

# **NJCAT TECHNOLOGY VERIFICATION**

## **Ocean Guardian Stormwater Treatment Device**

**S & M Precast, Inc.**

**May 2020**

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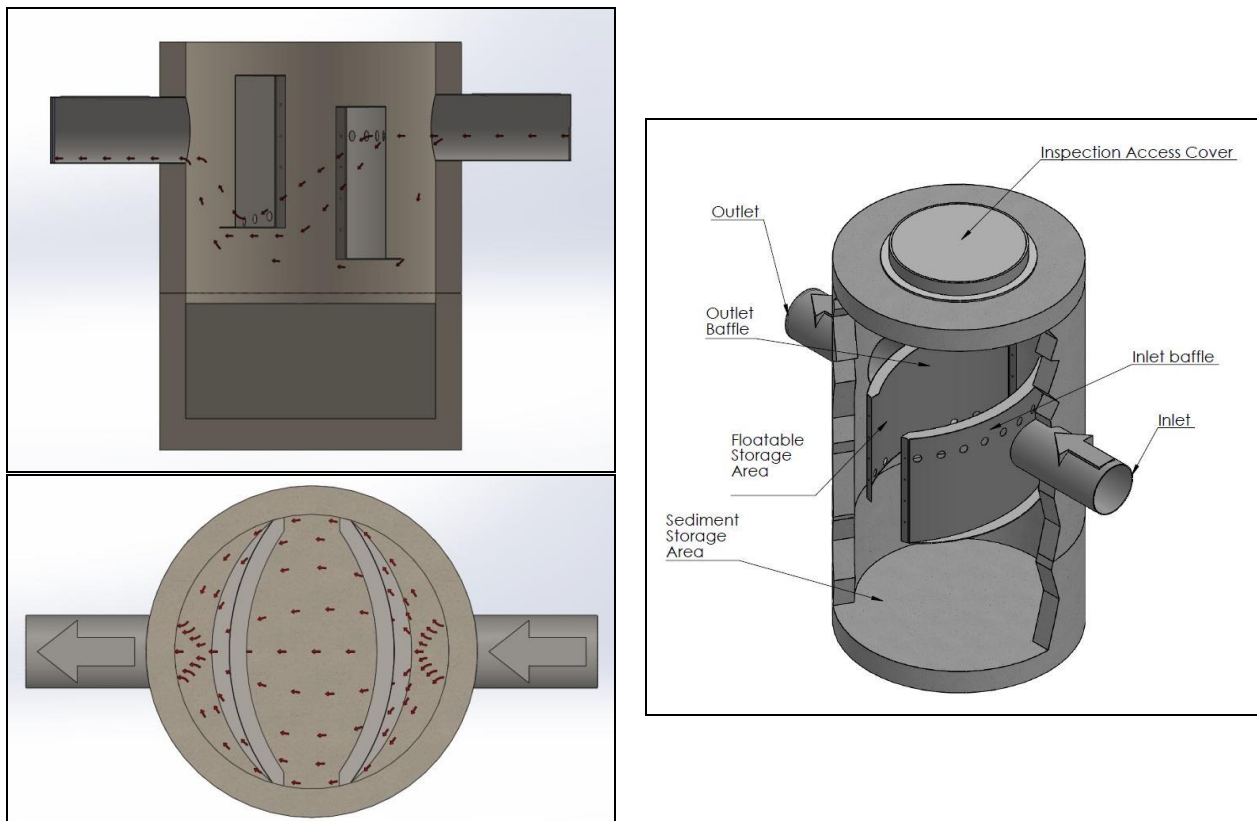
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## 1. Description of Technology

The S&M Precast, Inc. (SMP) Ocean Guardian™ (OG) hydrodynamic separator is a treatment device designed to remove sediment and harmful floatables such as oil, trash, and grease from stormwater runoff. The OG separator is housed in a water-tight concrete manhole.

Stormwater enters the OG and is bi-directionally diverted around the unit's central axis with the first baffle. The unique baffle system serves as an efficient way for sediment to settle out of the main water stream and floatables to rise up. The mainstream of water travels through holes and under the first baffle. Holes are located in both the first and second baffle so that the runoff water is treated evenly regardless of flowrate. Floatables and hydrocarbons pass over the first baffle but remain trapped in the OG by the second baffle. Since this is an online unit, there is not an internal bypass therefore stormwater is still always treated even in the highest of flows. A discharge pipe allows treated stormwater to leave the OG after the stormwater has passed under the second baffle exiting the unit. **Figure 1**



**Figure 1 OG Internal Flow Paths**

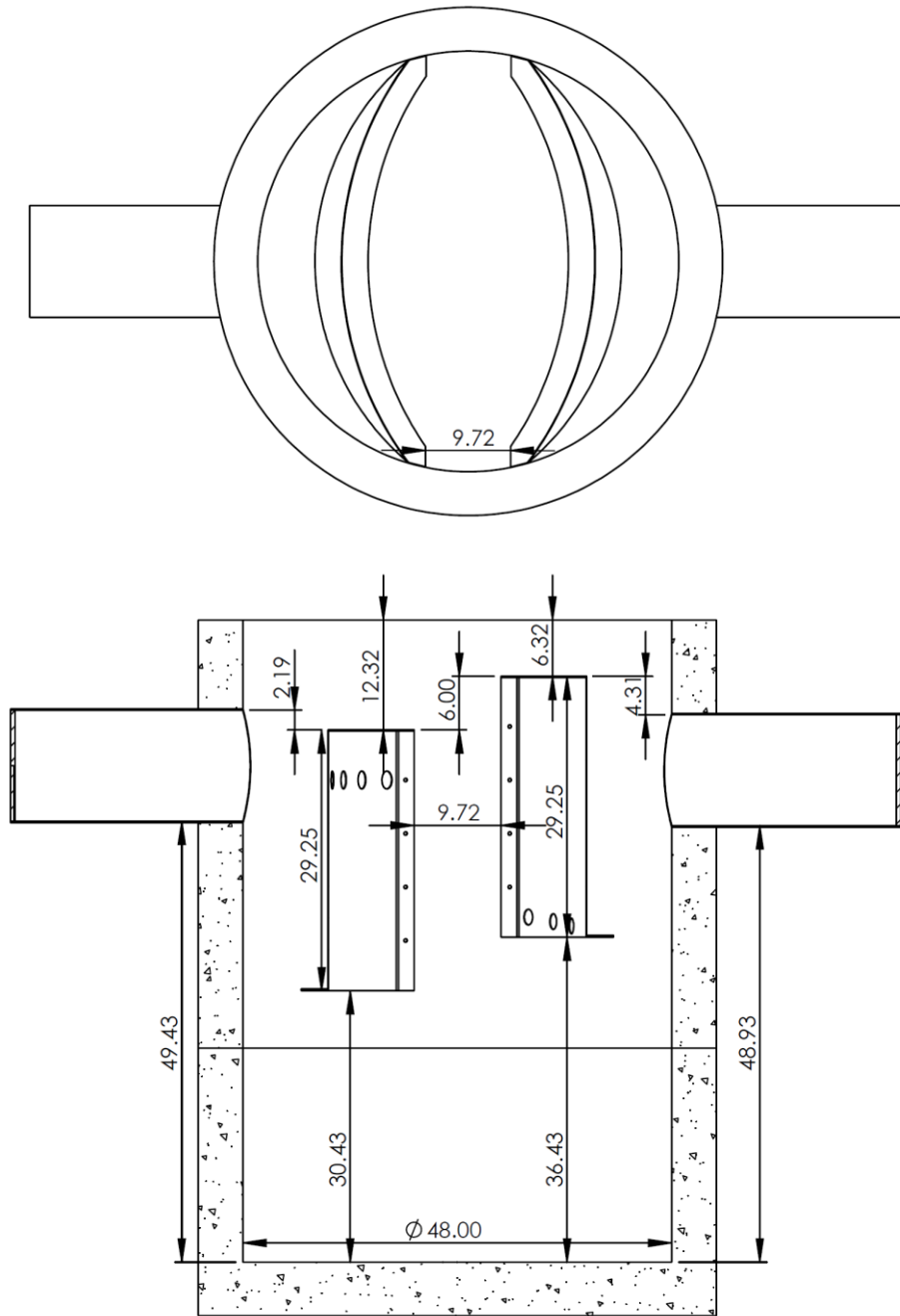
## 2. Laboratory Testing

The test program was conducted at the Alden Research Laboratory, Inc. (Alden), Holden, Massachusetts, under the direct supervision of Alden's senior stormwater engineer, James Mailloux. Alden has performed verification testing on Hydrodynamic Separator and Filtration Manufactured Treatment Devices (MTDs) for manufacturers under various state and federal testing protocols. Particle size distribution (PSD) analysis was conducted by GeoTesting Express, Inc., Acton, Massachusetts. GeoTesting is an AALA ISO/IEC 17025 accredited independent laboratory. Water quality samples collected during the testing process were analyzed in Alden's Calibration Laboratory, which is ISO 17025 accredited.

Laboratory testing was done in accordance with the New Jersey Department of Environmental Protection "Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" (January 2013a) (NJDEP Hydrodynamic Protocol). Prior to starting the performance testing program, a quality assurance project plan (QAPP) was submitted to, and approved by, the New Jersey Corporation for Advanced Technology (NJCAT) as per the NJDEP certification process.

### 2.1 Test Setup

The laboratory test used a full-scale S&M Precast (SMP) Ocean Guardian stormwater treatment unit (model OG-48) installed in a four (4) foot diameter steel cylindrical test tank. PVC inlet and outlet pipes, 12-inch in diameter, were oriented along the centerline of the unit, with the inverts located 49.43" and 48.93" above the sump floor, respectively. The pipes were set with 1% slopes. The 100% and 50% sediment capture depths of the unit were 22" and 11", respectively. The effective sedimentation treatment area was 12.57 ft<sup>2</sup>. The internal geometry consisted of two curved baffle walls 29.25" high, oriented normal to the pipes, with the center of the walls being closer to the pipes, and the mounting flanges near the center of the vault. The upstream wall was positioned 30.43" above the vault floor and contained nine 2" diameter holes in a single row positioned 1.34" below the centerline of the inlet pipe. The downstream wall was positioned 36.43" above the floor and contained three 1.75" diameter holes on either side of center. Drawings of the OG-48 test unit are shown on **Figure 2**. A photograph of the installed unit is shown on **Figure 3**.



**Figure 2 Drawing of the OG-48 Treatment Unit**



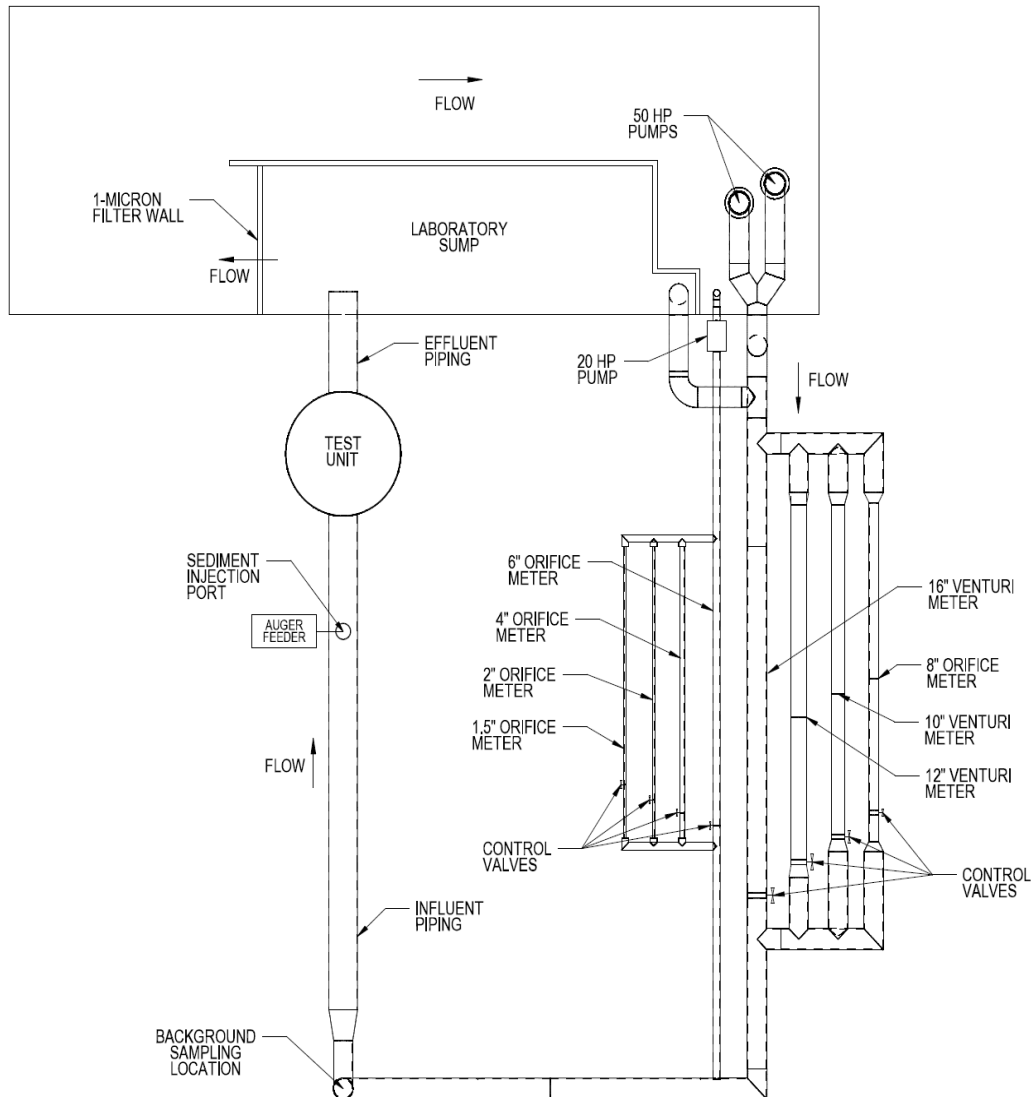
**Figure 3 OG-48 Test Unit Installed in Alden Flow Loop**

The sediment injection port riser pipe shown in the above photo was installed during hydraulic testing to prevent overtopping at the high flows.

The OG-48 test unit was installed in the Alden test loop, shown on **Figure 4**, which is set up as a recirculation system. The loop is designed to provide metered flow up to approximately 9 cfs, using calibrated orifice plate and venturi differential-pressure meters. Flow was supplied to the unit using either a 20HP or 50HP laboratory pump (flow dependent), drawing water from a 50,000-gallon supply sump. Thirty (30) feet of straight 12" pipe conveyed the metered flow to the unit. Eight (8) feet of 12" effluent piping returned the test flow back to the supply sump. The influent and effluent pipes were set at 1% slopes. A 12" tee was located 4 pipe-diameters (4 ft) upstream of the test unit for injecting sediment into the crown of the influent pipe.

Filtration of the test-loop flow, to reduce background concentration, was performed with an inline filter wall containing 1-micron filter bags.





**Figure 4 Plan View of Alden Flow Loop**

## **2.2 Hydraulic Testing**

The OG-48 unit was tested with clean water to determine its hydraulic characteristic curves. Flow and water level measurements were recorded for 9 steady-state flow conditions using a computer Data-Acquisition (DA) system, which included a data collect program, a 0-250" Rosemount Differential Pressure (DP) cell, and a Druck 0-2 psi Pressure Transducer. Flows were set and measured using calibrated differential-pressure flow meters and control valves. Each test flow was set and operated at steady state for approximately 10 minutes, after which time a minimum of 60 seconds of flow and pressure data were averaged and recorded for each pressure tap location. Water elevations were measured within the treatment unit and inlet and outlet pipes, one pipe-diameter upstream and downstream of the unit.

## 2.3 Removal Efficiency Testing

Removal testing was conducted on a clean unit utilizing the Mass Capture methodology. A false floor was installed at the 50% collection sump sediment storage depth of 11", as stated by SMP. All tests were run with clean water containing a background sediment concentration of less than 20 mg/L.

Five sediment removal efficiency tests were conducted at flows corresponding to 25%, 50%, 75%, 100% and 125% Maximum Treatment Flow Rate (MTFR).

The test sediment was prepared by Alden to meet the PSD gradation of 1-1000 microns in accordance with the distribution shown in **Table 1**. The sediment was silica based, with a specific gravity of 2.65. Random samples of each test batch were analyzed for PSD compliance by GeoTesting Express, Inc., an independent certified analytical laboratory, using the ASTM D422-63 (2007) analytical method. The average of the samples was used for compliance with the protocol specification.

The target influent sediment concentration was 200 mg/L (+/-20 mg/L) for all tests. The concentration was verified by collecting a minimum of six timed dry samples at the injector and correlating the data with the measured flow rate. Each sample volume was a minimum of 0.1 liters, with the collection time not exceeding 1-minute. The allowed Coefficient of Variance (COV) for the measured samples was 0.10. The reported test concentration was calculated based on the total mass injected during the test and total volume of water introduced during sediment dosing.

A minimum of 25 lbs of test sediment was introduced into the influent pipe for each test. The moisture content of the test sediment was determined using ASTM D4959-16 for each test conducted. In addition, the criterion for the supply water maximum temperature of 80 degrees F was met for all tests conducted.

Eight (8) background samples of the supply water were collected using an iso-kinetic sampler at evenly spaced intervals throughout each test. Collected samples were analyzed for Total Suspended Solids (TSS) using ASTM D3977-97 (2013).

**Table 1 NJDEP Target Test Sediment Particle Size Distribution**

	<b>TSS Removal Test PSD</b>	<b>Scour Test Pre-load PSD</b>
<b>Particle Size (Microns)</b>	<b>Target Minimum % Less Than<sup>2</sup></b>	<b>Target Minimum % Less Than<sup>3</sup></b>
1,000	100	100
500	95	90
250	90	55
150	75	40
100	60	25
75	50	10
50	45	0
20	35	0
8	20	0
5	10	0
2	5	0
<p>1. The material shall be hard, firm, and inorganic with a specific gravity of 2.65. The various particle sizes shall be uniformly distributed throughout the material prior to use.</p> <p>2. A measured value may be lower than a target minimum % less than value by up to two percentage points, provided the measured d<sub>50</sub> value does not exceed 75 microns.</p> <p>3. This distribution is to be used to pre-load the MTD's sedimentation chamber for off-line and on-line scour testing.</p>		

## **2.4 Scour Testing**

Sediment scour tests were conducted to evaluate the ability to retain captured material during high flows. A minimum of 4" of 50-1000-micron sediment was pre-loaded to the 50% capacity level. All test sediment was evenly distributed and levelled prior to testing.

The unit was filled with clean water ( $\leq 20$  mg/L background) to the invert of the outlet pipe prior to testing. Testing was conducted at a temperature not exceeding 80 degrees F. The test was initiated within 96 hours of filling the unit.

The scour testing was conducted at 200% and 300% MTFR for on-line certification. Testing consisted of conveying the selected target flow through the unit and collecting 15 time-stamped effluent samples (every 2 minutes) for TSS analysis, and a minimum of 8 time-stamped background samples evenly spaced throughout the test. The target flow was reached within 5 minutes of commencement of the test. Flow data was continuously recorded every 5 seconds throughout the test and correlated with the samples.

Each effluent grab sample for sediment concentration was collected from the end of the effluent pipe by sweeping a 2-liter beaker through the effluent stream.

## 2.5 Instrumentation and Measuring Techniques

### *Flow*

The inflow to the test unit was measured using one of five (5) calibrated differential-pressure flow meters (2", 4", 6", 8" or 12"). Each meter is fabricated per ASME guidelines and calibrated in Alden's Calibration Department prior to the start of testing. Flows were set with a butterfly valve and the differential head from the meter was measured using the Rosemount® 0 to 250-inch DP cell, also calibrated at Alden prior to testing. The test flow was averaged and recorded every 5-30 seconds (flow dependent) throughout the duration of the test using the in-house computerized DA program. The accuracy of the flow measurement is  $\pm 2\%$ . A photograph of the flow meters is shown on **Figure 5**.



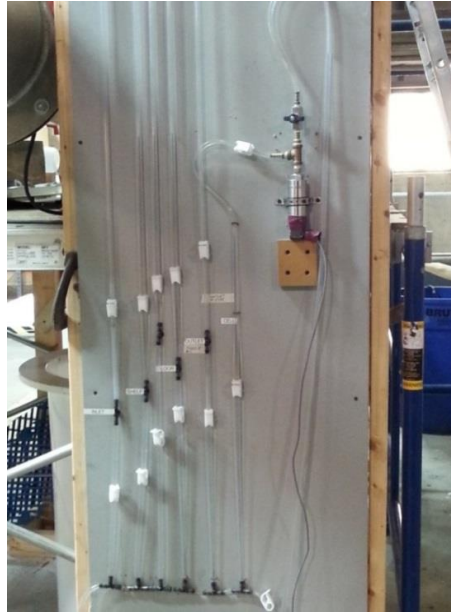
**Figure 5 Photograph Showing Laboratory Flow Meters**

### *Temperature*

Water temperature measurements within the supply sump were obtained using a calibrated Omega® DP25 temperature probe and readout device. The calibration was performed at the Alden laboratory prior to testing. The temperature measurement was documented at the start and end of each test, to ensure an acceptable testing temperature of  $\leq 80$  degrees F.

### *Pressure Head*

Pressure head measurements were recorded at multiple locations using piezometer taps and a Druck<sup>®</sup>, Model PTX510, 0 - 2.0 psi pressure transducer (PT). The PT was calibrated at Alden prior to testing. Accuracy of the readings is  $\pm 0.001$  ft. The cell was installed at a known datum in relation to the tank floor, allowing for elevation readings through the full range of flows. A minimum of 60 seconds of pressure data was averaged and recorded for each pressure tap during steady-state flow conditions, using the computer DA program. A photograph of the pressure measurement instrumentation is shown on **Figure 6**.



**Figure 6 Pressure Measurement Instrumentation**

### *Sediment Injection*

The test sediment was injected into the crown of the influent pipe using an Auger<sup>®</sup> volumetric screw feeder, model VF-1, shown on **Figure 7**. The feed screws used in testing ranged in size from 0.5-inch to 0.75 inch, depending on the test flow. Each auger screw, driven with a variable-speed drive, was calibrated with the test sediment prior to testing. The calibration, as well as test verification of the sediment feed was accomplished by collecting 1-minute timed dry samples and weighing them on a calibrated Ohaus<sup>®</sup> 4000g x 0.1g, model SCD-010 digital scale. The feeder has a hopper at the upper end of the auger to provide a constant supply of dry test sediment.



**Figure 7 Photograph Showing Variable-Speed Auger Feeder**

*Sample Collection*

Background concentration samples were collected from the center of the vertical pipe upstream of the test unit with the use of a 0.75-inch iso-kinetic sampler, shown on **Figure 8**. The sampler was calibrated for each test flow.



**Figure 8 Photograph Showing the Background Isokinetic Sampler**

*Sample Concentration Analysis*

Effluent and background concentration samples were analyzed by Alden in accordance with Method B, as described in ASTM Designation: D 3977-97 (2013), “Standard Test Methods for Determining Sediment Concentration in Water Samples”. The required silica sand used in the sediment testing did not result in any dissolved solids in the samples and therefore, simplified the

ASTM testing methods for determining sediment concentration.

## **2.6 Data Management and Acquisition**

A designated Laboratory Records Book was used to document the conditions and pertinent data entries for each test conducted. All entries are initialed and dated.

A personal computer running an Alden in-house Labview® Data Acquisition program was used to record all data related to instrument calibration and testing. A 16-bit National Instruments® NI6212 Analog to Digital (A/D) board was used to convert the signal from the pressure cells to a voltage. Alden's in-house data collection software, by default, collects one-second averages of data collected at a raw rate of 250 Hz. The system allows very long contiguous data collection by continuously writing the collected 1-second averages and their RMS values to disk. Data output from the program is in tab delimited text format with user-defined number of significant figures.

Test flow and pressure data were continuously collected at a frequency of 250 Hz. The flow data was averaged and recorded to file every 5 to 30 seconds, depending on the duration of the test. Steady-state pressure data was averaged and recorded over a duration of 60 seconds for each point. The recorded data files were imported into Excel for further analysis and plotting.

Excel based data sheets were used to record all sediment related data used for quantifying injection rate, effluent (scour) and background sample concentrations, flow, pressure, mass and PSD data. The data was input to the designated spreadsheet for final processing.

## **2.7 Quality Assurance and Control**

All instruments were calibrated prior to testing and periodically checked throughout the test program. Instrumentation calibrations were provided.

### *Flow*

The flow meters and pressure cells were calibrated in Alden's Calibration Laboratory, which is ISO 17025 accredited. All pressure lines were purged of air prior to initiating each test. A standard water manometer board and Engineers Rule were used to measure the differential pressure and verify the computer measurement of the selected flow meter.

### *Sediment Injection*

The sediment feed (g/min) was verified with the use of a NIST traceable digital stopwatch and 4000 g calibrated digital scale. The tare weight of the sample container was recorded prior to collection of each sample. The samples were a minimum of 0.1 liters in size, with a maximum collection time of 1-minute. The final mass/volume sediment concentrations were adjusted for moisture.

### *Sediment Concentration Analysis*

All sediment concentration samples were processed in accordance with ASTM D3977-97 (2013) analytical method. Gross sample weights were measured using a 4000 g x 0.1g calibrated digital scale. The dried sample weights were measured with a calibrated 0.0001g analytical balance. The change in filter weight due to processing was accounted for by including three control filters with each test set. The average of the three values, which was typically (+/- 0.1mg), was used in the final concentration calculations. Alden has assigned a Non-Detection Limit (NDL) of 0.25 mg/L. To be conservative, all concentrations below the NDL were assigned a value of 0 mg/L.

Analytical accuracy was verified by preparing two blind control samples and processing using the ASTM method. The final calculated values were within 0.26% and 0.87% of the theoretical sample concentrations, with an average of 99.4% accuracy.

### **3. Performance Claims**

The following performance claims for the SMP OG-48 are based on the results of the independent laboratory testing conducted in accordance with the NJDEP testing protocol.

#### *Total Suspended Solids (TSS) Removal Efficiency*

The TSS removal rate of the SMP OG-48 was calculated using the weighted method required by the NJDEP HDS MTD protocol. Based on a MTFR of 0.29 cfs (132 gpm), the OG-48 achieved a weighted TSS removal rate of 52.6%, which meets the 50% acceptance criterion.

#### *Maximum Treatment Flow Rate (MTFR)*

The SMP OG-48 has a total sedimentation area of 12.57 ft<sup>2</sup> and demonstrates a maximum treatment flow rate (MTFR) of 0.29 cfs (132 gpm). This corresponds to a surface loading rate of 10.5 gpm/ft<sup>2</sup> of sedimentation area.

#### *Maximum Sediment Storage Depth and Volume*

The maximum sediment storage depth is 22" which equates to 23.0 ft<sup>3</sup> of sediment storage volume. A sediment storage depth of 11" corresponds to 50% full sediment storage capacity (11.5 ft<sup>3</sup>).

#### *Effective Treatment/Sedimentation Area*

The effective treatment area is 12.57 ft<sup>2</sup>.

#### *Detention Time and Wet Volume*

The wet volume for the OG-48 is 383 gallons. The detention time of the OG-48 is dependent upon flow rate. At the MTFR, the detention time in the OG-48 is approximately 3 minutes.



### *Online/Offline Installation*

A 300% MTFR online sediment scour test was performed with the collection sump preloaded to 50% of the capture capacity (11”), using the NJDEP 50-1000-micron sediment PSD. The test resulted in an average effluent concentration of 11.7 mg/L, which meets the online installation acceptance criterion. Based on the scour testing results the SMP OG-48 qualifies for online installation.

### *System Loss*

Hydraulic testing was conducted at flows ranging from 0 to 1045 gpm. The maximum calculated system loss at 1045 gpm was 0.20 ft.

## **4. Supporting Documentation**

The NJDEP Procedure (NJDEP, 2013b) for obtaining verification of a stormwater manufactured treatment device (MTD) from the New Jersey Corporation for Advanced Technology (NJCAT) requires that “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.” 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 that it would not be prudent or necessary to include all this information in this verification report. This information was provided to NJCAT and is available upon request.

### **4.1 Test Sediment PSD Analysis**

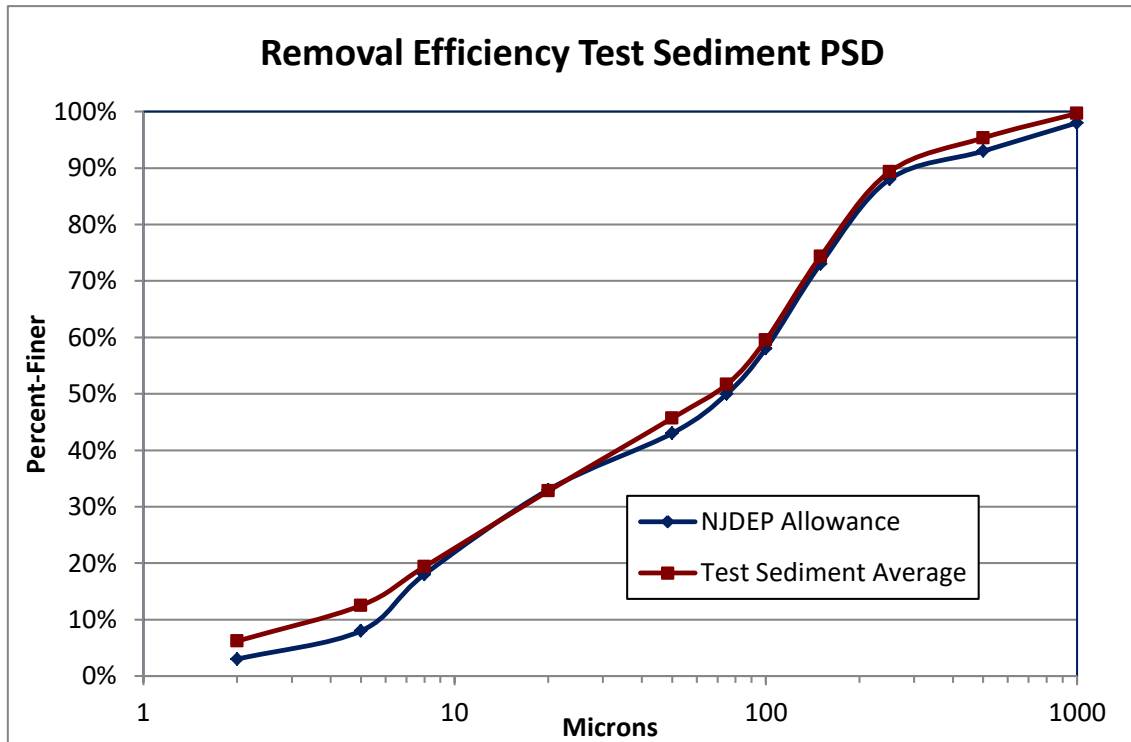
The sediment particle size distribution (PSD) used for scour and removal efficiency testing was comprised of 50-1000 and 1-1000-micron (respectively) silica particles with a SG of 2.65. Commercially available blends were provided by AGSCO Corp., a QAS International ISO-9001 certified company. The 1-1000-micron test batches were prepared by Alden as needed and a minimum of three random batch samples were analyzed in accordance with ASTM D422-63 (2007), by GeoTesting Express. The 50-1000-micron sediment was procured in bulk from AGSCO as certified material. The certification was performed by CTLGroup, an ISO/IEC 17025 accredited independent laboratory, and provided with the material shipment.

Sediment test batches of approximately 30 lbs each were prepared in individual 5-gallon buckets, which were arbitrarily selected for each removal test. A well-mixed sample was collected from each test batch and analyzed for PSD by GeoTesting Express. The average of the samples was used for compliance to the protocol specifications. The specified less-than (%-finer) values of the 3-sample average were within the 2 percentage-point tolerance listed in the protocol. The PSD data of the samples are shown in **Table 2** and the corresponding curves are shown on **Figure 9**.

**Table 2 Removal Efficiency Test Sediment Particle Size Distribution**

Particle size (µm)	NJDEP Allowance	Bucket 3	Bucket 8	Bucket 12	Bucket 14	Bucket 15	Average	QA/QC Compliant
1000	98%	100%	100%	100%	100%	100%	100%	Y
500	93%	96%	96%	96%	95%	96%	95%	Y
250	88%	89%	89%	90%	90%	90%	89%	Y
150	73%	72%	74%	76%	76%	75%	74%	Y
100	58%	59%	59%	61%	60%	60%	60%	Y
75	50%	51%	52%	54%	52%	51%	52%	Y
50	43%	49%	44%	45%	46%	48%	46%	Y
20	33%	33%	34%	31%	35%	31%	33%	Y
8	18%	19%	21%	20%	20%	18%	19%	Y
5	8%	13%	16%	14%	14%	12%	12%	Y
2	3%	7%	9%	6%	7%	7%	6%	Y
75	D50	63	67	64	67	68	66	Y

The sediment particle size distribution (PSD) used for removal efficiency testing exceeded the NJDEP PSD sediment specifications (**Table 1**) across the entire distribution. The D<sub>50</sub> of 66 microns was less than the required 75 microns.



**Figure 9 Average Removal Efficiency Test Sediment PSD**

## 4.2 Removal Efficiency Testing

### Testing Summary

Removal efficiency tests were conducted at the 5 required flows of 25%, 50%, 75%, 100% and 125% MTFR. Three initial tests were conducted at 43 gpm, 100 gpm and 150 gpm, to develop the removal curve. The selected 100% MTFR was 132 gpm, resulting in target flows of 33, 66, 99, 132 and 165 gpm. The target influent sediment concentration was 200 mg/L.

The target and measured flow and temperature parameters are shown in **Table 3** and the injected sediment and background data summary is in **Table 4**.

**Table 3 Test Flow and Temperature Summary**

MTFR	Target Flow		Measured Flow		Deviation from Target	Flow Measurement COV	Maximum Temperature	QA / QC Compliant
%	cfs	gpm	cfs	gpm			Deg. F	
25	0.07	33	0.07	33.1	0.3%	0.001	67.0	Y
50	0.15	66	0.14	63.1	-4.3%	0.001	63.4	Y
75	0.22	99	0.22	100.2	1.2%	0.001	67.2	Y
100	0.29	132	0.29	132.0	0.0%	0.001	59.7	Y
125	0.37	165	0.33	150.1	-9.0%	0.002	63.0	Y

**Table 4 Injected Sediment Summary**

MTFR	Flow	Target Concentration	Average Injected Concentration	Injector Measurements COV	Mass/Volume Concentration	Injected Mass	Maximum Background Concentration	QA / QC Compliant
%	gpm	mg/L	mg/L		mg/L	lbs	mg/L	
25	33.1	200	203	0.04	193	24.03	5.26	*N
50	63.1	200	201	0.01	210	28.70	1.69	Y
75	100.2	200	200	0.01	190	26.12	3.37	Y
100	132.0	200	201	0.00	197	29.26	5.96	Y
125	150.1	200	199	0.00	199	27.74	3.27	Y

\*Injected mass during the 33 gpm test was < 25 lbs, which was conducted over an 8-hr period.

### Repeat Tests

A test was conducted at 43 gpm during the curve development testing. This flow was 30% greater than the 25% MTFR target of 33 gpm, and therefore, not included in the weighted removal calculation.

The initial 33 gpm test resulted in a mass/volume influent concentration of 227 mg/L, which was above the 200  $\pm$ 10% mg/L allowable value. The test was repeated.

### Removal Efficiency Summary

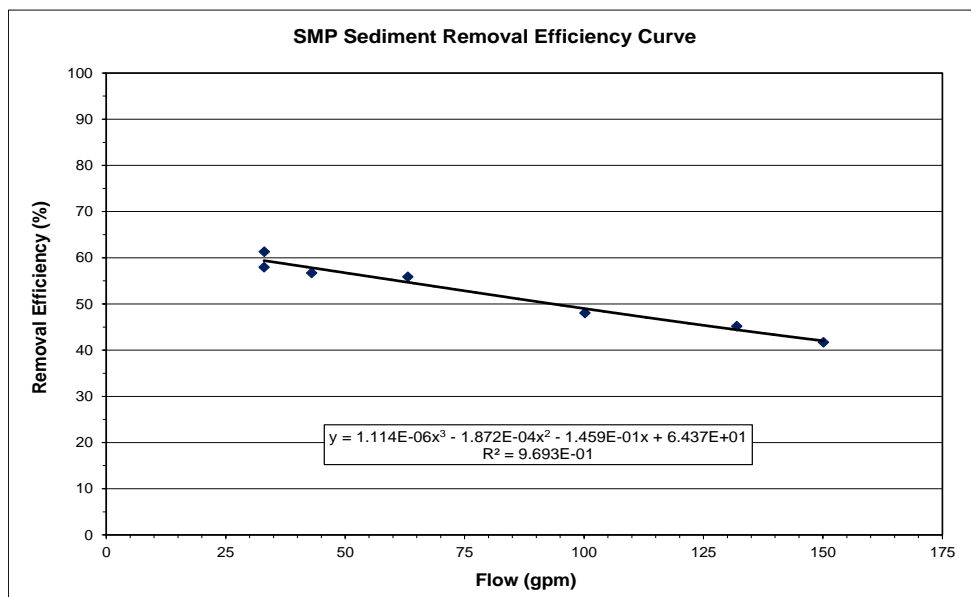
At the end of each test run, the captured sediment was collected and quantified. The removal efficiency was by:

$$\% \text{ Removal} = \frac{\text{Captured Sediment Mass}}{\text{Injected Sediment Mass}} \times 100$$

The calculated removal efficiencies ranged from 41.7% to 61.3%, with a weighted removal of 52.6% for the 5 flows tested. The removal summary is shown in **Table 5** with the corresponding removal curve shown on **Figure 10**. The additional 33 gpm and 43 gpm tests results are included in the curve and corresponding equation for completeness.

**Table 5 Removal Efficiency Summary**

MTFR	Flow	Mass Injected	Mass Captured	Removal Efficiency	NJDEP Wt. Factors	Wt'd Removal
%	gpm	Lbs.	Lbs.	%		%
25	33.1	24.03	14.73	<b>61.3</b>	0.25	15.3
50	63.1	28.70	16.03	<b>55.9</b>	0.30	16.8
75	100.2	26.12	12.55	<b>48.0</b>	0.20	9.6
100	132.0	29.26	13.22	<b>45.2</b>	0.15	6.8
125	150.1	27.74	11.57	<b>41.7</b>	0.10	4.2
					<b>1.00</b>	<b>52.6</b>



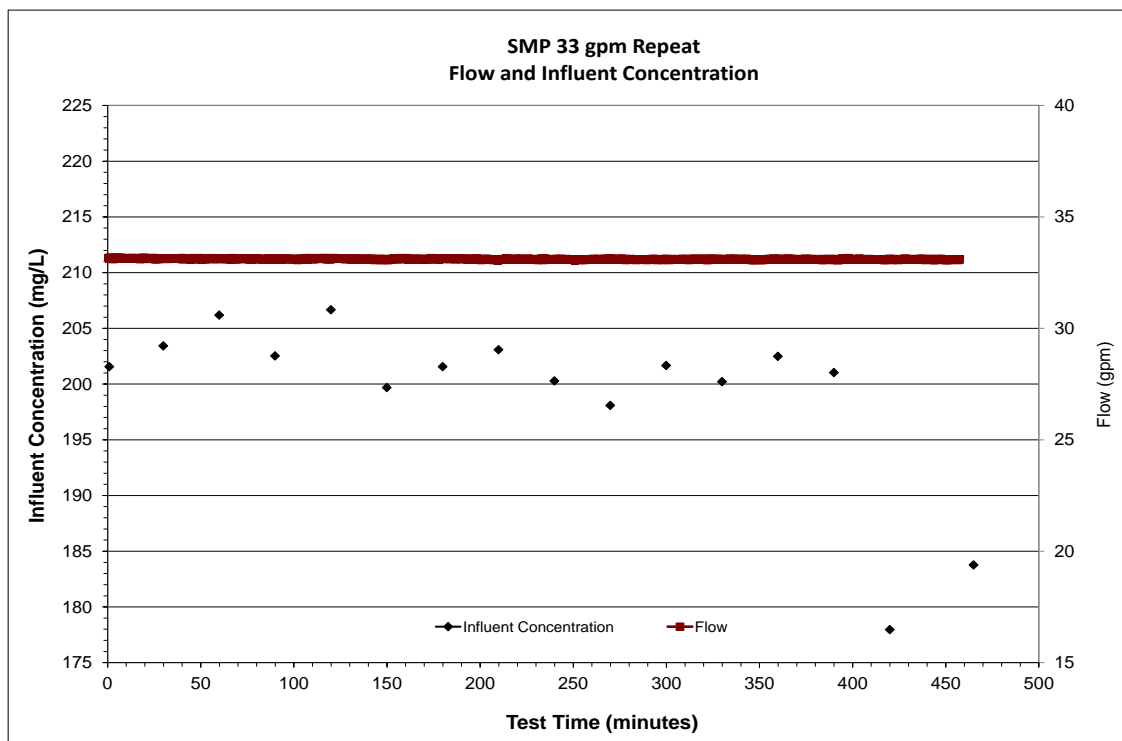
**Figure 10 OG-48 Removal Efficiency Curve**

### 25% MTFR (33 gpm)

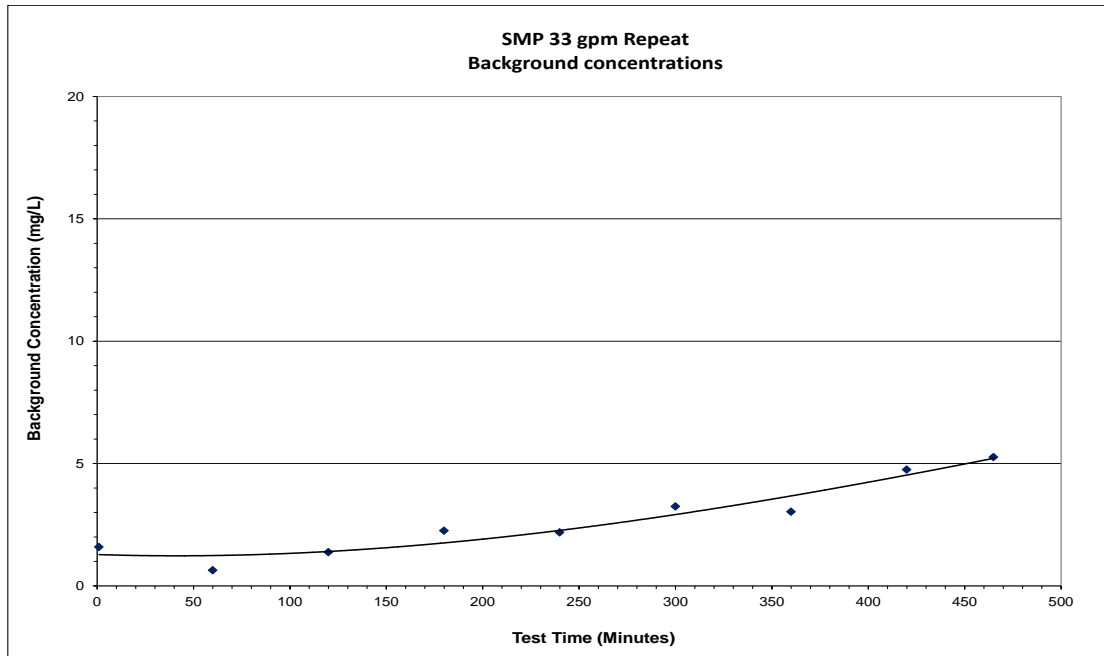
The test was conducted at 33 gpm over a period of 8 hours. The resulting removal efficiency was 61.3%. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 33.1 gpm, with a COV of 0.001. The recorded temperature for the test did not exceed 67 degrees F.

The injection feed rate of 25.0 g/min was verified by collecting 1-minute weight samples from the injector. Sixteen influent injection measurements (1 every 30 minutes) were taken throughout the test duration. The calculated concentrations for the full test ranged from 178 to 207 mg/L, with a mean of 203 mg/L and COV of 0.04. The total mass injected into the unit was 24.0 lbs. The calculated mass-flow concentration for the test was 193 mg/L. The measured influent concentration and flow data for the complete test is shown on **Figure 11**.

Eight (8) background concentrations samples were collected throughout the test (hourly) and ranged from 0.6 to 5.3 mg/L. The background concentration curve is shown on **Figure 12**.



**Figure 11 25% MTFR Measured Flow and Influent Concentrations**



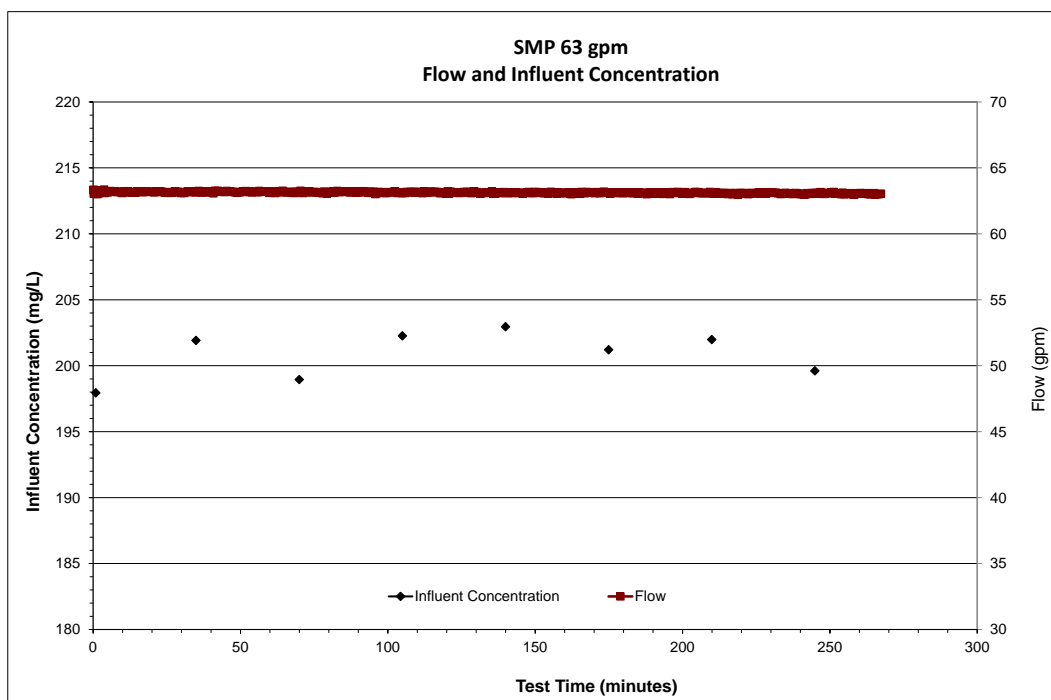
**Figure 12 25% MTFR Measured Background Concentrations**

### ***50% MTFR (66 gpm)***

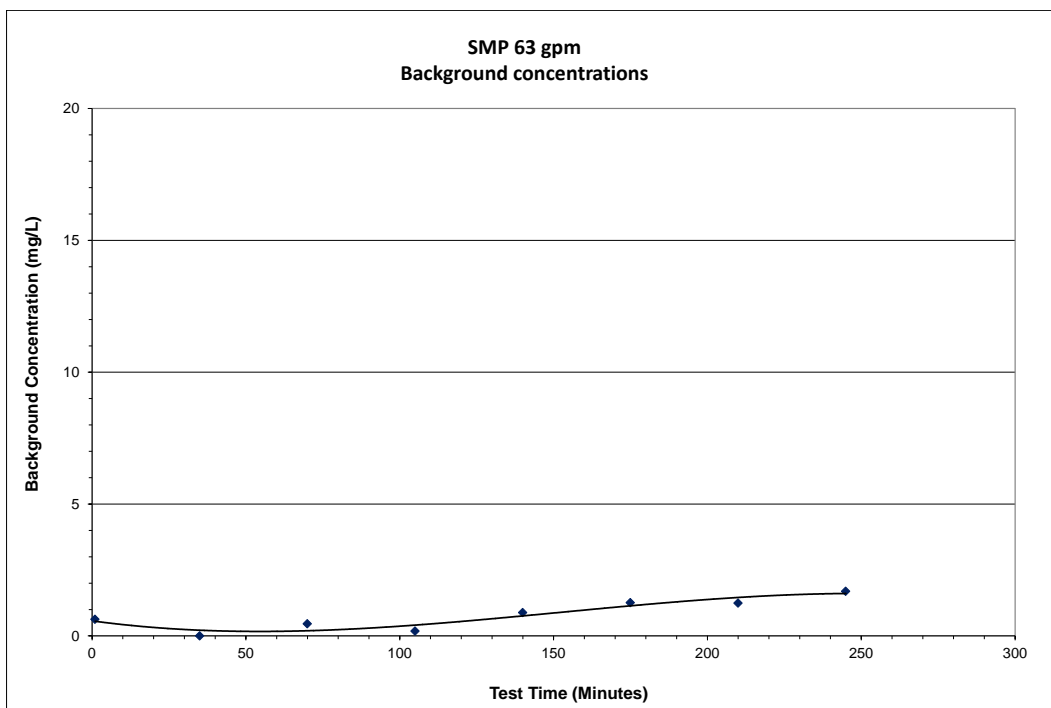
The test was conducted at 63 gpm over a period of 4 hours. The resulting removal efficiency was 55.9%. The test flow was averaged and recorded every 30 seconds throughout the test. The adjusted average recorded test flow was 63 gpm, with a COV of 0.001. The recorded temperature for the full test ranged from 63.3 to 63.4 degrees F.

The injection feed rate of 47.7 g/min was verified by collecting 1-minute weight samples from the injector. The measured influent injection concentrations for the full test ranged from 198 to 203 mg/L, with a mean of 201 mg/L and COV of 0.01. The total mass injected into the unit was 28.7 lbs. The calculated mass-flow concentration for the test was 210 mg/L. The measured influent concentration and flow data for the complete test is shown on **Figure 13**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.0 (ND) to 1.7 mg/L. The background concentration curve is shown on **Figure 14**.



**Figure 13 50% MTFR Measured Flow and Influent Concentrations**



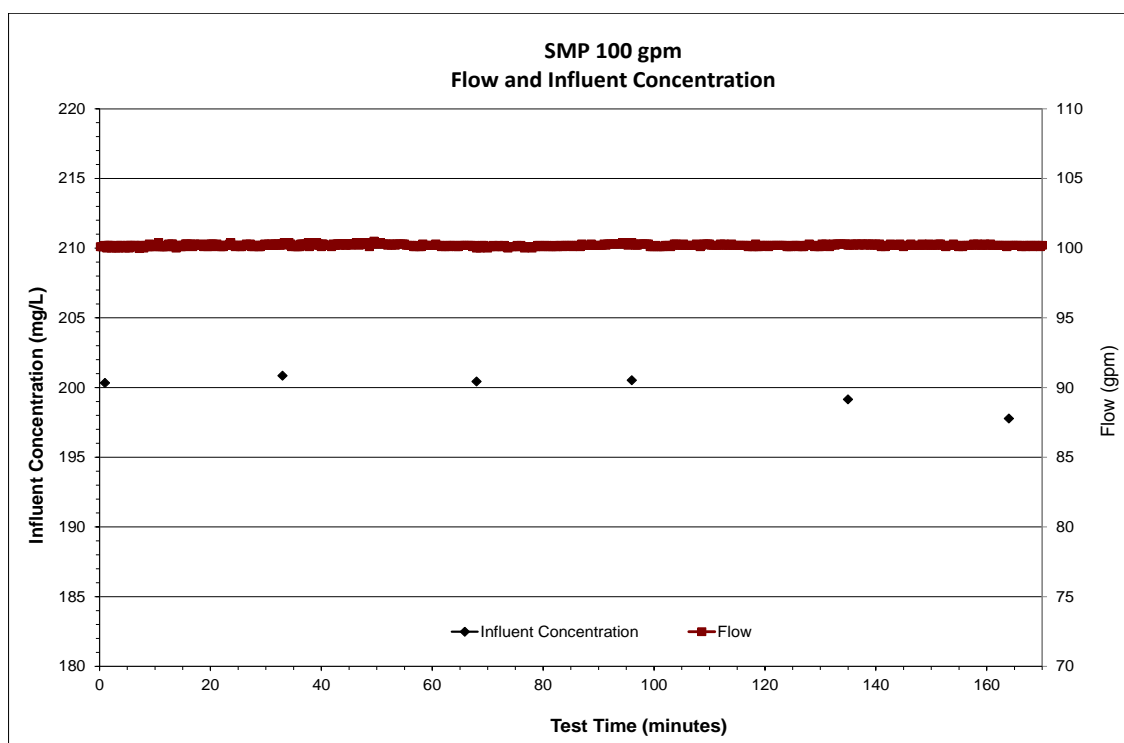
**Figure 14 50% MTFR Measured Background Concentrations**

### 75% MTFR (99 gpm)

The test was conducted at 99 gpm over a period of 164 minutes. The resulting removal efficiency was 48.0%. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 100 gpm, with a COV of 0.001. The recorded temperature for the full test ranged from 67.0 to 67.2 degrees F.

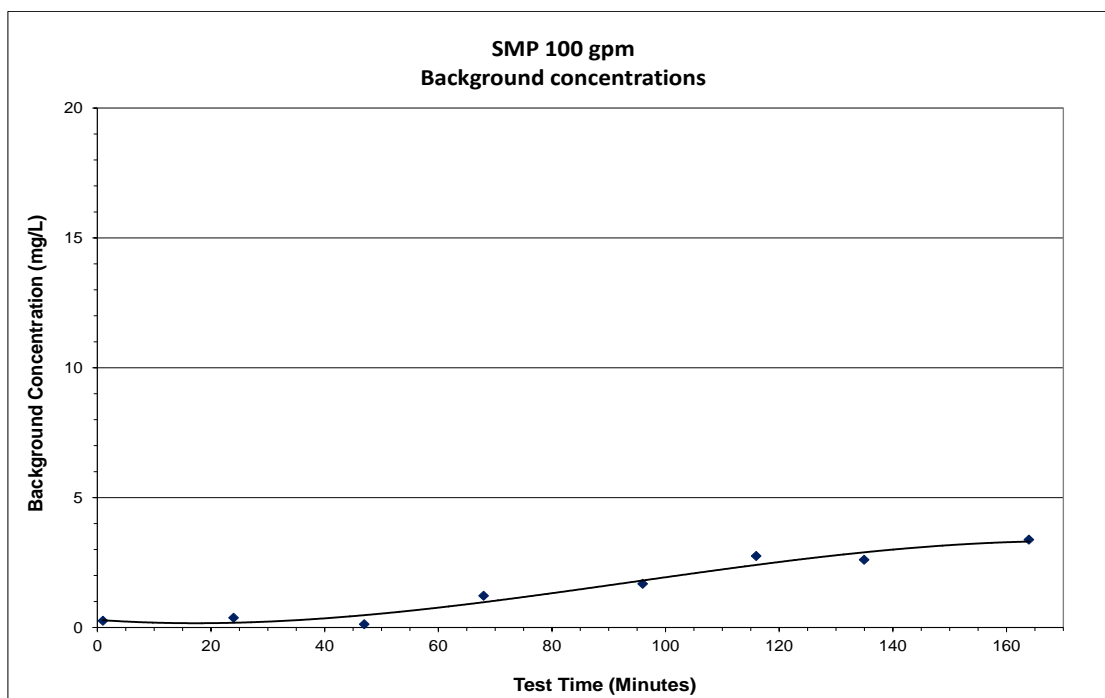
The injection feed rate of 75.7 g/min was verified by collecting 1-minute weight samples from the injector. The measured influent injection concentrations for the full test ranged from 198 to 201 mg/L, with a mean of 200 mg/L and COV of 0.01. The total mass injected into the unit was 26.1 lbs. The calculated mass-flow concentration for the test was 190 mg/L. The measured influent concentration and flow data for the complete test is shown on **Figure 15**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.0 (ND) to 3.4 mg/L. The background concentration curve is shown on **Figure 16**.



**Figure 15 75% MTFR Measured Flow and Influent Concentrations**





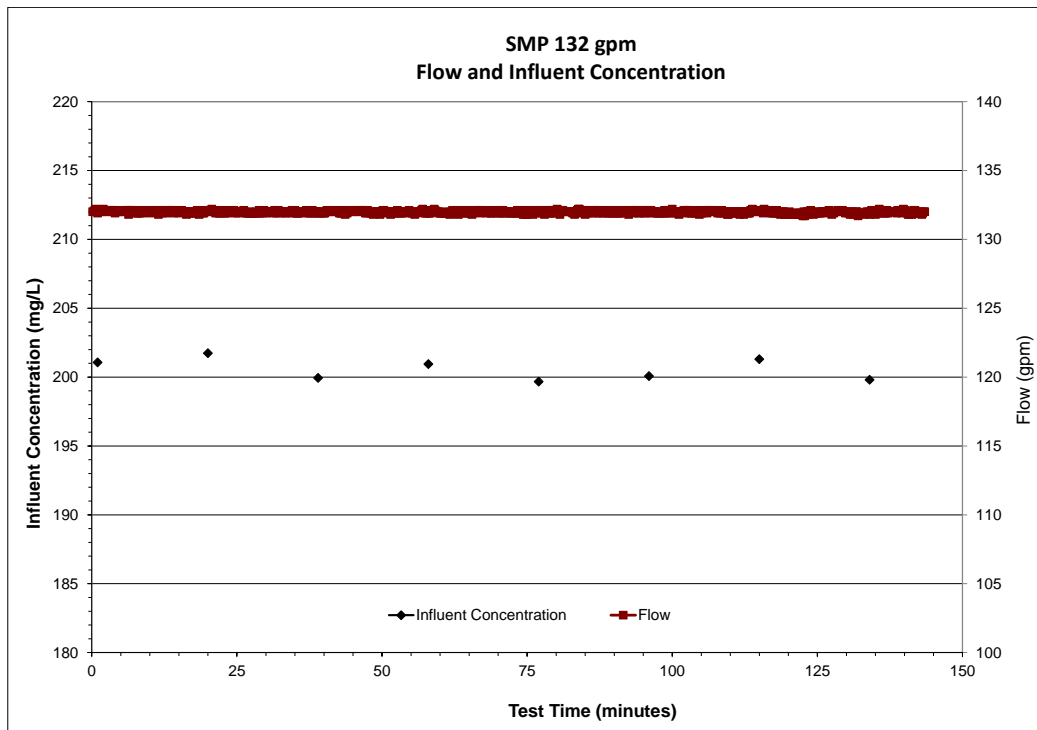
**Figure 16 75% MTFR Measured Background Concentrations**

### ***100% MTFR (132 gpm)***

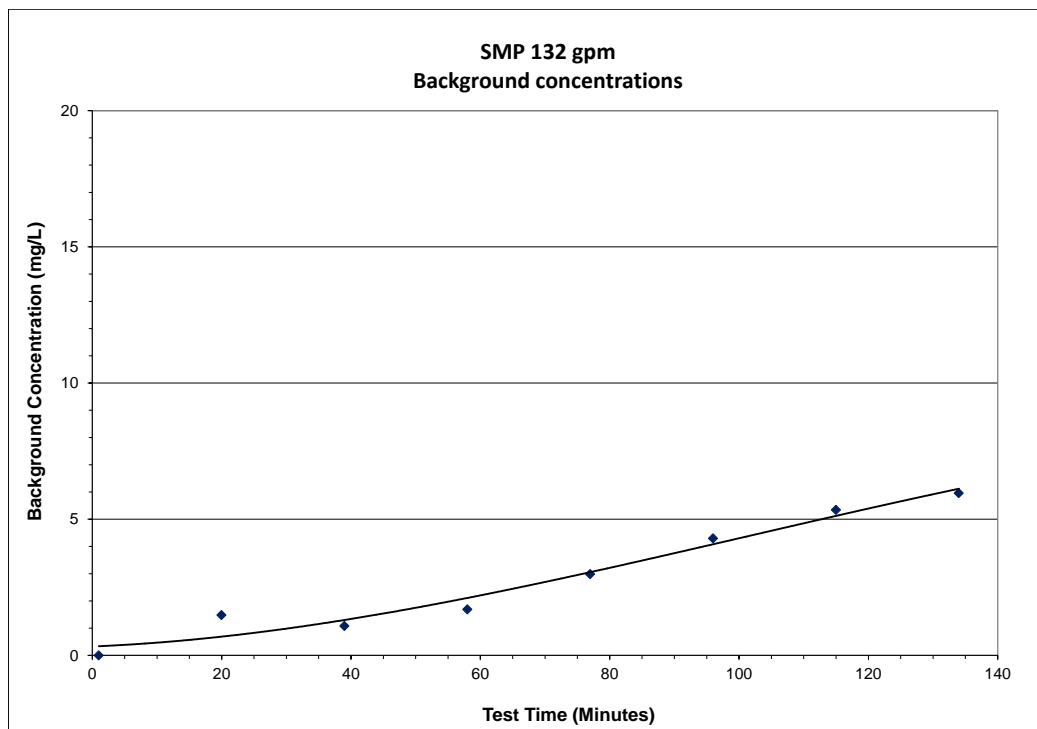
The test was conducted at 132 gpm over a period of 134 minutes. The resulting removal efficiency was 45.2%. The test flow was averaged and recorded every 10 seconds throughout the test. The adjusted average recorded test flow was 132 gpm, with a COV of 0.001. The recorded temperature for the full test ranged from 59.5 to 59.7 degrees F.

The injection feed rate of 99.9 g/min was verified by collecting 1-minute weight samples from the injector. The measured influent injection concentrations for the full test ranged from 200 to 202 mg/L, with a mean of 201 mg/L and COV of 0.00. The total mass injected into the unit was 29.3 lbs. The calculated mass-flow concentration for the test was 197 mg/L. The measured influent concentration and flow data for the complete test is shown on **Figure 17**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.0 (ND) to 6.0 mg/L. The background concentration curve is shown on **Figure 18**.



**Figure 17 100% MTFR Measured Flow and Influent Concentrations**



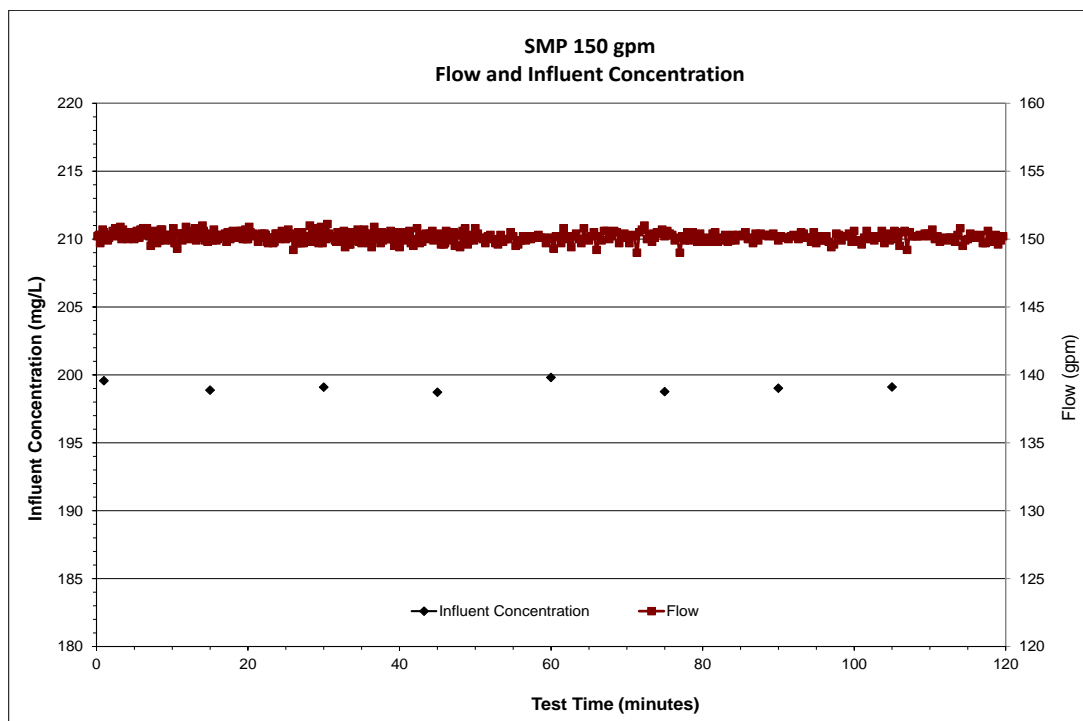
**Figure 18 100% MTFR Measured Background Concentrations**

### **125% MTFR (165 gpm)**

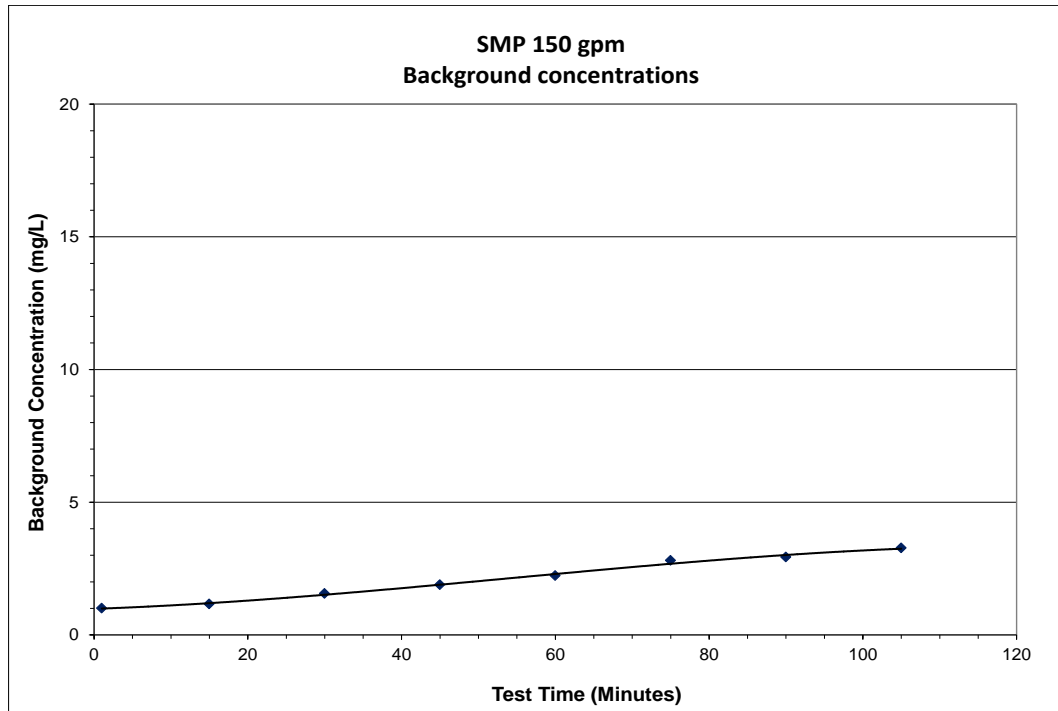
The test was conducted at 150 gpm over a period of 105 minutes. This test was conducted during the development of the characteristic curve and was included in the final MTFR tests, as it was within the 10% flow tolerance. The resulting removal efficiency was 41.7%. The test flow was averaged and recorded every 10 seconds throughout the test. The adjusted average recorded test flow was 150 gpm, with a COV of 0.002. The recorded temperature for the full test was 63.0 degrees F.

The injection feed rate of 113.6 g/min was verified by collecting 1-minute weight samples from the injector. The measured influent injection concentrations for the full test ranged from 199 to 200 mg/L, with a mean of 199 mg/L and COV of 0.00. The total mass injected into the unit was 27.7 lbs. The calculated mass-flow concentration for the test was 199 mg/L. The measured influent concentration and flow data for the complete test is shown on **Figure 19**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 1.0 to 3.3 mg/L. The background concentration curve is shown on **Figure 20**.



**Figure 19 125% MTFR Measured Flow and Influent Concentrations**



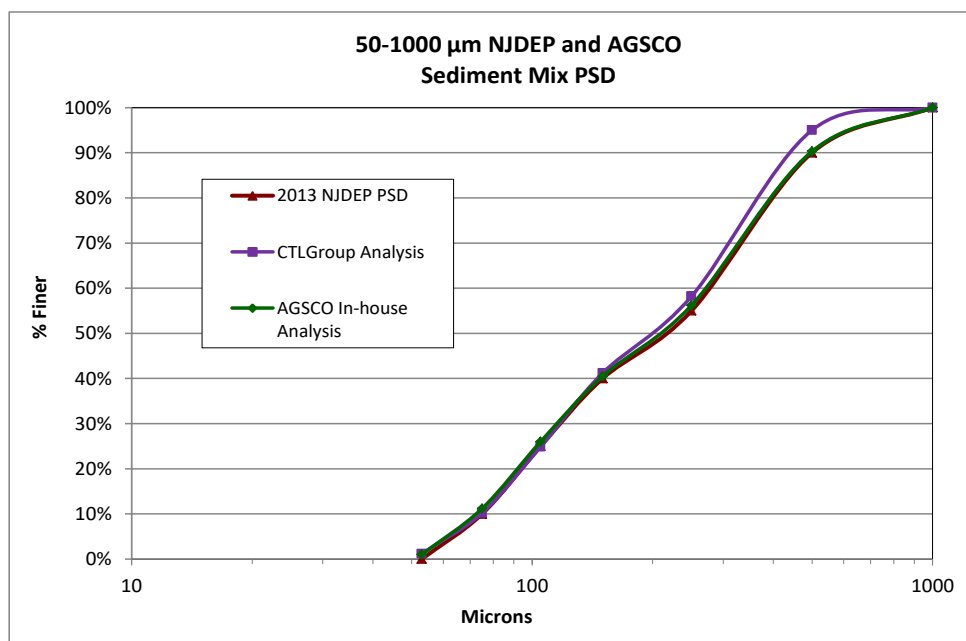
**Figure 20 125% MTR Measured Background Concentration**

### 4.3 Scour Test

The commercially available AGSCO NJDEP 50-1000 certified sediment mix was utilized for the scour test. Three samples of the batch mix were analyzed in accordance with ASTM D422-63 (2007), by CTLGroup, an ISO/IEC 17025 accredited independent laboratory, and provided with the sediment shipment. The specified less-than (%-finer) values of the sample average were within the specifications listed in **Column 3 Table 1**, as defined by the protocol. The  $D_{50}$  of the 3-sample average was 202 microns. The PSD data of the samples are shown in **Table 6** and the corresponding curves, including the initial AGSCO in-house analysis, are shown on **Figure 21**.

**Table 6 PSD Analyses of AGSCO NJDEP 50-1000 Batch Mix**

Particle size ( $\mu\text{m}$ )	NJDEP %-Finer Specifications	Test Sediment Particle Size (%-Finer)			
		Sample 1	Sample 2	Sample 3	Average
1000	100	100	100	100	<b>100</b>
500	90	95	95	95	<b>95</b>
250	55	58	58	59	<b>58</b>
150	40	41	41	42	<b>41</b>
100	25	23	23	23	<b>23</b>
75	10	10	10	11	<b>10</b>
50	0	1	1	1	<b>1</b>



**Figure 21 PSD Curves of AGSCO Batch Analysis and NJDEP Specifications**

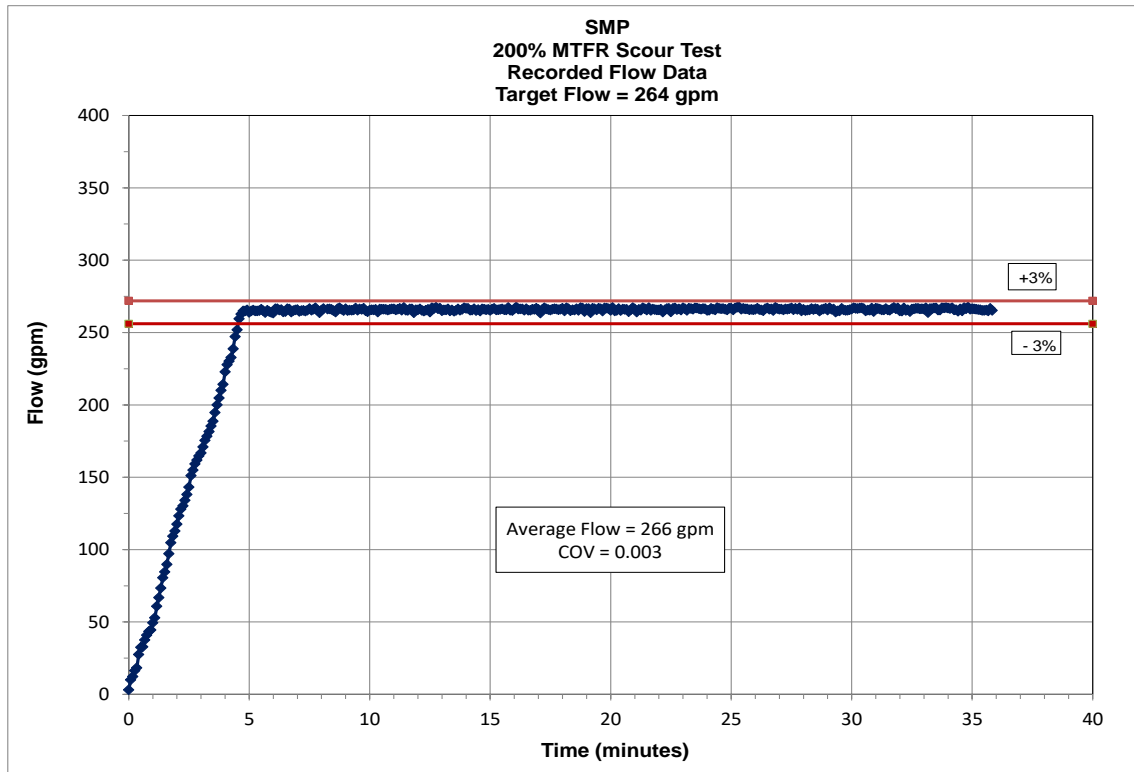
The scour test was conducted with the unit preloaded with 4" of sediment to the 50% capacity level (11").

#### *200% MTR*

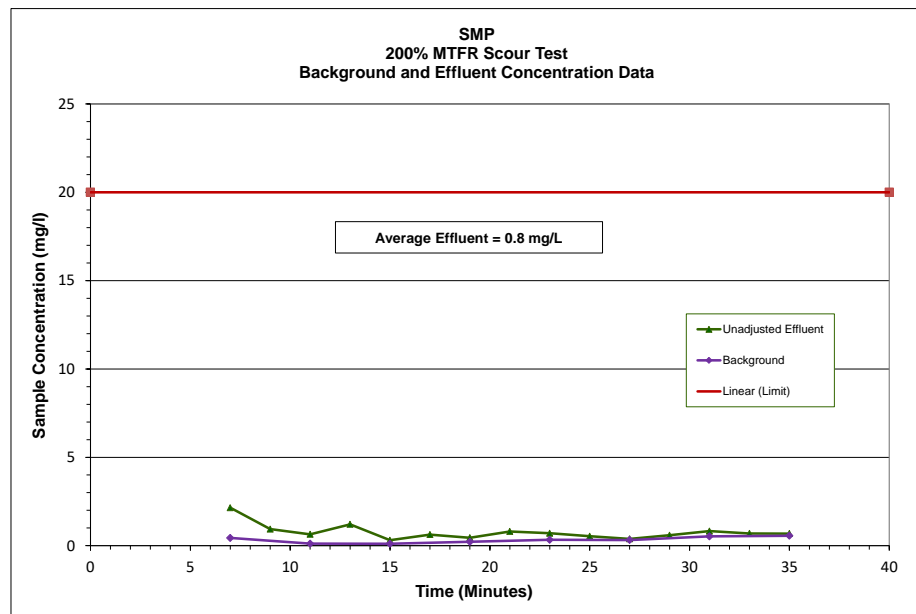
The test was conducted at a target flow of 264 gpm, which is equal to 200% MTR. The flow data was recorded every 5 seconds throughout the test and is shown on **Figure 22**. The target flow was reached within 5 minutes of initiating the test. The average recorded steady-state flow was 266 gpm, with a COV of 0.003.

Eight background samples were collected throughout the duration of the test. The measured concentrations ranged from 0.0 (ND) to 0.6 mg/L, with an average concentration of 0.3 mg/L. The recorded water temperature was 66.2 degrees F.

A total of 15 effluent samples were collected throughout the test. The measured concentrations ranged from 0.3 to 2.1 mg/L, with an average concentration of 0.8 mg/L. The effluent and background concentration data are shown in **Table 7** and on **Figure 23**.



**Figure 22 200% MTFR Scour Test Recorded Flow Data**



**Figure 23 200% MTFR Measured Background and Effluent Concentrations**

**Table 7 200% MTFR Unadjusted Effluent Concentration Data**

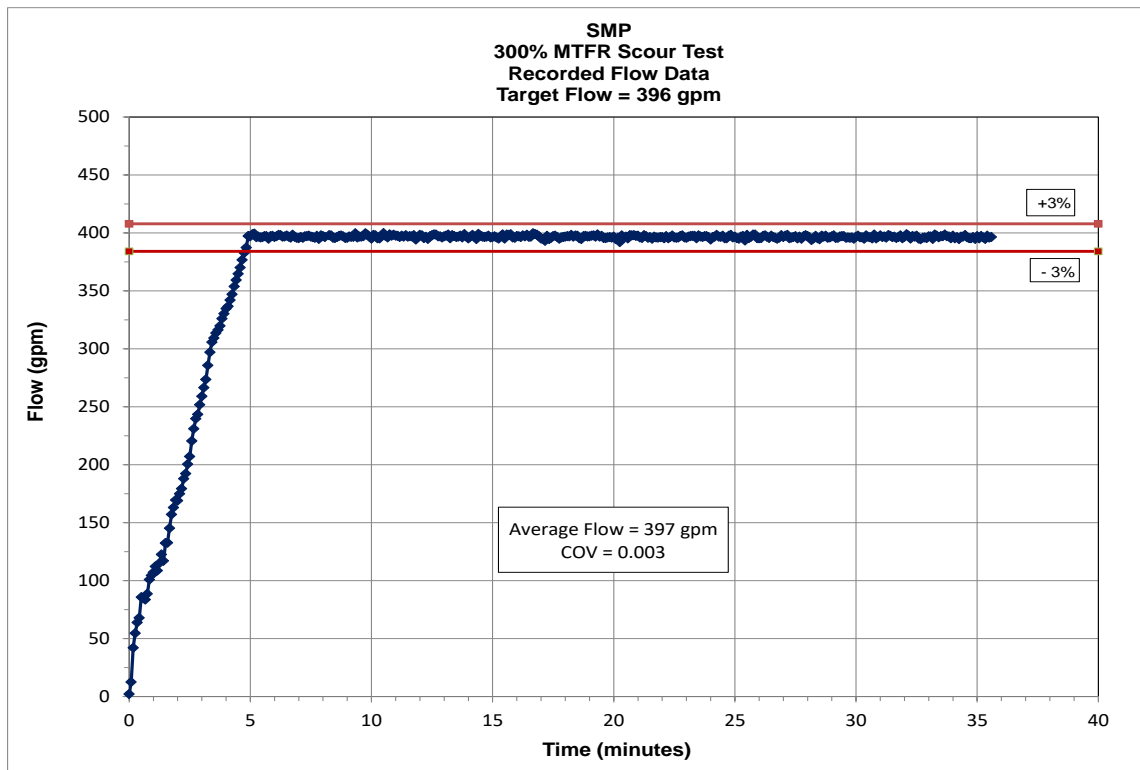
Sample ID	Timestamp (minutes)	Effluent Concentration (mg/L)
EFF 1	7	2.1
EFF 2	9	0.9
EFF 3	11	0.6
EFF 4	13	1.2
EFF 5	15	0.3
EFF 6	17	0.6
EFF 7	19	0.4
EFF 8	21	0.8
EFF 9	23	0.7
EFF 10	25	0.5
EFF 11	27	0.4
EFF 12	29	0.6
EFF 13	31	0.8
EFF 14	33	0.7
EFF 15	35	0.7
	Average	0.8

### *300% MTFR*

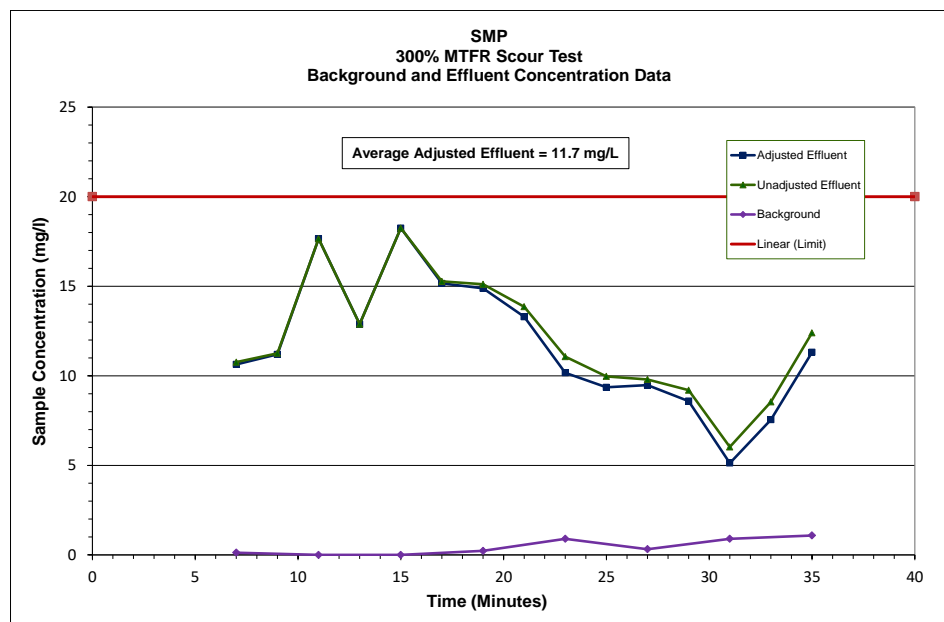
The test was conducted at a target flow of 396 gpm, which is equal to 300% MTFR. The flow data was recorded every 5 seconds throughout the test and is shown on **Figure 24**. The target flow was reached within 5 minutes of initiating the test. The average recorded steady-state flow was 397 gpm, with a COV of 0.003. The recorded water temperature was 66.3 degrees F.

Eight background samples were collected throughout the duration of the test. The measured concentrations ranged from 0.0 (ND) to 1.1 mg/L, with an average concentration of 0.5 mg/L.

A total of 15 effluent samples were collected throughout the test. The measured concentrations ranged from 6.0 to 18.2 mg/L, with an average concentration of 12.1 mg/L. The average unadjusted and adjusted effluent concentrations for the test were 12.1 and 11.7 mg/L, respectively. The effluent and background concentration data are shown in **Table 8** and on **Figure 25**.



**Figure 24 300% MTFR Scour Test Recorded Flow Data**



**Figure 25 300% MTFR Measured Background and Effluent Concentrations**



**Table 8 300% MTFR Background and Effluent Concentration Data**

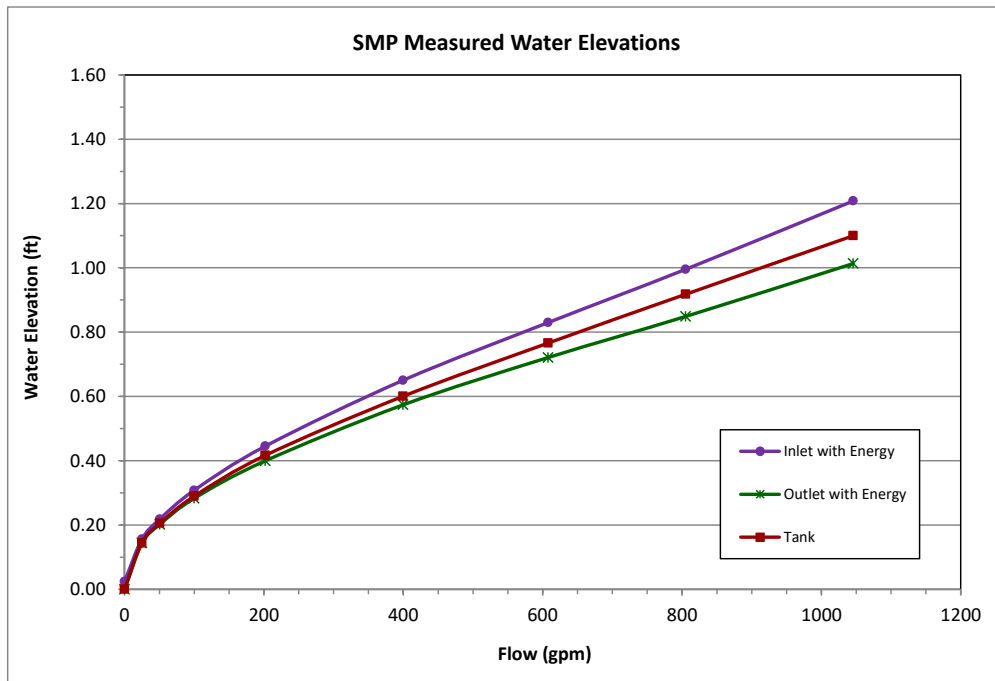
Sample ID	Timestamp (minutes)	Effluent Concentration (mg/L)	Background Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
EFF 1	7	10.8	ND	10.8
EFF 2	9	11.3	ND	11.3
EFF 3	11	17.6	ND	17.6
EFF 4	13	12.9	ND	12.9
EFF 5	15	18.2	ND	18.2
EFF 6	17	15.3	ND	15.3
EFF 7	19	15.1	ND	15.1
EFF 8	21	13.9	0.4	13.5
EFF 9	23	11.1	0.9	10.2
EFF 10	25	10.0	0.6	9.4
EFF 11	27	9.8	0.3	9.5
EFF 12	29	9.2	0.6	8.6
EFF 13	31	6.0	0.9	5.1
EFF 14	33	8.5	1.0	7.5
EFF 15	35	12.4	1.1	11.3
Average		12.1	0.4	11.7

#### 4.4 Hydraulics

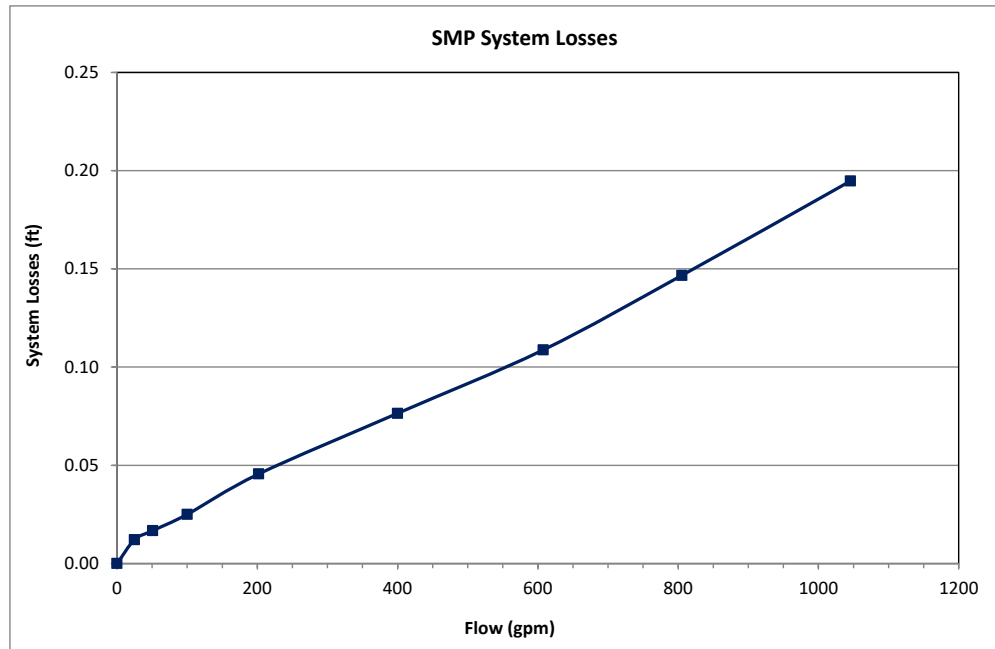
Piezometer taps were installed in the unit as described in **Section 2.2**. Flow (gpm) and water level (ft) within the system were measured for 9 flows ranging from 0 to 1045 gpm (3.3 cfs). The influent pipe was flowing full at approximately 800 gpm. The entrance to the effluent pipe was submerged at approximately 1045 gpm. The recorded data and calculated losses are shown in **Table 9**. The Elevation Curves for each pressure tap location are shown on **Figure 26** and the system losses on **Figure 27**.

**Table 9 Recorded Flow and Elevation Data**

Flow			Water Elevations (measured)			Water Elevations (adjusted to outlet invert)			Losses		
			Inlet Pipe	Tank	Outlet Pipe	Inlet Pipe	Tank	Outlet Pipe	Inlet El. (A')	Outlet El. (C')	System Energy Loss
gpm	cfs	Lpm	A	B	C	A	B	C	Corrected for Energy	Corrected for Energy	A'-C'
			ft	ft	ft	ft	ft	ft	ft	ft	ft
0.0	0.00	0.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25.0	0.06	94.5	0.517	0.525	0.512	0.135	0.144	0.131	0.147	0.143	0.003
50.7	0.11	192.0	0.575	0.587	0.562	0.194	0.205	0.181	0.211	0.202	0.009
100.0	0.22	378.5	0.659	0.671	0.633	0.278	0.290	0.251	0.301	0.282	0.019
202.0	0.45	764.4	0.787	0.798	0.729	0.406	0.417	0.348	0.439	0.399	0.040
399.8	0.89	1513.4	0.978	0.982	0.876	0.597	0.601	0.495	0.645	0.573	0.072
607.7	1.35	2300.0	1.142	1.147	0.996	0.761	0.766	0.615	0.825	0.720	0.105
805.3	1.79	3048.1	1.293	1.299	1.100	0.912	0.918	0.719	0.992	0.848	0.143
1045.7	2.33	3957.9	1.473	1.481	1.242	1.092	1.100	0.861	1.208	1.013	0.195



**Figure 26 Measured Flow vs Water Elevations**



**Figure 27 Calculated Losses**

## 5. Design Limitations

S&M Precast, Inc. has inhouse engineers to assist with submittals for every construction project. Working closely with site design engineers, the right product will be selected. Every installation is unique, and many factors play into account to ensure the unit's performance. The following list some possible design limitations of the OG.

### *Required Soil Characteristics*

Since all Ocean Guardian units are installed in a watertight concrete manhole, the unit can be installed in many different soil types.

### *Slope*

The Ocean Guardian product line includes multiple sizes to meet the maximum treatment flow rate (MTFR) required at the jobsite. Slope leading up to the unit can be virtually 0% due to the unique design of the internals. Contact S&M Precast, Inc. with any pipe slope questions.

### *Maximum Flow Rate*

The OG product line has many options so the desired treatment rate can be achieved at any site. The unit has also been tested for an online configuration, meaning a diversion structure is not required. Since this is an online unit, there is not an internal bypass therefore stormwater is still always treated even in the highest of flows. Hydrocarbons remain trapped in the unit at high flow rates. It is recommended to contact S&M Precast, Inc. directly with any flow MTFR questions.

### *Maintenance Requirements*

Maintenance for the OG depends on installation site. Certain sites may be more prone to sediment, hydrocarbon runoff, and trash. Regular inspection for the first year will give good insight to the maintenance interval for the following years. If a hydrocarbon spill has occurred, the OG must be cleaned. See the maintenance plan section for further details.

### *Driving Head*

The OG is designed with the inlet slightly higher than the outlet so that the unit is able to drain once the rain event has ended. The exceptional design of the internals allow for minimal head loss throughout the unit's range of flows.

### *Installation Limitations*

A lift plan should be in place and proper rigging is required to install the OG. The unit can be shipped assembled or in pieces and assembled onsite. Installation instructions will be provided with every unit.

### *Configurations*

The OG may be installed online or offline.

### *Load Limitations*

The OG meets an HS-20 load rating by basis of design. If additional load requirement must be met, reach out directly to S&M Precast, Inc. engineering staff.

#### *Pretreatment Requirements*

None required.

#### *Depth to Seasonal High-Water Table*

Since all units are installed in concrete manholes, high ground water is of little concern. The site engineer should reach out to S&M Precast, Inc. if buoyancy of the OG is of concern.

#### *Additional Limitations*

None.

### **6. Maintenance**

The OG captures floatables and sediment from stormwater runoff during rain events. The unit needs to be cleaned of the collected pollutants so the unit can efficiently remove sediment and floatables for many years to come. Frequency for cleaning depends on the installation site. There may be state or local guidelines in place for the MTD's maintenance. Certain sites may be more prone to hydrocarbon runoff, trash, or sediment; therefore additional sediment storage can be provided. S&M Precast Inc. recommends bimonthly inspection for the first year which will give good insight to the maintenance interval for the following years. The inspections can be reduced after an expected pollutant capture rate is determined. If a hydrocarbon spill has occurred, the OG must be cleaned. An Inspection and Maintenance Manual can be accessed at: [www.smprecast.com](http://www.smprecast.com). Scroll down the page for the Ocean Guardian link.

The OG can be offered with several types of lids, but the most common will be a manhole lid or aluminum hatch. This allows easy access to the internals without the use of special tools.

#### *Inspection*

This is simple to accomplish with the easy access lid. After the hatch has been opened or the manhole lid has been removed, there is a clear line of sight to the bottom of the unit. A few tools may be needed for a proper inspection: tape measure, pen, paper, manhole hook, measuring stick, sludge sampler, net for trash, flashlight, etc. All inspections do not require someone to enter the unit, but it is important to visually inspect the baffles. It is recommended to pump-out the OG once it has reached a 50% sediment depth of the maximum capacity. Hydrocarbons and floatables should be removed when they reach 9-3/8" (larger units will be greater) regardless of sediment depth.

#### *Maintenance Cleanout*

Maintenance should take place after an inspection has occurred requiring the unit to be cleaned. Do not clean the unit while stormwater is flowing through the OG. Trash can be skimmed off of the top with a net or other apparatus. A vacuum truck may then dewater the unit until all pollutants have been emptied. A wash down may be required to fully clean and breakaway all debris. Due to the two-baffle system of the OG, cleaning is easy with the open design. The unit does not need to be refilled with water after maintenance has been completed.

Sorbent pads maybe placed in some units depending on site requirements. They should be fished

out from the surface not requiring entry into the unit. If entry is required, the OSHA confined space guidelines are required. Reach out to S&M Precast Inc. safety personnel before entry

All material that has been removed must be disposed of in accordance with local regulations.

## **7. Statements**

The following signed statements from the manufacturer (S&M Precast, Inc.), independent testing laboratory (Alden Research Laboratory) 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.

Plant:  
16700 Sima Gray Road  
Henryville, IN 47126



Visit our website @ [www.smprecast.com](http://www.smprecast.com)  
Ph (812) 246-6258 • Fax (812) 294-4862

Mailing:  
7515 Old Highway 111  
Memphis, IN 47143

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April 08, 2020

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: Verification of Ocean Guardian

Dear Dr. Magee,

S&M Precast Inc. has tested the Ocean Guardian (OG) hydrodynamic separator at Alden Research Laboratory, Inc. The testing was 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" dated January 25, 2013. This letter is being sent to you required by the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology" dated January 25, 2013. The testing conducted at Alden met or exceeded this protocol. Mr. James Mailloux oversaw and conducted all water quality tests of our 4ft unit. Sediment samples were sent by Alden to a third party lab for particle size analysis. The testing verification report enclosed is supported by the protocol and procedure documents for approval.

Feel free to reach out with any questions you may have.

Sincerely,

A handwritten signature in black ink, appearing to read "Becky Graf", written over a horizontal line.

Becky Graf  
President

A handwritten signature in black ink, appearing to read "Ray Graf", written over a horizontal line.

Ray Graf  
Vice President



April 20, 2020

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

Conflict of Interest Statement

Alden Research Laboratory (ALDEN) is a non-biased independent testing entity which receives compensation for testing services rendered. ALDEN does not have any vested interest in the products it tests or their affiliated companies. There is no financial, personal or professional conflict of interest between ALDEN and S & M Precast, Inc.

Protocol Compliance Statement

Alden performed design research testing, as well as verification testing on the S & M Precast Ocean Guardian 48 (OG 48) stormwater treatment unit. All data collected on the selected final design was submitted. The Technical Report and all required supporting documentation has been submitted as required by the protocol.

Testing performed by ALDEN on the S & M Precast Ocean Guardian OG 48 unit met or exceeded the requirements as stated in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", (January 25, 2013).

James T. Mailloux

A handwritten signature in blue ink that reads 'James T. Mailloux'.

Senior Engineer  
Alden Research Laboratory  
[jmailloux@aldenlab.com](mailto:jmailloux@aldenlab.com)  
(508) 829-6000 x6446



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

April 23, 2020

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 S&M Precast Ocean Guardian™ (Model OG-48) hydrodynamic separator at the Alden Research Laboratory, Inc. (Alden), Holden, Massachusetts, under the direct supervision of Alden's senior stormwater engineer, James Mailloux, the test protocol requirements contained in the "*New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 25, 2013)*" (NJDEP HDS Protocol) were met or exceeded. 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 ( $<75\mu$ ); the test sediment  $d_{50}$  was 66 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 the Ocean Guardian (OG-48), a 4-ft. diameter commercially available unit, to establish the ability of



the Ocean Guardian to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the target MTFR. The OG-48 demonstrated 52.6% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The flow rates, feed rates and influent concentration all met the NJDEP HDS test protocol's coefficient of variance requirements and the background concentration for all five test runs never exceeded 20 mg/L (maximum of 6.0 mg/L).

### *Scour Testing*

To demonstrate the ability of the Ocean Guardian to be used as an online treatment device, scour testing was conducted at 200% and 300% of the MTFR. The scour tests were conducted with the unit preloaded with 4" of sediment to the 50% capacity level (11").

At the 200% MTFR test the average background sediment concentration was 0.3 mg/L and the unadjusted effluent sediment concentration was 0.8 mg/L. At the 300% MTFR test the average background sediment concentration was 0.4 mg/L. The average unadjusted and adjusted effluent concentrations for the test were 12.1 and 11.7 mg/L, respectively. These results confirm that the OG-48 meets the criteria for online use.

### *Maintenance Frequency*

The predicted maintenance frequency for all Ocean Guardian models is 23.8 years.

Sincerely,



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

## 8. References

ASME (1971), *“Fluid Meters Their Theory and Application- Sixth Edition”*.

ASTM (2007), *“Standard Test Method for Particle Size Analysis of Soils”*, Annual Book of ASTM Standards, D422-63, Vol. 04.08.

ASTM (2016), *“Standard Test Methods for Determination of Water (Moisture) Content of Soil by Direct Heating”*, Annual Book of ASTM Standards, D4959-07, Vol. 04.08.

ASTM (2013), *“Standard Test Methods for Determining Sediment Concentration in Water Samples”*, Annual Book of ASTM Standards, D3977-97, Vol. 11.02.

NJDEP 2013a. *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device*. Trenton, NJ. January 25, 2013.

NJDEP 2013b. *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.

## **VERIFICATION APPENDIX**

### ***Introduction***

- Manufacturer – S&M Precast, Inc., 16700 Sima Gray Road, Henryville, IN 47126.  
[www.smprecast.net](http://www.smprecast.net) (812) 246-6258
- S&M Precast Ocean Guardian verified models are shown in **Table A-1** and **Table A-2**.
- TSS Removal Rate – 50%
- Online installation

### ***Detailed Specification***

- NJDEP sizing table and physical dimensions of the S&M Precast Ocean Guardian 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 OG-48 model has a maximum treatment flow rate (MTFR) of 0.29 cfs (132 gpm), which corresponds to a surface loading rate of 10.5 gpm/ft<sup>2</sup> of sedimentation area.
- Maximum recommended sediment depth prior to cleanout is 11 inches for all model sizes based on the depths provided in **Table A-2**. S&M Precast can increase the overall depth of any model to increase the sediment storage depth for any site-specific storage/maintenance criteria.
- Inspection and Maintenance Manual is at: [www.smprecast.com](http://www.smprecast.com). Scroll down the page for the Ocean Guardian link.
- The maintenance frequency for all the Ocean Guardian models is 23.8 years.
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the Ocean Guardian to be used in series with another hydrodynamic separator to achieve an enhanced TSS removal rate.

**Table A-1 MTFRs and Sediment Removal Intervals for Ocean Guardian Models**

<b>Model</b>	<b>Diameter (ft)</b>	<b>Maximum Treatment Flow Rate<sup>1</sup> (cfs)</b>	<b>Treatment Area (ft<sup>2</sup>)</b>	<b>Hydraulic Loading Rate (gpm/ft<sup>2</sup>)</b>	<b>50% Maximum Sediment Storage<sup>3</sup> (ft<sup>3</sup>)</b>	<b>Sediment Removal Interval<sup>2</sup> (years)</b>
OG-48	4	0.29	12.6	10.5	11.5	23.3
OG-60	5	0.46	19.6	10.5	18.0	23.3
OG-72	6	0.66	28.3	10.5	25.9	23.3
OG-84	7	0.90	38.5	10.5	35.3	23.3
OG-96	8	1.18	50.3	10.5	46.1	23.3
OG-120	10	1.84	78.5	10.5	72.0	23.3
OG-144	12	2.65	113.1	10.5	103.7	23.3
<ol style="list-style-type: none"> <li>1. Based on a verified loading rate of 10.5 gpm/ft<sup>2</sup> for test sediment with a mean particle size of 66 µm and an annualized weighted TSS removal of at least 50% using the methodology in the current NJDEP HDS protocol.</li> <li>2. Sediment Removal Interval (years) = (50% HDS MTD Max Sediment Storage Volume) / (3.366 * MTFR * TSS Removal Efficiency) calculated using equation in Appendix B, Part B of the NJDEP HDS Protocol.</li> <li>3. 50% Sediment Storage Capacity is equal to manhole area x 11 inches of sediment depth. Each Ocean Guardian separator has a 22-inch-deep sediment sump.</li> </ol>						

**Table A-2 Standard Dimensions for Ocean Guardian Models**

<b>Model</b>	<b>Diameter (in)</b>	<b>Maximum Treatment Flow Rate (cfs)</b>	<b>Total Chamber Depth<sup>1</sup> (in)</b>	<b>Treatment Chamber Depth<sup>2</sup> (in)</b>	<b>Aspect Ratio<sup>3</sup> (Depth/Diameter)</b>	<b>Sediment Sump Depth (in)</b>
OG-48	48	0.29	48.9	37.9	0.79	22
OG-60	60	0.46	48.9	37.9	0.63	22
OG-72	72	0.66	48.9	37.9	0.53	22
OG-84	84	0.90	67.3	56.3	0.67	22
OG-96	96	1.18	75.3	64.3	0.67	22
OG-120	120	1.84	91.4	80.4	0.67	22
OG-144	144	2.65	107.5	96.5	0.67	22
<ol style="list-style-type: none"> <li>1. Minimum inlet invert to sump bottom.</li> <li>2. Treatment chamber depth is defined as the total chamber depth minus ½ the sediment storage depth (11 in). The aspect ratio is the unit's treatment chamber depth/diameter. The aspect ratio for the tested unit (OG-4) is 0.79. Larger models (&gt;250% MTFR of the unit tested, &gt;0.73 cfs) must be geometrically proportionate to the test unit. A variance of 15% is allowable (0.67 to 0.91).</li> <li>3. For units &lt;250% MTFR (OG-60 and OG-75 models), the depth must be equal or greater than the depth of the unit treated.</li> </ol>						