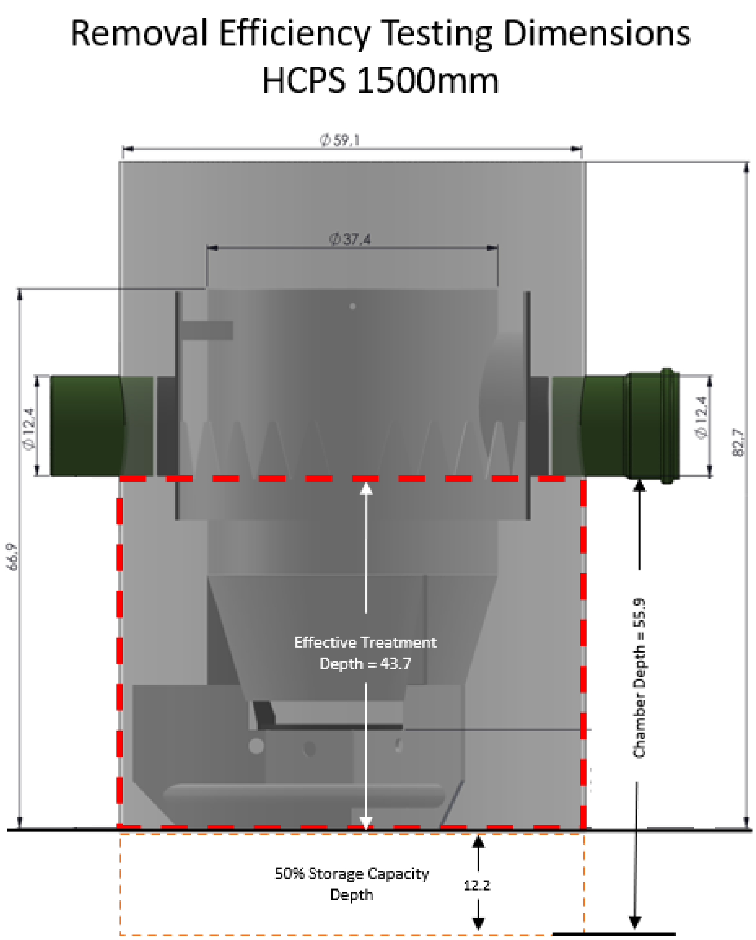

Figure 6 HCPS-5 Test Unit With False Floor

The flow breakers in the sump were cut down to one-half their standard height to simulate a false floor at the 50% sediment depth. With shortened flow breakers, the height from pipe invert to sump floor, or the effective treatment depth, was 43.7 inches. The chamber depth of a standard HCPS-5 is 55.9 inches so that the 50% storage capacity depth is 12.2 inches. Influent and effluent piping to the unit were 12-inches in diameter, had a 2% slope and both inverts were at the same elevations. Potable tap water was added to three underground and one aboveground supply tanks having a total capacity of 21,134 gallons (80 m^3). This feed water was stored in the supply tanks and then pumped to the test unit as shown **Figure 7.**

A calibrated ultrasonic flow meter (Panametrics PT878, IKT-Geräte-Nr.2 with sensor Type 402, IKT-Geräte-Nr. 3A/3B) was used for all test runs. After passing through the flow meter, the supply water passed the background sampling point, sediment injection and sampling points, and lastly into the test unit's inlet pipe. The background sampling point was located 0.82-ft before the sediment injection point and 2.95-ft from the test unit. The distance between the injection point and test unit was 2.13-ft. **Figure 8** shows the inlet pipe entering the test unit, 600 mm high riser used to inject sediment into the inlet pipe, and sediment feeder.

A K-Tron twin-screw feeder (K-MV-KT20) was used to inject test sediment into the inlet flow. Treated water flowed from the test unit's outlet pipe into a portable catch basin connected to a sewer pipe. No water discharged to the sewer was recirculated. Only potable water was used to fill the storage tanks and supply test water.

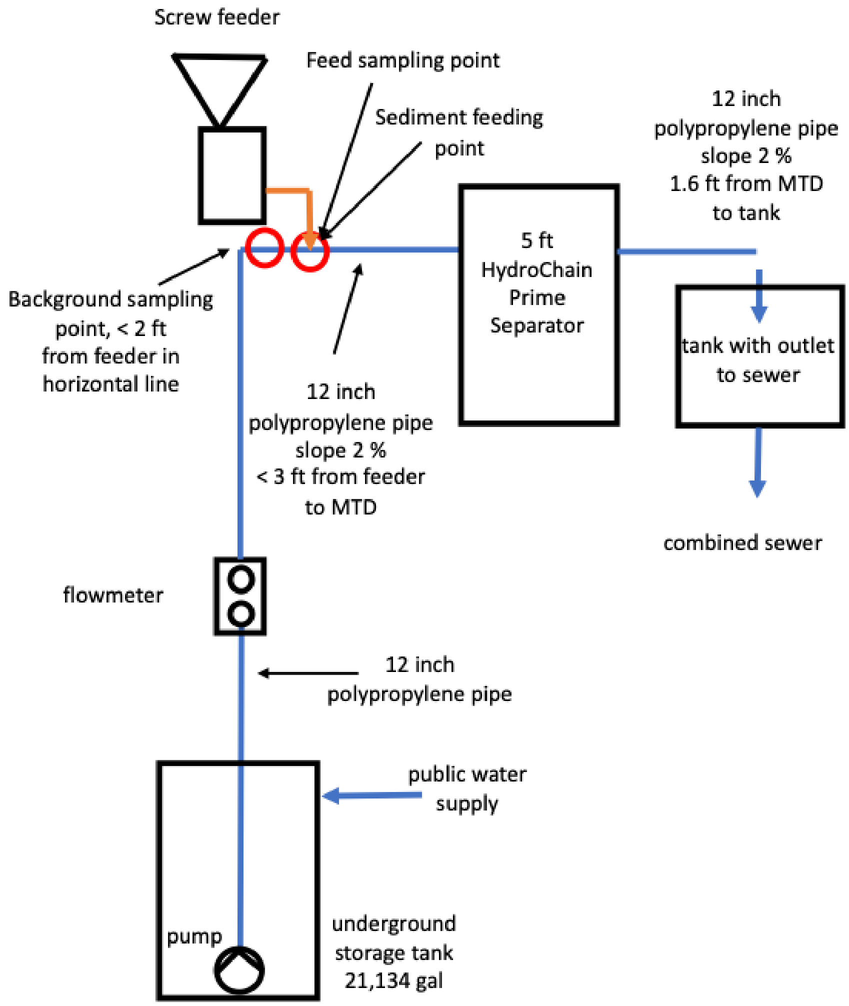

Figure 7 Test Setup with Sampling Points

Flow and corresponding water levels in the inlet and outlet pipes were measured and recorded to establish the head loss across the device. As shown in **Figure 9**, manometers with calibrated scales were used to measure head pressures for each flow rate. The pressure measurements were taken approximately one pipe-diameter (1-ft) upstream and downstream of the test tank and at the separator. Pressure measurements and head loss data are presented in **Table 5**, Section 2.4: Hydraulic Testing.

Temperatures were measured using a digital thermometer positioned in the separator for test runs at 25%, 50%, 75% and 150% of MTFR and the Keller probes for test runs at 10%, 100% and 125% of the MTFR. The water temperature was consistently below 55°F, well below the 80°F (26.67°C) required by the NJDEP HDS Protocol. Temperature data are presented in **Table 10**, Section 4.1: Removal Efficiency Testing.

Figure 8 View of Inlet to Test Unit – Sediment Feeder and Riser

Figure 9 Test Unit Showing Inlet and Outlet Manometers

2.2 Test Sediment

The test sediment used in removal efficiency and scour testing was a blend of commercially available silica (quartz) supplied by Quarzwerke GmbH, Frechen/Germany. The sediment was blended and sampled by 3P Technik Filtersysteme GmbH under observation of Dr.-Ing. Carsten Dierkes, H2O Research GmbH, who provided third-party observation. Samples were packaged and shipped by the third-party observer directly to RMB Environmental Laboratories in Hibbing, MN.

Three samples of the test sediment for removal efficiency and scour testing were collected for PSD analysis and moisture content. The results of the PSD analysis for the removal efficiency test sediment are shown in **Table 3** and **Figure 10** and results of the PSD analysis for the scour test sediment are shown in **Table 4** and **Figure 11**. The average of the three samples was used to assess compliance with the target PSD. Each sample was taken from a different part of the mixed sediment. A copy of the laboratory results was provided to NJCAT with this report. Both sediment particle size distributions (PSD) were finer than required by the protocol.

As shown in **Table 3** and **Figure 10**, the d_{50} for all three samples was 51.8 microns (µm), which was considerably less than the protocol target median (d_{50}) of 75 µm. All three samples complied with the protocol requirements.

Table 3 Particle Size Distribution of Removal Efficiency Test Sediment

Particle Size (microns)	NJDEP Target Min. % Less Than[1]	Sample 1	Sample 2	Sample 3	Average
1,000	100	100	100	100	**100**
500	95	98.0	97.6	98.0	**97.9**
250	90	91.3	90.0	91.3	**90.9**
150	75	77.7	73.8	77.8	**76.4**
100	60	67.8	63.9	67.7	**66.5**
75	50	62.9	59.0	62.6	**61.5**
50	45	49.1	48.8	49.4	**49.1**
20	35	44.4	35.5	32.2	**37.4**
8	20	21.9	21.5	22.1	**21.8**
5	10	15.0	16.1	15.6	**15.5**
2	5	7.9	8.0	7.2	**7.7**
d_{50}	≤75	51.6	53.0	51.1	**51.8**

[1] A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 3% of the particles must be less than 2 microns in size [target is 5%]), provided the measured d_{50} value does not exceed 75 microns for TSS test removal efficiency PSD. Where required, particle size data has been interpolated to allow for comparison to the required PSD specification.

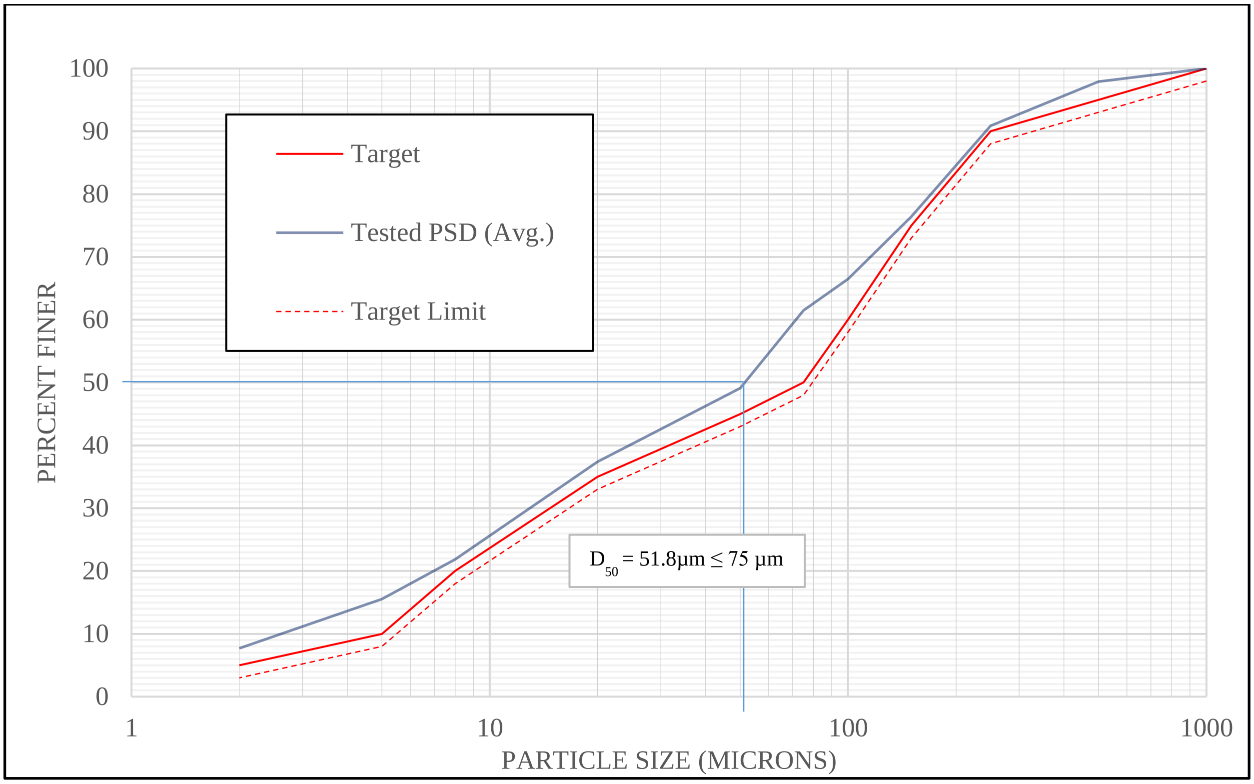

Figure 10 Particle Size Distribution Results of Removal Efficiency Test Sediment Samples

The scour sediment was also a blend of commercially available silica sand grades. Samples were collected as described above. Results of the particle size gradation testing are shown in **Table 4** and **Figure 11**. All three samples were finer than required by the protocol requirements and included particles less than 50 µm.

Table 4 Particle Size Distribution of Scour Test Sediment

Particle Size (microns)	NJDEP Target Min. % Less Than[1]	Sample 1	Sample 2	Sample 3	Average
1,000	100	100	100	100	**100**
500	90	98.7	98.9	99.0	**98.9**
250	55	81.8	84.2	83.4	**83.1**
150	40	61.1	69.9	63.1	**64.7**
100	25	46.2	48.2	46.6	**47.0**
75	10	10.8	11.1	10.6	**10.8**
50	0	7.5	7.2	7.1	**7.2**

[1] A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 3% of the particles must be less than 2 microns in size [target is 5%]) Where required, particle size data has been interpolated to allow for comparison to the required PSD specification.

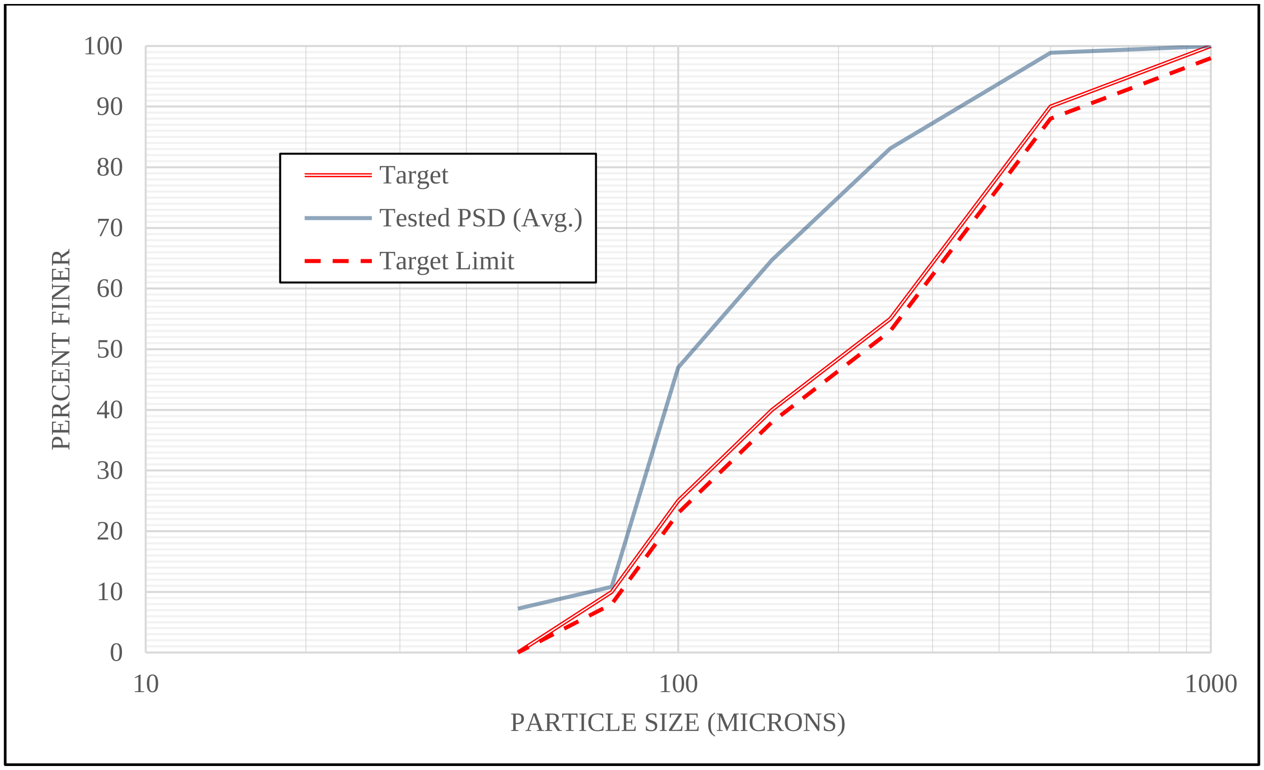

Figure 11 Particle Size Distribution Results of Scour Test Sediment Samples

2.3 Removal Efficiency Testing

TSS removal efficiency testing was performed per Section 4 of the NJDEP HDS Protocol. The Mass Capture Test Method was used to comply with the NJDEP HDS Protocol. Seven flow rates were tested to determine a 50% sediment removal efficiency at the target MTFR (10%, 25%, 50%, 75%, 100%, 125% and 150%). As shown previously in **Figure 6**, the height of the flow breakers at the bottom of the Prime Separator were cut down to reduce the sediment storage volume by 50%.

Eight background TSS samples were taken upstream of the test sediment feeder in accordance with the approved test plan. Effluent was not recirculated throughout the test; therefore, the background TSS concentrations were not expected to increase during the test. Background samples were collected from the inlet pipe before the sediment injection point. Each background sample was collected in a clean 1,000 ml PE bottle over an interval timed to the nearest second. The collection time of the samples was recorded.

The test water was not recirculated and was from a potable water source. The highest average background concentration for all test runs was 2.1 mg/L, much less than the 20 mg/L protocol limit.

The test sediment feed rate was adjusted to supply a target TSS concentration of 200 mg/L (180 – 220 mg/L) during the test runs. The sediment feed rate of the test runs had an accuracy of ± 10 % of the targeted values.

Six sediment calibration samples, no less than 26 grams, were collected over the course of the testing. Samples were equally distributed, and each sample was collected for 5, 10 or 30 seconds depending on the flow rate. The total mass input was determined from the weight difference measured in the hopper before and after each test run. The six feed sediment calibration samples were subtracted from the weight difference to determine the total mass input to the separator.

The test flow was maintained for one detention time, or a minimum of one minute, after the sediment feed was stopped. This allowed for sediment that would not otherwise be captured by the separator to pass through the test unit. The inlet pipe was inspected and cleaned out following each flow rate test.

The moisture content of the well-mixed feed sample was determined to be 0.07% by following ASTM Method D 4959-07, "Standard Test Method for Determination of Water (Moisture) Content of Soil by Direct Heating". The injected sediment mass was adjusted for moisture content.

After each test run the water above the sediment chamber was pumped out and filtered through a pre-weighed polypropylene filter with a 0.1 µm mesh size (**Figure 12** and **Figure 13**).

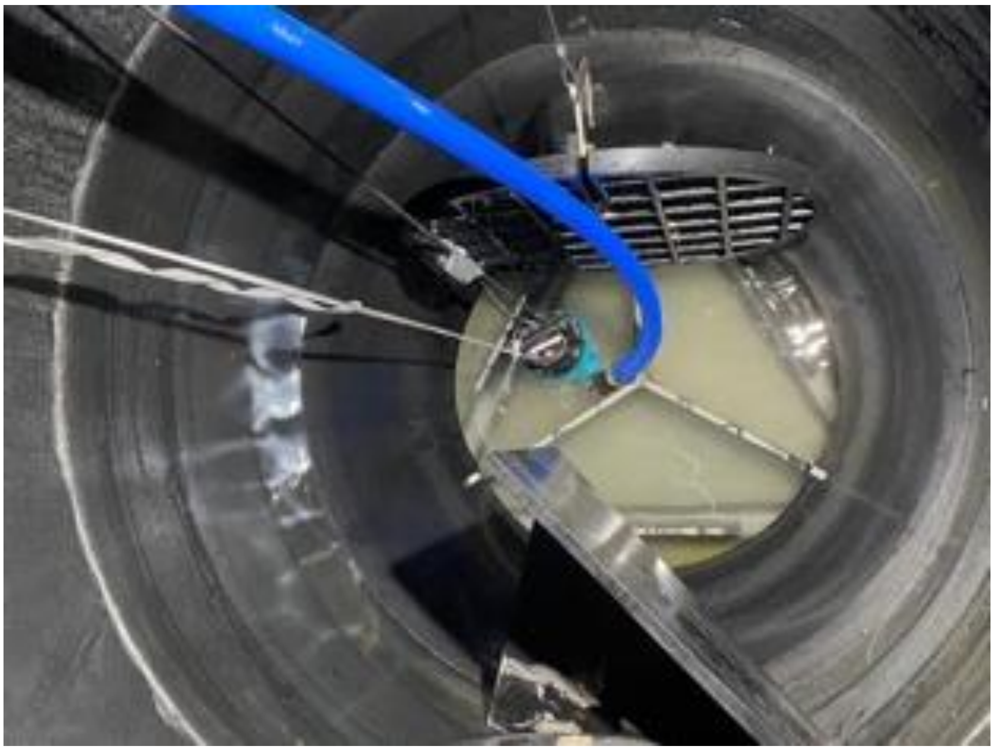

Figure 12 Pumping Out The Water Above The Sediment Sump

Figure 13 Filter Units: 0.1 µm

The filters were placed into a vented drying oven at 100ºC (212ºF) until a constant weight was obtained at room temperature, as determined by two consecutive measurements taken less than two hours apart. The measurements were less than 0.1% difference in mass weighed to a precision of 10 grams.

The remaining sediment in the sump of the separator was accessed through three sampling ports (**Figure 14**) that were 120˚ apart. Each port gave direct access to the three areas in the sump created by the sump baffles (Flow Breakers). A vacuum was used and emptied into polyethylene storage containers (**Figure 15**).

Figure 14 Sediment Sump Removal Port

Sediment was allowed to settle in the storage containers and the remaining water from the containers was decanted and discarded. The remaining mixture of water and test sediment was removed from the storage containers and placed into pre-weighed non-ferrous trays. The trays were placed into a vented drying oven at 100ºC (212ºF) until a constant weight was obtained at room temperature. The measurements were less than 0.1% difference in mass weighed to a precision of 10 grams.

Figure 15 Captured Sediment Collected with Vacuum

The sediment mass captured in the separator included the sediment from the water extracted from the test unit chamber and the sediment deposited in the sump.

2.4 Hydraulic Testing

Prior to sediment removal testing, the head loss through the Prime Separator HCPS-5 was measured and is reported in **Table 5** and shown in **Figure 16** per NJDEP HDS protocol. Flow measurements were taken at 10% to 200% of the MTFR. Flow was increased to the capacity of the test setup and a final measurement of 3.53 cfs recorded with the water elevation at the top of the vortex chamber. Head losses were less than 7.5 inches for flow rates between 10% and 200% MTFR. Losses were less than 10 inches when at the highest tested flow rate of 3.5 cfs, which was at the overflow elevation.

Table 5 Water Elevation and System Loss

% MTFR	Target Flow Rate			Actual Flow Rate			Water Elevation Measurements				
							Inlet		Outlet		Loss
	(l/s)	(cfs)	(gpm)	(l/s)	(cfs)	(gpm)	(cm)	(inches)	(cm)	(inches)	(inches)
10	4.5	0.16	71.3	4.50	0.16	71.3	7.2	2.83	5.0	1.97	0.87
25	11.3	0.40	179.1	11.2	0.40	177.5	12.0	4.72	8.2	3.23	1.50
50	22.5	0.80	356.6	22.3	0.79	353.5	18.3	7.20	11.4	4.49	2.72
75	33.8	1.20	535.7	33.1	1.17	524.6	23.2	9.13	14.7	5.79	3.35
100	45.0	1.60	713.3	42.9	1.51	680.0	27.6	10.87	17.5	6.89	3.98
125	56.3	2.00	892.4	55.7	1.97	882.9	32.1	12.64	21.1	8.31	4.33
150	67.5	2.40	1,070	66.6	2.35	1,056	35.2	13.86	22.6	8.90	4.96
200	90.0	3.20	1,427	86.0	3.04	1,363	42.5	16.73	23.5	9.25	7.48
222	100.0	3.53	1,585	100.4	3.55	1,591	54.0	21.26	29.0	11.42	9.84

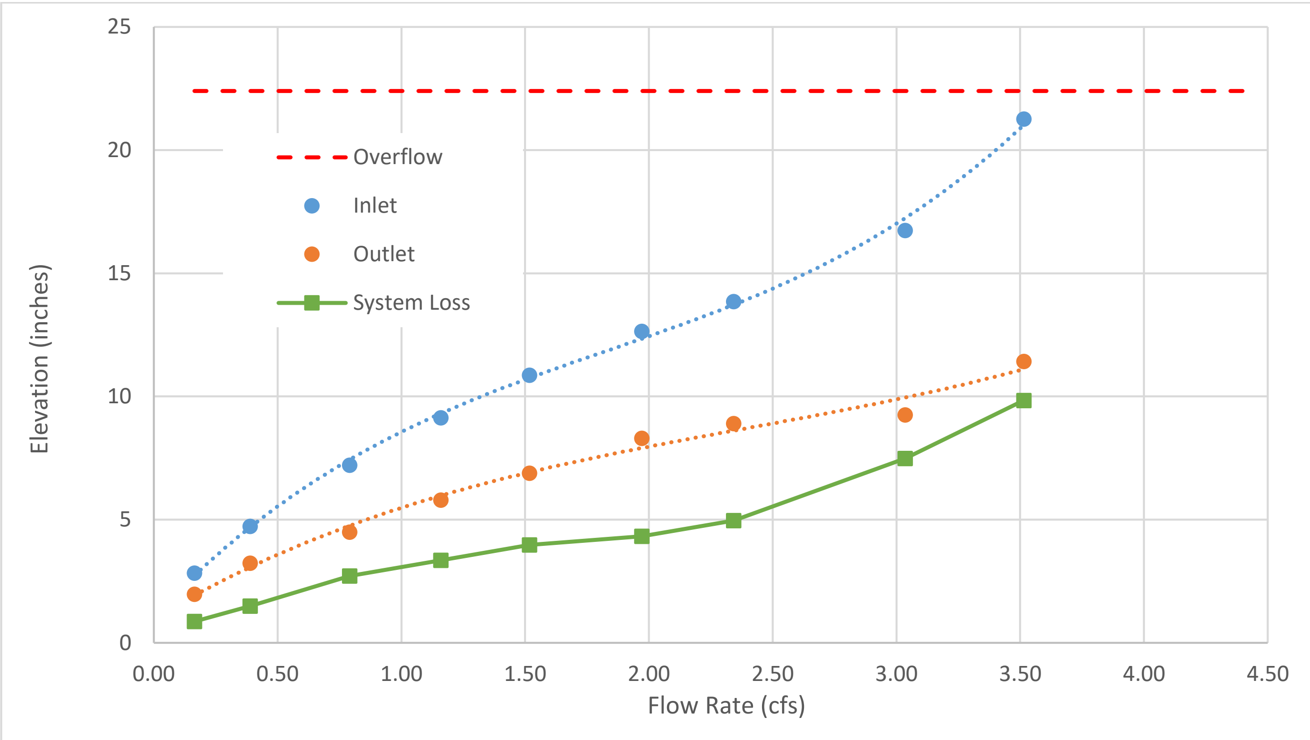

Figure 16 Water Elevation and System Loss

2.5 Scour Testing

The Prime Separator can be designed as an on-line stormwater treatment system, or it can be designed with an external bypass or other upstream diversion structure when infrequent but large flow rates risk causing unreasonably high head losses or loss of previously captured pollutants. To quantify the loss of sediment and head losses at higher flow rates, testing at 200% of the MTFR was completed. The test demonstrated that the Prime Separator does not resuspend and discharge previously captured sediment above 20 mg/L, at the tested scour flow rate, which is the effluent concentration discharge limit for on-line applications.

As discussed in Section 2.1: Test Setup, internal components were lowered by cutting the deflector baffles. This created a sump that was 50% of a full-scale sump supplied for commercial applications. The floor was pre-loaded with 4 inches of leveled scour test sediment, conservatively setting the top of the sediment pile above the 50% sediment storage elevation by four inches. The dimensions of the tested unit with scour test sediment added is shown in **Figure 17**.

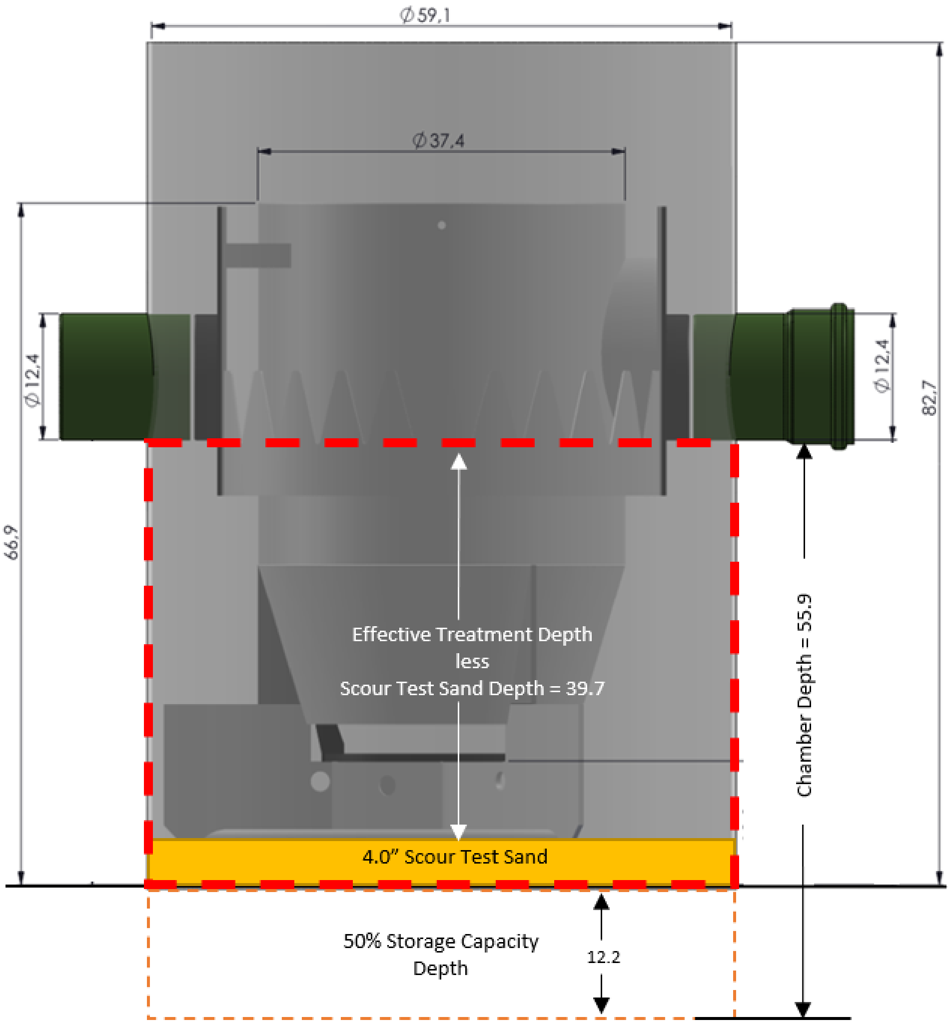

Figure 17 Dimensions of Test Unit with Scour Sediment Preload

The unit was filled with tap water and testing commenced within 96 hrs. of preloading with sediment. The test began when flow was directed to the pre-loaded unit.

The flow rate was increased to 200% of the MTFR within three minutes of commencement of the test and held constant (±10%) for the remainder of the test duration. Effluent samples were taken at 1, 3 and 5 minutes and then every two minutes thereafter for an additional 12 samples. The duration of the sampling period was 29 minutes. Water temperature remained below 80°F during the test.

Each grab sample was at least 0.5 L and was collected in a clean, 1 L polyethylene bottle by sweeping the bottle through the cross-section of the free-discharge effluent stream in a single pass.

The fifth background sample taken at a time of 17 minutes during the scour test run was damaged so there was no sample to analyze. All other background samples from the scour test were less than 1 mg/L. Given potable water was used for the supply water and all other background samples were less than 1 mg/L, the fifth background sample was assumed to be the same as the rest of the samples or 1 mg/L.

2.6 Lab Proficiency Tests

Twelve blind sediment samples were prepared by Inter Ag Services (IAS) Laboratories in Phoenix, Arizona using the same test sediment as for the removal performance testing. IAS is an ISO 17025:2017 certified laboratory. Six samples were submitted to Fredericktowne Environmental Testing Labs (FTL) who along with IAS, added 1L of distilled water to each sample. Samples were analyzed by FTL for sediment concentration (SSC) in accordance with ASTM Method D 3977-97 "Standard Test Methods for Determining Sediment Concentrations in Water Samples". The results of the proficiency testing are summarized in Table 6 below. Based on the two proficiency test criteria provided in the notes of Table 6, FTL passed the lab proficiency tests.

Table 6 Lab Proficiency Results

Sample ID	Control Mass	Recovered Mass		Percent Recovered	Concentration	Test 1	Average Concentration	Test 2
	(g)	(g)	(mg)		(mg/L)		(mg/L)	
3	0.0200	0.0206	20.6	103%	20.6	Pass	18.8	Pass
5	0.0200	0.0173	17.3	87%	17.3	Pass		
6	0.0200	0.0185	18.5	93%	18.5	Pass		
1	0.0500	0.0452	45.2	90%	45.2	Pass	45.8	Pass
2	0.0500	0.0484	48.4	97%	48.4	Pass		
4	0.0500	0.0439	43.9	88%	43.9	Pass		

Notes:
1. Sample volume = 1L
2. Test 1: Concentrations must be 20 mg/L or 50 mg/L ± 5 mg/L
3. Test 2: Average concentration must be >17mg/L, or >42.5 mg/L (<15%)

3. Performance Claims

The following performance claims for the HydroChain Prime Separator model HCPS-5 are made based on the laboratory testing.

Total Suspended Solids (TSS) Removal Rate

The TSS removal rate of the Prime Separator model HCPS-5 was calculated using the weighted method required by the NJDEP HDS MTD protocol. Based on a MTFR of 1.62 cfs, the Prime Separator model HCPS-5 achieved an annualized weighted TSS removal rate of 51.9%.

Maximum Treatment Flow Rate (MTFR).

The Prime Separator model HCPS-5 demonstrated a maximum treatment flow rate (MTFR) of 1.62 cfs (727 gpm). This corresponds to a hydraulic loading rate of 38.2 gpm/ft^2.

Maximum Sediment Storage Depth and Volume

The Prime Separator model HCPS-5 in a 4.92-ft (1500 mm) diameter manhole has a maximum sediment storage depth of 24.5 inches, which equates to 38.84 cubic feet of sediment storage volume. A 50% sediment storage depth of 12.25 inches corresponds to 50% full sediment storage capacity (19.42 cubic feet).

Effective Sedimentation Treatment Area (ESTA)

The Prime Separator model HCPS-5 tested in a 4.92-ft (1500 mm) diameter system has an effective sedimentation treatment area of 19.02 square feet.

Detention Time and Wet Volume

The permanent pool volume for the tested Prime Separator model HCPS-5 is 69.3 ft^3 (518.2 gallons). This is the volume from the false floor to the outlet pipe invert, which is 43.7-inches in height. The detention time of the Prime Separator model HCPS-5 is dependent upon flow rate. The detention time of the tested HCPS-5 at the 100% MTFR or 1.62 cfs is 42.8 seconds.

On-line/Offline Installation

The HydroChain Prime Separator can be installed online or offline. Scour testing was completed to demonstrate that effluent concentrations remain less than 20 mg/L at 200% of the MTFR.

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 if such documentation could be made available upon request it would not be prudent or necessary to include all this information in this verification report. All supporting documentation will be retained securely by Xerxes and has been provided to NJCAT.

4.1 Removal Efficiency Testing

Tests were conducted at the seven (7) required flows of 10%, 25%, 50%, 75%, 100%, 125%, and 150% of the MTFR. The target MTFR was 45 l/s, or 1.6 cfs.

The test run sediment removal efficiency is calculated using the following equation:

$$\textbf{Removal Efficiency (\%)} = \left(\frac{\text{Total Mass Collected in MTD}}{\text{Total Mass Input During Run}} \right) \times 100$$

The results from the test runs were used to calculate the overall annualized weighted removal efficiency. The Prime Separator model HCPS-5 annualized weighted removal efficiency of 51.9% at an MTFR of 1.62

cfs was calculated using a third-order polynomial equation ($y = 4.8035x^3-9.1135x^2-29.715x + 85.184$) derived from the measured flow rates and removal efficiencies. The curve fitting approach results in an R^2 value of 0.9983 in accordance with the NJDEP HDS Protocol minimum of 0.95.

The removal efficiency curve and equation are shown in **Figure 18** and summary of removal efficiency results based on the ***actual*** MTFR is presented in **Table 7**. The testing demonstrates that the Prime Separator model HCPS-5 provides at least 50% weighted annualized TSS per NJDEP HDS protocol.

NJDEP Protocol QA/QC parameters are shown in **Table 8** through **Table 13.** All the influent concentrations were within the ±10% protocol target influent TSS concentration of 200 mg/L (180 mg/L-220 mg/L). (**Table 8**). The mass capture removal efficiencies are shown in **Table 9** and on **Figure 18**. All measured flows used to calculate the annualized weighted removal efficiency were within the ±10% of the target flow with a COV ≤ 0.03 per protocol requirement. (**Table 10**).

Average temperatures are shown in **Table 10.** Injected sediment calibration sampling timelines, samples, and background data summary are shown in **Table 11, Table 12,** and **Table 13**.

The inlet and outlet were inspected by the third-party independent observer after each run. No measurable sediment was collected in either the inlet or outlet piping during any of the TSS removal tests.

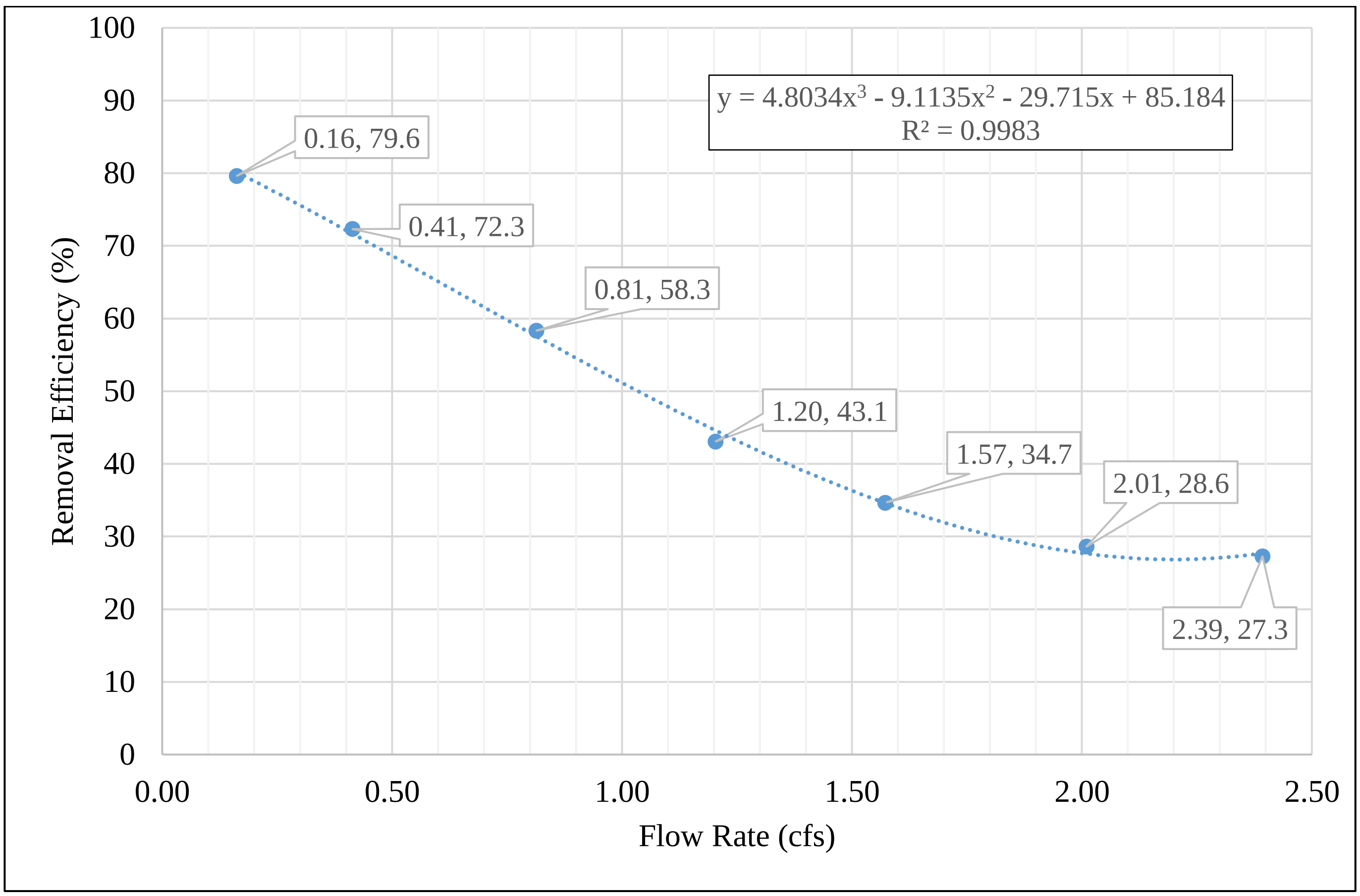

Figure 18 Removal Efficiency vs. Flow Rate

Table 7 MTFR Removal Efficiency Results

% MTFR	Flow Rate (cfs)	Removal Efficiency (%)	Weighting Factor	Weighted Removal
10	0.16	79.9	-	
25	0.41	71.8	0.25	18.0
50	0.81	57.7	0.30	17.3
75	1.22	44.1	0.20	8.8
100	1.62	33.6	0.15	5.0
125	2.03	27.5	0.10	2.8
150	2.43	28.1	-	
Annualized Weighted Removal Efficiency at **MTFR=1.62 cfs**				**51.9%**

Table 8 Summary of Inlet TSS Concentrations

Test Run	Average Flowrate		Sediment Feed Time[1]		Total Water Volume	Moisture Adjusted Total Mass Input[2]	Average Inlet Concen-tration	Difference (Target 200 mg/L)	Percent Difference
No.	L/s	cfs	sec	min	m^3	g	mg/L	mg/L	(±10%)
1	4.6	0.16	13,620	227	62.6	12,462	199	-1.0	- 0.5
2	11.7	0.41	5,400	90	63.3	12,099	191	-9.0	- 4.5
3	23.1	0.81	2,460	41	56.7	12,341	218	+18.0	+9.0
4	34.1	1.20	1,740	29	59.3	12,822	216	+16.0	+8.0
5	44.5	1.57	1,560	26	69.5	13,502	194	- 6.0	- 3.0
6	56.9	2.01	1,260	21	71.7	14,101	197	- 3.0	- 1.5
7	67.8	2.39	870	14.5	58.9	12,140	206	+6.0	+3.0

1. Total Sediment Feed Time is the test duration less the time taken for the six calibration samples.
2. Total Mass Input was determined by weighing the difference in the hopper feed sediment before and after each test run and subtracting the sediment mass removed for the six calibration samples taken.

Table 9 Mass Capture Removal Efficiencies

% MTFR	Target Flow Rate (cfs)	Average Flow Rate (cfs)	Total Mass Input (g)	Total Mass Captured (g)	Mass Capture Removal Eff. (%)
10	0.16	0.16	12,462	9,924	79.6
25	0.40	0.41	12,099	8,749	72.3
50	0.80	0.81	12,341	7,200	58.3
75	1.20	1.20	12,822	5,523	43.1
100	1.60	1.57	13,502	4,679	34.7
125	2.00	2.01	14,101	4,034	28.6
150	2.40	2.39	12,140	3,312	27.3

Table 10 Test Flow and Temperature Summary

% MTFR	Target Flow Rate (cfs)	Average Flow Rate (cfs)	% Difference (<10%)	Flow Rate COV (≤ 0.03)	Ave. Water Temp. (≤ 80° F)
10	0.16	0.16	0.0	0.026	51.1
25	0.40	0.41	+2.5	0.012	54.7
50	0.80	0.81	+1.3	0.005	54.7
75	1.20	1.20	0.0	0.016	54.7
100	1.60	1.57	-1.9	0.014	50.9
125	2.00	2.01	0.5	0.018	50.9
150	2.40	2.39	-0.4	0.005	54.7

Table 11 Sediment Feed and Sampling Timeline

% MTFR	Sediment Feed Runtime (hh:mm:ss)						Sedi-ment Feed Stopped	Pump Off Time[1]
	Sediment Feed Sample Number							
	S-1	S-2	S-3	S-4	S-5	S-6		
10	0:00:00	0:45:52	1:31:44	2:17:36	3:03:28	3:49:20	3:50:00	3:58:00
25	0:00:00	0:18:36	0:37:12	0:55:48	1:14:24	1:33:00	1:33:00	1:36:00
50	0:00:00	0:08:24	0:16:48	0:25:12	0:33:36	0:42:00	0:42:00	0:44:00
75	0:00:00	0:06:00	0:12:00	0:18:00	0:24:00	0:30:00	0:30:00	0:31:00
100	0:00:00	0:05:12	0:10:24	0:15:36	0:20:48	0:26:00	0:27:00	0:28:00
125	0:00:00	0:04:12	0:08:24	0:12:36	0:16:48	0:21:00	0:22:00	0:23:00
150	0:00:00	0:03:00	0:06:00	0:09:00	0:12:00	0:15:00	0:15:00	0:16:00

[1] After the sediment feeder was stopped the flow was continued for at least one detention time before the pump was stopped.

Table 12 Sediment Feed Calibration Samples

% MTFR	Sediment Feed Calibration Sample Mass[1] (g)						Total Mass Removed	Avg.	Std. Deviation	COV (≤ 0.1)
	S-1	S-2	S-3	S-4	S-5	S-6	(grams)			
10	28.89	30.62	27.45	29.04	26.13	26.78	168.91	28.15	1.67	0.06
25	70.82	74.99	70.04	71.23	67.47	67.46	422.01	70.34	2.80	0.04
50	47.14	48.79	48.31	51.03	48.85	56.09	300.21	50.04	3.22	0.06
75	72.82	76.91	74.11	75.94	79.58	79.78	459.14	76.52	2.83	0.04
100	88.13	87.91	90.67	88.34	91.87	92.76	539.68	89.95	2.11	0.02
125	116.39	111.78	112.45	116.82	114.52	115.23	687.19	114.53	2.05	0.02
150	71.00	80.56	72.99	73.31	75.37	78.09	451.32	75.22	3.56	0.05

1. The sediment feed calibration samples were collected over 30, 10 and 5 second periods.

Table 13 Background Sediment Concentrations

% MTFR			Background TSS Concentration (≤ 20 mg/L)						Average
	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	
10	1.03	1.06	1.06	1.07	1.04	1.05	1.04	1.03	1.0
25	7.40	1.00	1.00	1.82	1.82	1.00	1.85	1.00	2.1
50	5.10	1.60	1.00	2.20	1.00	1.83	1.90	1.87	2.1
75	1.00	1.00	1.00	1.00	1.93	1.00	1.00	1.00	1.1
100	1.04	1.05	1.03	1.02	1.03	1.02	1.04	1.03	1.0
125	1.04	1.06	1.04	1.04	1.05	1.05	1.03	1.03	1.0
150	1.00	1.00	1.00	1.70	1.00	1.00	1.00	1.00	1.1

Concentration = 1 mg/L when the "Modified Detection Limit" (MDL) < 1.0.

4.2 Scour Testing

Scour testing was conducted in accordance with Section 5 of the NJDEP Protocol at a target flow rate of 200% of the Prime Separator MTFR to qualify the MTD for on-line installation. Results are shown in **Table 14** below. As previously explained in Section 2.5, background Sample 5 taken at time 17 minutes was damaged and there was no sample to analyze. All other background concentrations were less than 1 mg/L and since the supply water used was potable water, Sample 5 was assumed to be the same as all the other background samples or 1.0 mg/L.

The average scour test flow rate was 3.23 cfs and the flow rate COV ≤ 0.003. The maximum adjusted scour concentration was 17 mg/L, and the average adjusted scour concentration was 7.3 mg/L, which is less than the allowable average concentration of 20 mg/L.

Table 14 Scour Testing Results

Sample #	Time	Flow Rate					Max. Temp	Quality Check ≤80°F	Effluent TSS	Background TSS	Adjusted Effluent TSS	Quality Check ≤20 mg/L
		Target	Actual	Mean	Std. Dev.	COV						
	(mins)	(cfs)					(F)	(Y/N)	mg/L			(Y/N)
1	1		2.93	Ramp Up Period			54.7	Y	17.0	1.0	16.5	Y
	2		3.25									
2	3		3.24						13.7		13.2	
	4	3.20	3.22	3.23	0.008	0.0025	54.7	Y				
3	5		3.22						15.0	1.0	14.5	Y
	6		3.22									
4	7		3.21						7.4		6.9	
	8		3.23									
5	9		3.24						8.8	1.0	8.3	Y
	10		3.25									
6	11		3.24						3.2		2.7	
	12		3.23									
7	13		3.24						3.5	**1.0**	3.0	Y
	14		3.24									
8	15		3.24						5.4		4.9	
	16		3.24									
9	17		3.24						7.9	1.0	7.4	Y
	18		3.24									
10	19		3.24						10.3		9.8	
	20		3.24									
11	21		3.23						6.4	1.0	5.9	Y
	22		3.23									
12	23		3.23						6.3		5.8	
	24		3.23									
13	25		3.23						4.6	1.0	4.1	Y
	26		3.23									
14	27		3.23						5.3		4.8	
	28		3.23									
15	29		3.24						2.1	1.0	1.6	Y
	30		3.24									
	31		3.23									

5. Design Limitations

Xerxes provides complete engineering support to clients for all projects. Each system is specified to meet the site specific conditions such as treatment, bypass flow rates, load rating requirements, and pipe depth. The site constraints and project requirements are addressed during the design process.

Required Soil Characteristics

The HydroChain Prime Separator is a flow-through MTD contained within a watertight structure. Therefore, the HCPS system can be installed and function as intended in all soil types.

Slope

Xerxes recommends contacting our design engineers when the HCPS system is going to be installed on a drainage line with a slope exceeding 10%. With steeply sloping pipe, site specific parameters such as pipe size, online vs. offline arrangement of the HCPS system and the frequency of peak flow are taken into consideration by Xerxes engineers.

Maximum Treatment Flow Rate (MTFR)

The MTFR of the HCPS system varies for each model. Refer to **Table A-1,** and **Table A-2** for a listing of the MTFR flow rates for standard Prime Separator models.

Maintenance Requirements

For all stormwater quality control systems, effective performance requires regular and proper maintenance. Maintenance frequency and requirements are dependent on the conditions and pollutant loading of each site. Inspections and/or maintenance should be conducted on a regularly occurring basis to ensure continued functionality of the system. Maintenance activities may be required after an extreme rainfall event, chemical spill or heavier than anticipated pollutant loading. A discussion of inspection and maintenance requirements and recommendations is included in Section 6.

Operating Head

There is an operational head loss associated with each HydroChain Prime Separator device. The head loss is dependent on the structure design. Site specific treatment flow rates, peak flow rates, pipe diameters and pipe slopes are evaluated to ensure an appropriate head for the system to function properly.

Installation Limitations

HydroChain Prime Separator systems have few installation limitations. Systems are typically delivered to the site with all necessary components. The contractor is responsible for installation of the system following any requirements that would apply to any manhole structure. This typically includes:

- preparing the appropriate excavation and base layer,

- providing and using the appropriate lifting equipment to unload and set the Prime Separator and components,
- providing and connecting the inlet and outlet piping, and,
- following the construction plans for selection of backfill material and placement.

Pick weights vary with model size. Xerxes provides contractors with project-specific unit pick weights and installation instructions prior to delivery. The contractor is responsible for protecting the HCPS system from construction runoff until site construction is complete.

Configurations

The HydroChain Prime Separator components are available in several diameters that are installed into standard precast manhole sizes between 3 feet (1000 mm) and 10 feet (3000 mm) diameters. The Prime Separator can be installed online or offline, which is evaluated for each project.

Structural Load Limitations

The HydroChain Prime Separator is intended for use inside a structure designed for H-20 traffic load rating or other load rating, like HS-25, depending on the installed location. Xerxes provides full-service technical design support throughout design and installation to ensure the system is constructed for the appropriate structural load requirements.

Pretreatment Requirements

The HydroChain Prime Separator does not require pretreatment.

Limitations in Tailwater

Tailwater conditions influence the driving head of the HydroChain Prime Separator. Specific project conditions should be assessed during the design process to ensure design and peak flow rates do not cause upstream flooding.

Depth to the Seasonal High Water Table

The operation of the HydroChain Prime Separator is typically not impacted by the seasonal high-water table. However, the high-water table may impact the buoyancy of the manhole. Buoyancy calculations are recommended for high water table conditions.

6. Maintenance

The HydroChain Prime Separator must be inspected and maintained at regular intervals like all stormwater treatment facilities. A copy of the Installation, Operation, and Maintenance Manual is included with this submission. A copy of the manual can also be obtained from Xerxes's website by navigating to "Composite Systems" and "Stormwater Management & Treatment". A direct link to the document is here: Link to Prime Separator O&M

Proper and optimum operation of the Prime Separator requires following these recommended inspection, maintenance, and cleaning guidelines.

The site owner is responsible for creating, recording, and retaining inspection and maintenance records in accordance with their own site requirements and applicable regulations. A log is provided in the Prime Separator O&M manual as an example.

After installation, we recommend that the Prime Separator be inspected at a minimum of every 6 months, and after major rainfalls or storm events. Inspection may then be increased or decreased based on observations. The owner is responsible for determining the inspection schedule.

We recommend that the site owner establish an inspection schedule based on the following factors:

- Manhole or vault size
- Site and environmental conditions
- Drainage area
- Annual rainfall
- Volume of stormwater runoff
- Volume of sediment, dirt, debris, and trash entering the system
- Volume and type of pollutants collected

Typically, the manhole must be emptied of sediment every 6 to 36 months based on field experience.

Maintenance frequency is determined by the same factors stated above for determining inspection frequency. The owner is responsible for determining the maintenance schedule.

We recommend cleaning the separator using a pump-out vehicle equipped with suction and flushing capabilities, or a submersible sediment (sludge) pump with hoses.

Follow these steps to clean the Prime Separator:

- Remove the floatables and oils from the water surface.
- Suction out the water until it is level with the top of the grate.
- Remove any existing debris from the grate.
- Lift and secure the hinged grate.
- Suction out the sediment and solids from each section of the manhole.
- Rinse the manhole and separator with water.

Close and lock the grate and manhole cover. Dispose of all removed water and waste material in accordance with applicable regulations. Log details of maintenance performed in the inspection, maintenance and cleaning records provided by the site owner.

7. Statements

The following signed statements from the manufacturer (3P Technik Filtersysteme GmbH)), third-party observer (IKT), 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.

XERXES®

September 29th, 2022

New Jersey Corporation for Advanced Technology
Stevens Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030

Attention: Dr. Richard Magee, Sc.D., P.E., BCEE
Subject: Xerxes HydroChain™ Prime Separator (HCPS) Verification Report

Dear Dr. Magee,

We certify that the Xerxes HydroChain Prime Separator (HCPS) was tested in strict adherence to the New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (NJDEP, January 1, 2021).

We certify that all requirements and criteria were met or exceeded during testing of the HCPS device.

Please do not hesitate to contact us if you have any questions regarding this letter.

Sincerely,

Jim Merchlewitz
Business Development Manager, Shawcor

7901 Xerxes Avenue South
Suite 201
Minneapolis, MN
55431-1288

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- An-Institut der Westfälischen Hochschule Gelsenkirchen
- Partner-Institut der Universität der Bundeswehr München
- Staatlich anerkannte Prüfstelle für Durchfluss-Messungen

neutral
unabhängig
gemeinnützig

IKT - Institut für Unterirdische Infrastruktur

forschen | prüfen | beraten | testen

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to whom it concern

Gelsenkirchen, 9th August 2023
USGT\PEPPER\dfm\D00600-D01399\D01329 Begleitung NJDEP-Test 3P\Ergänzung Sommer 2023\3P-Letter.docx

Subject: Statement of Third-Party Observer of Tests Performed on the HydroChainTM Prime Separator (HCPS)

The IKT - Institute for Underground Infrastructure gGmbH is a neutral, independent non-profit institute, and works on solving practical and operational issues concerning underground sewers, pipes, and other conduit engineering. Its primary focus is on sewer systems, construction, operation, and renovation of underground infrastructures. The institute conducts research projects, material testing, consultations and seminars and is one of the state-approved test centers for flow measurement and moreover a test centre used by the Deutsches Institut für Bautechnik (DIBt), which is the German institute for structural construction and rainwater engineering.

I hereby confirm my observation and review of the HydroChainTM Prime Separator (HCPS), which is marketed as the Hydroshark® by 3P Technik Filtersysteme GmbH (3P) in Germany, performance testing conducted in December of 2021 and August 2023. Testing methods and procedures were based on an approved Quality Assurance Project Plan (QAPP) that adhered to the New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 2021). Testing was performed by 3P staff at their laboratory located at Robert-Bosch-Straße 16-18, 73337 Bad Überkingen/Germany. Testing assessed the TSS removal efficiency performance and ability to retain captured sediment of the HCPS. I verified compliance with the laboratory test protocol above and I was physically present to observe the full duration of all testing procedures.

I have reviewed the data, calculations, and results associated with the removal efficiency and the scour testing performance report titled, "HydroChainTM Prime Separator (HCPS) Systems", by Shawcor. I state that they conform to what I observed as the third-party observer.

Statement of Disclosure - Third Party Observer

The IKT has provided the service of third-party observer for performance testing, performed by 3P, from December 6th through December 9th, 2021 and from 7th through August 8th. The IKT has no financial conflict of interest regarding the performance testing results of the HCPS.

Beyond this, the IKT, 3P and Shawcor 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 observation of this performance test.

Kind regards

IKT – Institute for Underground Infrastructure gGmbH

Marcel Goerke, M.Sc.
- Head of test centre for flow measurement -

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

September 8, 2022

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

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on a full-scale, commercially available Xerxes HydroChain™ Prime Separator (HCPS-5) by IKT – Institut für Unterirdische Infrastruktur gGmbH (Exterbruch 1, 45886 Gelsenkirchen, Germany) under the direction of Marcel Goerke, M.Sc., 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) were met or exceeded consistent with the NJDEP Approval Process.

All testing was conducted at the manufacturer's (3P Technik Filtersysteme GmbH) test facility. IKT is an independent third-party testing organization that specializes in testing and verifying underground infrastructure for the Deutsches Institut für Bautechnik (DIBt). The DIBt is a technical authority based in Berlin authorized to provide numerous public tasks in the field of construction on behalf of the 16 federal states and the Federation in Germany. DIBt is widely known in the industry as the German technical approval body and a leading European Assessment Body.

Removal Efficiency Test Sediment

The test sediment used in removal efficiency and scour testing was a blend of commercially available silica (quartz) supplied by Quarzwerke GmbH, Frechen/Germany. The sediment was blended and sampled by 3P Technik Filtersysteme GmbH under observation of Dr.-Ing. Carsten Dierkes, H2O Research GmbH, who provided third-party observation. Samples were packaged and shipped by the third-party observer directly to RMB Environmental Laboratories in Hibbing, MN.

Three samples of the test sediment for removal efficiency and scour testing were collected for PSD analysis. The average of the three samples was used to assess compliance with the target PSD. Each sample was taken from a different part of the mixed sediment. The d_{50} for all three samples was 51.8 µm, which was considerably less than the protocol target d_{50} of 75 µm. All three samples were in compliance with the protocol requirements. In addition to particle size distribution, RMB performed a moisture analysis of the test sediment and determined the water content to be < 0.30%, the method detection limit.

Scour Test Sediment

The scour sediment was also a blend of commercially available silica sand grades. Three samples were collected as described above. All three samples were finer than required by the protocol requirements and included particles less than 50 microns. Again, the moisture content was found to be <0.30%.

Removal Efficiency Testing

Removal efficiency testing followed the mass capture test method outlined in Section 4.C of the NJDEP HDS Protocol. The sediment removal efficiency of the HCPS-5 at an MTFR of 1.62 cfs was 51.9%.

Scour Testing

Scour testing of the HCPS-5 was conducted in accordance with Section 5 of the NJDEP HDS Protocol at a flow rate 200% of the MTFR to qualify the MTD for online conveyance installation. The average scour test flow rate was 3.23 cfs and the flow rate COV ≤ 0.003. The maximum adjusted scour concentration was 17 mg/L, and the average adjusted scour concentration was 7.3 mg/L, which is less than the maximum allowable concentration of 20 mg/L for online installation.

Sincerely,

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

8. References

NJDEP 2013. *New Jersey Department of Environmental Protection Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology*. Trenton, NJ. January 25, 2013.

NJDEP 2021a. *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.

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

VERIFICATION APPENDIX

Introduction

- Manufacturer – 3P Technik Filtersysteme GmbH, Robert-Bosch-Straße 16 – 18 D-73337 Bad Überkingen. *General Phone: +49 (0) 7334 92460-0. Website:* info@3ptechnik.de
- Distributor (North America) – Xerxes, 7901 Xerxes Ave. South Minneapolis, MN USA 55431-1288. *General Phone: 952-887-1890*. *Website:* http://www.xerxes.com/.
- HydroChain Prime Separator system verified models are shown in **Table A-1** and **Table A-2.**
- TSS Removal Rate – 50%
- Online and offline installation

Detailed Specification

- NJDEP sizing tables and physical dimensions of the HydroChain Prime Separator verified models are attached (**Table A-1** and Table **A-2**).
- New Jersey requires that the peak flow rate of the NJWQ Design Storm event of 1.25 inch in 2 hours shall be used to determine the appropriate size for the MTD. The HCPS-5 model has a maximum treatment flow rate (MTFR) of 1.62 cfs (727 gpm), which corresponds to a surface loading rate of 38.2 gpm/ft^2 of effective sedimentation treatment area.
- Maximum sediment depth prior to cleanout is the 50% maximum sediment storage depth provided in **Table A-2**. Custom units with an increased sediment storage depth can be provided based on the protocol scaling requirements.
- Operations and Maintenance Guide is at: Link to Prime Separator O&M
- The projected sediment removal intervals are attached (**Table A-1**).
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the Prime Separator to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

Table A-1 MTFR and Sediment Removal Intervals for the Xerxes HydroChain™ Prime Separator

Model	Diameter	MTFR[1]	Effective Treatment Area	Hydraulic Loading Rate	50% Max. Storage Depth	50% Max. Storage Volume[2]	Sediment Removal Interval[3]
	(feet)	(cfs)	(ft^2)	(gpm/ft^2)	(ft)	(ft^3)	(Years)
HCPS-5 (test unit)	**4.92**	**1.62**	**19.02**	**38.2**	**1.02**	**19.4**	**7.1**
HCPS-3	3	0.60	7.07	38.2	1.57	11.1	11.0
HCPS-4	4	1.07	12.57	38.2	0.92	11.6	6.4
HCPS-5	5	1.67	19.63	38.2	1.02	20.0	7.1
HCPS-6	6	2.41	28.27	38.2	0.92	25.9	6.4
HCPS-8	8	4.28	50.27	38.2	0.92	46.1	6.4
HCPS-10	10	6.69	78.54	38.2	0.92	72.0	6.4

1. Maximum Treatment Flow Rate (MTFR) is based on a verified loading rate of 38.2 gpm/ft^2 and annualized weighted TSS removal of at least 50% of a particle size distribution with d_{50}=52 microns, which is finer than required by the test protocol.
2. The 50% Max. storage volume is calculated using the 50% Max. Storage Depth and the model's Effective Treatment Area. The Chamber Depth less the 50% Max. Storage Depth is equal to the Effective Treatment Depth shown in **Table A-2**.
3. The sediment Removal Interval is calculated by dividing the 50% Max Storage Volume by the volume of sediment per acre per year calculation provided in the test protocol.

Table A-2 Standard Dimensions for the Xerxes HydroChain™ Prime Separator[1]

Model	Effective Treatment Area (ft^2)	Effective Treatment Depth[2] (ft)	50% Max. Storage Depth (ft)	Chamber Depth[3] (ft)	Aspect Ratio[4]	Maximum Pipe Diameter (inches)
HCPS-5 (test unit)	**19.02**	**3.64**	**1.02**	**4.66**	**0.74**	**18.0**
HCPS-3	7.07	3.66	1.57	5.23	-	8.00
HCPS-4	12.57	3.83	0.92	4.75	-	15.0
HCPS-5	19.63	3.65	1.02	4.67	-	18.0
HCPS-6	28.27	3.64	0.92	4.56	-	24.0
HCPS-8	50.27	5.04	0.92	5.96	0.63	30.0
HCPS-10	78.54	6.30	0.92	7.22	0.63	30.0

1. The dimensions of the HCPS internals ensure that the scaling requirements of the protocol are met. The internals are hand fabricated, and the sump baffles can be adjusted to match as reported in Table A-2.
2. Effective treatment depth is defined as depth from outlet pipe invert to 50% maximum sediment storage depth.
3. Chamber depth is defined as depth from the outlet pipe invert to sump floor.
4. Aspect ratio is defined as the ratio of effective treatment depth to manhole diameter. The aspect ratio for the tested model is 0.74. Models larger than 250% of MTFR (4.05 cfs) must be geometrically proportional to the tested model within the allowable ±15% tolerance (.63-.85). For models with MTFR less than 250%, the treatment depth must be equal or greater than the depth of the tested model.