NJCAT TECHNOLOGY VERIFICATION

Ultra-Urban® Filter

(DI 304-150M Filter Models)

AbTech Industries

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1. Introduction

The AbTech Ultra-Urban® Filter (UUF) is a manufactured treatment device (MTD) designed and produced by AbTech Industries. Its intended use is to capture pollutants like trash, sediments, hydrocarbons and sediment-bound pollutants and prevent them from entering the storm drain infrastructure. To assess Total Suspended Solids (TSS) removal efficiency of the UUF, a full-scale commercially available model (DI 1616N-304-150M) was tested at AbTech's laboratory located in Phoenix, Arizona.

The test procedures used to develop a Quality Assurance Project Plan (QAPP) were based on those approved by the New Jersey Department of Environmental Protection (NJDEP), that established a process for verifying and certifying MTDs. As part of this process, there is currently a laboratory test procedure for assessing Total Suspended Solids (TSS) capture in filtration devices. The NJDEP utilizes the New Jersey Corporation for Advanced Technology (NJCAT) to provide a comprehensive evaluation of the technology specific performance claims relative to the test protocol.

Except for the particle size distribution (PSD) of the test sand, all the requirements of the NJDEP testing protocol: *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device,"* dated January 25, 2013 (NJDEP 2013b), were met. The QAPP or test plan was submitted and approved by NJCAT prior to testing. The particle size distribution used for this performance assessment was coarser than what is specified in the NJDEP test protocol, but it is considered suitable depending on the water quality objectives. **For this reason, the performance test results have been verified by NJCAT but do not meet the NJDEP certification requirements.**

This performance assessment and verification includes quantifying the TSS removal efficiency, the total mass of sediment captured and resulting changes in head loss through the MTD, while operating at a constant flow rate. Additionally, higher flow rate tests were conducted to quantify the effluent concentrations that were used as a measure of the filter's ability to retain previously captured sediment, also referred to as scour or washout.

All tests were witnessed by an independent observer, Mike Kimberlain, P.E. of Kimberwerks, Rancho Santa Fe, CA. Mr. Kimberlain submitted his qualifications to NJCAT and was subsequently approved as an independent third-party observer. All analytics were performed by a certified laboratory, IAS Laboratories (IAS), located in Phoenix AZ.

2. Description of Technology

The UUF is an engineered screening and filtration technology designed specifically for stormwater source control. Intended for use at the inlets of drainage networks, components are designed to intercept pollutants from surface runoff flows where they are the most concentrated. There are two inlet types the filters can be fitted into, but the filter components are identical. The UUF Drop-Inlet or DI as shown in **Figure 1** was the tested MTD. The UUF DI does not require modification of existing structures and can be customized for any geometry. Standard models are designed with stainless steel collars or mounting brackets with corrugated recycled plastic or stainless-steel bodies.

Each UUF can be specifically designed to target several pollutants of concern and meet a variety of water quality objectives. To achieve this flexibility, the UUF is supplied with a stainless-steel screen and optional Smart Sponge filtration media. However, this performance evaluation is focused on

screening and removal of settleable sediment; no Smart Sponge or variant of Smart Sponge was added to the tested UUF. Consequently, Smart Sponge was not evaluated as part of this assessment and performance verification. A specialized stainless-steel screen, designed to capture sediment larger than 50 microns, is an integral component of the tested UUF. This 16-inch square Drain-Inlet Ultra Urban Filter Model is identified as "UUF DI 1616N-304-150M", with the 'N" denoting a "Normal" height of 18-inches.

Custom sizes can be fabricated to fit most inlet designs and alternative materials for construction are available to satisfy site-specific requirements.

Figure 1 UUF Model DI 1616N-304-150M

3.   Laboratory Testing

To test the commercially available UUF DI 1616N-304-150M, the filter was installed into a 24-inch catch basin. The filter system was evaluated using a pumped flow scheme with known test sediment added at a constant rate to minimize inlet concentration variability. Test runs were at a constant flow rate and each was a single batch run. Inlet flows were conveyed directly into the tested UUF from above, simulating the way flow is intended to enter a standard grated inlet catch basin. Treated flows were sampled to measure an effluent average sediment concentration and were not recirculated. Background samples were taken prior to adding test sediment to characterize the source water and account for any influence on efficiency calculations. Water elevations and temperatures were also monitored and recorded throughout the test period. Following performance testing, the flow rate was increased to measure effluent scour concentrations to confirm suitability for on-line installation.

3.1   Test Setup

Testing was conducted in the laboratory test facility at AbTech Industries, located in Phoenix, AZ. The laboratory test setup is depicted in **Figure 2** and consisted of a clean water holding tank, constant head supply tank, pump with VFD, supply pump, flow meter, dry feed auger, streetscape with 24-inch square surface inlet collar, 16-inch square UUF DI filter and discharge pipe.
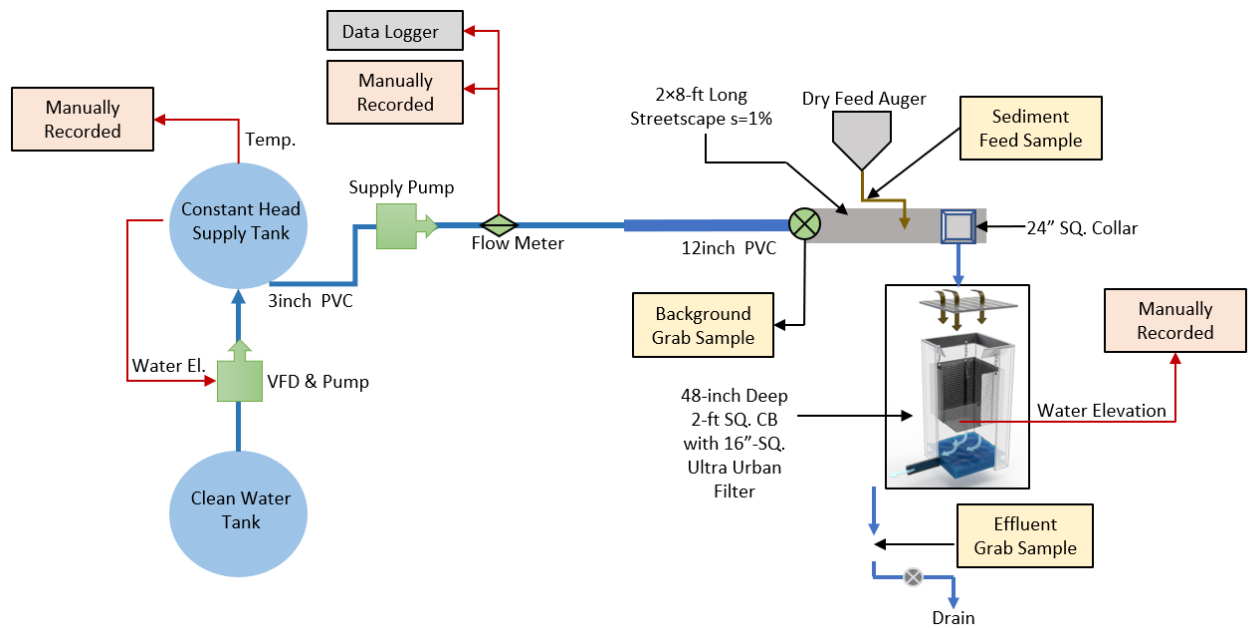
Figure 2 Schematic of Laboratory Test Setup

Testing involved storing water from the City of Phoenix potable water supply in a 2,000 gal. polyethylene tank that was used to maintain a constant water elevation in a 1,000 gal. supply tank. A 3-inch 7.5HP pump with 10HP variable speed drive was used to convey flows from the clean water tank to the constant head supply tank. Water temperatures in the constant head supply tank were measured and recorded manually every minute. A submersible water elevation transmitter was used to control the pump used to fill the constant head supply tank. A second 3-inch pump was used to convey flow from the constant head supply tank through a 3-inch schedule 40 PVC inlet pipe that transitions from pressure flow to gravity flow in a 12-inch PVC pipe. Flow was measured with a Rosemont magnetic flow meter (mag meter) located after the supply pump and before the transition from the 3-inch to 12-inch piping. Flow measurements were recorded both manually and by the data logger.

The 12-inch inlet pipe was connected to an 8-ft long by 2-ft wide "streetscape" with 1% slope draining towards the inlet collar. A Barracuda volumetric auger feeder was used to deposit test sediment onto the streetscape approximately 24-inches upstream of the UUF. Gravity flow through the filter was directly discharged through a solid 8-inch schedule 40 PVC pipe having the invert set at the bottom of the basin floor. Key dimensions of the tested UUF and catch basin are shown in **Figure 3**.

Figure 3 Key Dimensions of Test Apparatus (Elevation View)

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3.2   Test Sediment

The test sediment used for this study was #10 silica sand from AGSCO Corporation. Prior to testing, twenty 5-gallon pails were filled with 40 to 50 pounds of test sediment and delivered to IAS Laboratories. A sample was removed from each pail a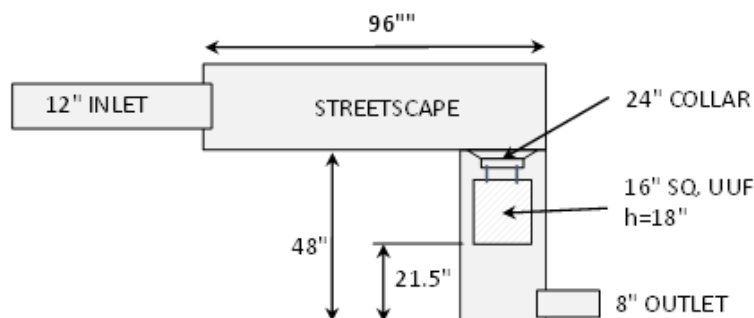nd analyzed for PSD and moisture content by IAS personnel, who then weighed and sealed each pail and returned them to the independent observer. All pails were stored at the testing facility and used as needed for each test run. No seals were opened prior to a test run and without the independent observer present. At the end of each test run, any material remaining in the auger was removed and placed in the same pail and returned to IAS for final weighing. The difference in mass, accounting for moisture content, between each pre and post test run was used to quantify the total dry mass of test sediment used in each test run.

The results of the particle size analysis were averaged and plotted in **Figure 4**. In general, the test sediment was larger than 53 microns and less than 300 microns and the average d_{50} was 117µm. The average moisture content (ASTM Method D4959) of the twenty sediment samples was 0.05%.
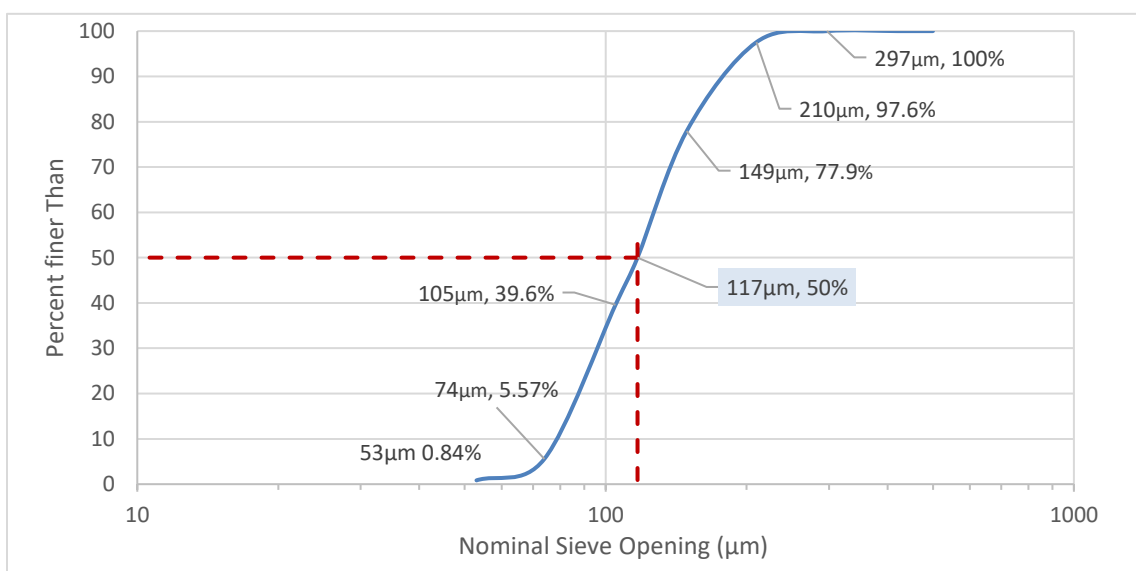
Figure 4 Test Sediment Particle Size Distribution

3.3   Removal Efficiency Testing

Removal Efficiency Testing was conducted based on Section 5 of the NJDEP Laboratory Protocol for Filtration MTDs. Testing was conducted at a flow rate of 0.29 cfs (130 gpm) and with a target influent sediment concentration of 200 mg/L.

Five effluent grab samples, three sediment feed rate samples and three background samples were taken each test run, with each test run lasting 33 minutes in duration, followed by a drain down period. Background samples were taken with every odd-numbered effluent sample (1st, 3rd and 5th). When the test sediment feed was interrupted for measurement, the next effluent sample was collected following a 4-minute delay, which was approximately the same as the longest drain down period. At the tested flow rate and based on the filter's maximum storage volume before bypass, the hydraulic detention time was less than 30 seconds. The sampling schedule followed

during the efficiency testing is summarized in **Table 1**. Effluent and background samples were collected in clean 1L containers supplied by IAS.

Three sediment feed samples were collected during each run to confirm the sediment feed rate, one sample at the start of dosing, one sample in the middle of the test run and one sample just prior to the conclusion of dosing. Each sediment feed rate sample was a minimum of 100 mL and collected in a clean 500 mL sample container, also supplied by IAS. Sediment sampling was timed to the nearest $1/10^{th}$ of a second using a calibrated stopwatch and samples were weighed to the nearest milligram.

Table 1 Removal Efficiency Sampling Frequency

Time	Volume	Auger Feed Mass*	Sed. Feed Rate	Effluent Sample	Background Sample	Drain down (DD) Sample
(minutes)	(gal.)	(lbs)				
0	0	0.00				Not sampled during this part of the test run
1	130	0.22	1			
3	390	0.65				
5	650	1.08		1	1	
7	910	1.52				
9	1,170	1.95				
11	1,430	2.39		2		
13	1,690	2.82				
15	1,950	3.25	2			
17	2,210	3.69				
19	2,470	4.12		3	2	
21	2,730	4.56				
23	2,990	4.99				
25	3,250	5.42		4		
27	3,510	5.86	3			
29	3,770	6.29				
31	4,030	6.73		5	3	
33	4,290	7.16				
End of Test Run. Drain down period begins. Two drain down samples taken at evenly spaced volumes.						

*Excluding mass removed during test sediment sampling

Two drain down samples were collected at the end of each removal efficiency run based on evenly spaced volumes; one at about 15 gallons and one at 30 gallons, to estimate the amount of sediment lost during the drain down period. As the filter had no sump, the drain down period lasted less than 1 minute during the first test runs when there was little sediment in the filter. However, this did increase as sediment accumulated in the UUF over time to about 4 minutes.

3.4   Sediment Mass Loading Testing

The Sediment Mass Loading Capacity testing of the filter is a continuation of the Removal Efficiency testing, after the water elevation exceeded the bypass (height of the filter), which is 18-inches for this UUF model. Except for the flow rate and influent concentrations, all aspects of the test procedures remained unchanged. The influent sediment concentration was increased but was limited due to the maximum discharge rate of the auger. On test run #10, the water elevation recorded was 16-inches, only 2-inches less than bypass. Removal efficiency testing was concluded, and the flow rate reduced to 90% of the treatment flow rate, or 117 gpm, for the remaining sediment mass load test runs. At the lower flow rate, the target maximum influent concentration for the remaining sediment mass load tests was 225 mg/L.   An additional four test runs were completed prior to water elevations reaching 18 inches.

3.5   Scour testing

Testing at 200% (260 gpm) of the treatment flow rate was completed as described in the test protocol. On-line stormwater treatment systems, like the UUF, function with an internal bypass to route all conveyed flows without the use of an external bypass or other upstream diversion. The test is designed to demonstrate that the MTD will not resuspend and discharge previously captured sediment above 20 mg/L, which is the effluent concentration discharge limit for on-line applications.

Without removing any captured sediment from the previous performance test runs, three sequential scour tests were conducted. The first scour test was at 130 gpm or 100% of the TTFR (Tested Treatment Flow Rate) and the remaining two at 260 gpm. The second scour test, or first attempt to run a minimum 30-minute test at 260 gpm was unsuccessful. The capacity of the first 3-inch pump with VFD was exceeded and stopped pumping after 5 minutes. Only four effluent samples and three background samples were taken. An additional storage tank and pump was added to the filter's discharge to return flow directly to the Constant Head Supply Tank. The third scour test was successful with both the Clean Water Tank and pump combined with the additional discharge tank and pump.

Both successful scour test runs included a 5-minute ramp-up period to reach the tested scour flow rates. The flow rates remained constant while 15 effluent samples were collected every two minutes. Eight evenly spaced background samples were taken throughout the duration of the first scour test. No background samples were taken during the second 260 gpm scour test since previous testing had demonstrated that background sediment concentration was < 1 mg/L.   Accordingly, effluent concentrations were not adjusted, which is considered conservative.

4.   Performance Claims

Following the, *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device," dated January 25, 2013",* and using test sediment #10 silica sand from AGSCO Corporation, the following performance claims have been demonstrated:

Verified Total Suspended Solids (TSS) Removal Rate

Based on the laboratory testing conducted, the UUF DI 1616N-304-150M, having dimensions 16

inches square and 18 inches in height, can achieve an overall removal efficiency of 99.5% of TSS with a PSD between 53 microns and 300 microns, with average $d_{50}=117\mu m$.

Maximum Treatment Flow Rate (MTFR)

As tested, the UUF DI 1616N-304-150M, with Effective Filtration Treatment Area (EFTA) of 9.78 ft^2, has a MTFR of 130 gpm (loading rate of 13.3 gpm/ft^2).

Maximum Sediment Storage Depth

The UUF DI 1616N-304-150M, has a maximum sediment storage depth of 5-inches based on maintaining the MTFR while accumulating sediment without exceeding a bypass elevation of 18 inches.

Detention Time and Wet Volume

The UUF DI 1616N-304-150M, does not have a sump or wet volume and does not create a tailwater condition that can cause longer hydraulic detention times. The maximum volume of the tested UUF is 20 gallons, but as observed in testing, the drain down volume can be 50-60 gallons depending on the volume of residual water remaining in the system when the pump is turned off. The drain down time increases as sediment accumulates but is expected to be less than 5 minutes with 6 inches of sediment stored in the filter. Neither the drain down time nor volume influenced the test results and as such, does not need to be considered for this type of filter and its intended use.

Sediment Mass Loading Capacity

The sedimentation mass loading capacity is the mass of captured sediment during all removal efficiency and mass load test runs. The sediment mass loading capacity of the UUF DI 1616N-304-150M, was determined to be 90.5 lbs.

On-line/Off-line Applications

The UUF DI 1616N-304-150M will not resuspend and release previously captured sediment that will cause the effluent concentration to exceed 20 mg/L for flow rates less than 200% of the MTFR or 260 gpm.

Maximum Allowable Inflow Drainage Area

The maximum allowable inflow drainage area will vary depending on many factors like: rainfall characteristics (intensity, duration, frequency, inter-event dry period, etc.), the project site, topography, pollutant characteristics and loads, etc. The UUF is intended for source control of surface runoff and is used upstream of retention/detention systems or other practices that limit their discharge flows and can have large drainage catchment areas. Similar to many flow-through treatment practices, the maximum inflow drainage area will be determined by the peak water quality flow rate (Q_{wq}) method (Example: Rational Method), that is directly proportional to the drainage area, and the MTFR; where, the $Q_{wq} \leq MTFR$. Generally, the hydraulic limitations of standard catch basin design and drainage area will apply and more filters per acre will result in lower annual loading rates and fewer filter service events.

5. Supporting Documentation

The NJDEP Procedure (NJDEP 2013a) 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.

5.1 Removal Efficiency and Mass Loading Capacity Results

A total of 10 removal efficiency test runs were completed and except for test run #1 (Refer to "Average Influent Concentrations"), all were in accordance with the NJDEP filter protocol. Following the first 10 removal efficiency tests, the MTFR was reduced by 10%, followed by another four test runs to determine the mass load capacity. The target MTFR and influent sediment concentration were 130 gpm and 200 mg/L, respectively. The results from all 10 test runs were used to calculate the overall removal efficiency of the UUF. The removal efficiency was 99.5% for all 14 test runs.

Flow Rate

Flow rates were manually measured and recorded by reading the mag meter for all test runs except test run 1, scour test run 1 and scour test run 3. Manual readings were needed for runs 2-14 because the data logger was being interrupted while attempting to calibrate water elevation sensors and were recorded once every minute to the nearest $1/10^{th}$ of a gpm. For the three test runs successfully recorded by the data logger, flow rates were recorded twice every minute. The flow rate variability for all test runs was less than 1.4% and had a COV (coefficient of variation) of <0.006 (**Table 2a and Table 2b**).

The flow data has been summarized in **Table 2a and 2b**, including compliance to the QA/QC acceptance criteria. The average flow rate for all 10 removal efficiency runs was 130.6 gpm, and 117.5 gpm for the remaining four mass load tests.

Table 2a Removal Efficiency Test Runs – Flow Rates, Temperature, Water Elevation

Test Run	Target Flow Rate (gpm)	Avg. Flow Rate (gpm)	Std. Dev.	% Var.	% Var. ≤ 10% (Y/N)	COV	COV <.03 (Y/N)	Max. Temp (°F)	Max. Temp ≤80°F (Y/N)	Max. Water Elevation (inches)	Less than bypass weir? (Y/N)
1	130	131.8	0.7636	1.38%	Y	0.006	Y	60.0	Y	5.0	Y
2	130	130.4	0.4673	0.31%	Y	0.004	Y	60.5	Y	7.0	Y
3	130	130.2	0.5036	0.15%	Y	0.004	Y	60.1	Y	10.0	Y
4	130	130.5	0.4946	0.38%	Y	0.004	Y	58.5	Y	11.0	Y
5	130	130.3	0.4717	0.23%	Y	0.004	Y	59.3	Y	12.0	Y
6	130	130.8	0.7739	0.62%	Y	0.006	Y	58.6	Y	12.3	Y
7	130	130.4	0.4375	0.31%	Y	0.003	Y	60.3	Y	13.0	Y
8	130	130.4	0.4638	0.31%	Y	0.004	Y	59.2	Y	14.3	Y
9	130	130.6	0.3621	0.46%	Y	0.003	Y	58.5	Y	15.3	Y
10	130	130.4	0.4338	0.31%	Y	0.003	Y	59.2	Y	16.0	Y

Avg. Flow Rate = 130.6

Table 2b Mass Load Test Runs – Flow Rates, Temperature, Water Elevation

Test Run	Target Flow Rate (gpm)	Avg. Flow Rate (gpm)	Std. Dev.	% Var.	% Var. ≤ 10% (Y/N)	COV	COV <.03 (Y/N)	Max. Temp (°F)	Max. Temp ≤80°F (Y/N)	Max. Water Elevation (inches)	Less than bypass weir? (Y/N)
11	117	117.5	0.3812	0.44%	Y	0.003	Y	59.6	Y	15.3	Y
12	117	117.5	0.4138	0.41%	Y	0.004	Y	59.8	Y	16.5	Y
13	117	117.4	0.5599	0.37%	Y	0.005	Y	60.8	Y	17.0	Y
14	117	117.5	0.3889	0.43%	Y	0.003	Y	59.9	Y	17.8	Y

Avg. Flow Rate = 117.5

Sediment Addition

The target sediment concentration was 200 ± 20 mg/L with a COV less than 0.10. Each test run included three 1-minute samples to verify the sediment feed rates complied. All sediment feed sample weights were measured by IAS Laboratories using certified scales to the nearest milligram. **Tables 3a and 3b** summarize feed sample times, weights and rates. All sediment feed rate criteria were met. Visual observations by the third-party independent observer after each run confirmed that none of the sediment remained on the streetscape.

The data obtained from the sediment feed rate sampling is strictly used for quality assurance related to the injection feed rate throughout the test runs. Inlet concentrations for each test run are based on the initial sediment in the auger minus the sediment remaining in the auger, less what is removed for feed rate sampling, or the total feed sample mass.

Table 3a Sediment Feed Data

Run	Feed Sample Duration (seconds)			Total Feed Sample Time	Calibration Feed Sample Mass			Total Feed Sample Mass
Time (min)	1	15	27	(mins)	(grams)	(grams)	(grams)	(grams)
1	60.0	60.0	60.0	3.00	101.011	100.244	102.714	304
2	60.0	60.0	60.0	3.00	98.765	101.777	101.478	302
3	60.0	60.0	60.0	3.00	101.531	102.019	102.984	307
4	60.0	60.0	60.0	3.00	99.347	101.316	102.184	303
5	60.0	60.0	60.0	3.00	99.329	100.001	100.357	300
6	60.0	60.0	60.0	3.00	99.935	104.184	101.469	306
7	60.0	60.0	60.0	3.00	99.644	99.729	100.762	300
8	60.0	60.0	60.0	3.00	98.084	102.590	99.074	300
9	60.0	60.0	60.0	3.00	98.542	100.027	98.837	297
10	60.0	60.0	60.0	3.00	96.963	100.627	100.213	298
11*	60.0	60.0	60.0	3.00	98.337	98.938	101.528	299
12*	60.0	60.0	60.0	3.00	97.502	99.690	100.536	298
13*	60.0	60.0	60.0	3.00	96.556	98.611	100.167	295
14*	60.0	60.0	60.0	3.00	98.212	99.475	100.641	298

Table 3b Sediment Feed Rate Data

Run	Feed Rates (g/min)			Avg.	SD	COV	Compliant (<0.1) (Y/N)
	1	15	27	(g/min)	(g/min)		
1	101	100	103	101	1.26	0.01	Y
2	99	102	101	101	1.66	0.02	Y
3	102	102	103	102	0.74	0.01	Y
4	99	101	102	101	1.45	0.01	Y
5	99	100	100	100	0.52	0.01	Y
6	100	104	101	102	2.15	0.02	Y
7	100	100	101	100	0.62	0.01	Y
8	98	103	99	100	2.37	0.02	Y
9	99	100	99	99	0.79	0.01	Y
10	97	101	100	99	2.01	0.02	Y
11	98	99	102	100	1.70	0.02	Y
12	98	100	101	99	1.57	0.02	Y
13	97	99	100	98	1.81	0.02	Y
14	98	99	101	99	1.21	0.01	Y

Effluent and Background Sampling

To assess the removal efficiency for each test run, five effluent and three background samples were taken. Sampling times and concentrations for both the effluent and background samples are provided in **Table 4**. The discrete effluent and background concentrations are averaged, although all concentrations were less than the reporting limit, or 1 mg/L. For removal efficiency calculations, the background concentrations were assigned 0 mg/L and the effluent concentrations assigned 1 mg/L. The average adjusted effluent concentration accounts for any background concentration.

Table 4 Effluent and Background Concentration Data

Run	Sample	Time (minutes)					Avg. Background TSS	Background ≤ 20 mg/L	Avg. Effluent TSS	Avg. Adjusted Effluent TSS
		5	11	19	25	31	(mg/L)	(Y/N)	(mg/L)	(mg/L)
1	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
2	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
3	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
4	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
5	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
6	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
7	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
8	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
9	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
10	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
11	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
12	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
13	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		
14	Effluent TSS	ND	ND	ND	ND	ND			<1	<1
	Background* TSS	ND		ND		ND	<1	Y		

*Five effluent samples taken at 5, 11, 19, 25 and 31 minutes
*Three background samples taken at 5, 19 and 31 minutes
*Runs 1-10 = Removal Efficiency Test Runs, Runs 11-14 = Mass Load Test Runs
*ND = non-detect. Minimum reporting limit (MRL) = 1 mg/L.

Filter Drain Down

The tested UUF has a post-operation drain down that varies depending on the volume of water and sediment in the filter when the drain down begins. The filter does not create a tailwater or impact storage of water in the upstream piping or streetscape. However, as mentioned earlier, the drain down volume includes any residual water remaining in the system at the time when the pump is turned off.

The drain down volume was measured by diverting flow to a storage barrel when the pump was turned off. Some variability in measuring the volumes was caused by the inaccuracy of diverting the flow to the storage barrel exactly when the pump was stopped and given most of the drain down volume occurred in the first 30 seconds. The drain down time was measured from when the pump was turned off until the volume in the storage barrel "stopped increasing". Often there was still a trickle as the sediment in the filter continued to drain out.

The two drain down samples were taken approximately when the volume was at one-third and two-thirds of the total volume discharged. Samples were sent to IAS Laboratories to determine the drain down concentrations. Accounting for any background concentrations, the mass of sediment lost during the drain down period was calculated.

All drain down measurements are provided in **Table 5**. As shown, all concentrations were ND and reported as <1 mg/L. As was done for the ND concentrations measured for the effluent samples, the drain down concentrations were also conservatively assumed to be 1 mg/L.

Table 5 Drain Down (DD) Results

Run	Total DD Time (minutes)	Total DD Volume (gallons)	DD TSS	Avg. DD TSS	Avg. Background TSS	Avg. Adj. DD TSS	Mass DD (grams)
					(mg/L)		
1	3.07	24	<1 <1	<1	<1	<1	<1
2	3.27	45	<1 <1	<1	<1	<1	<1
3	3.10	45	<1 <1	<1	<1	<1	<1
4	4.12	47	<1 <1	<1	<1	<1	<1
5	3.73	46	<1 <1	<1	<1	<1	<1
6	3.98	47	<1 <1	<1	<1	<1	<1
7	3.92	51	<1 <1	<1	<1	<1	<1
8	4.15	52	<1 <1	<1	<1	<1	<1

9	4.43	53	<1 <1	<1	<1	<1	<1
10	4.53	56	<1 <1	<1	<1	<1	<1
11	4.62	51	<1 <1	<1	<1	<1	<1
12	4.85	51	<1 <1	<1	<1	<1	<1
13	4.92	51	<1 <1	<1	<1	<1	<1
14	5.22	51	<1 <1	<1	<1	<1	<1

Influent and Effluent Flow Volumes

Table 6 includes the influent, drain down and effluent volumes for each test run. These are used for calculating the average influent concentrations as well as influent, drain down and effluent mass of sediment entering and leaving the filter. Because each test run was 33 minutes, including a 3-minute feed rate sampling period, the time when sediment is being injected into the influent flow stream is 30 minutes. The product of average flow rate for each test run and the sediment injection time is used to calculate the influent volume. The effluent volume is calculated from the difference between the influent volume and drain down volume, rounded to the nearest gallon.

Table 6 Drain Down (DD) Results

Run	Test Run Duration (min)	Total Feed Rate Sampling Duration (min)	Sediment Injection Time (min)	Average Flow Rate	Influent Volume	DD Volume	Effluent Volume
	33 mins	≤3 min	≥30 min	(gpm)	(gallons)	(gallons)	(gallons)
1	30.0	3.00	27.0	131.8	3,558	24	3,534
2	33.0	3.00	30.0	130.4	3,912	45	3,867
3	33.0	3.00	30.0	130.2	3,907	45	3,862
4	33.0	3.00	30.0	130.5	3,915	47	3,868
5	33.0	3.00	30.0	130.3	3,908	46	3,862
6	33.0	3.00	30.0	130.8	3,923	47	3,876
7	33.0	3.00	30.0	130.4	3,913	51	3,862
8	33.0	3.00	30.0	130.4	3,911	52	3,859
9	33.0	3.00	30.0	130.6	3,917	53	3,864
10	33.0	3.00	30.0	130.4	3,913	56	3,857
11*	33.0	3.00	30.0	117.5	3,526	51	3,475
12*	33.0	3.00	30.0	117.5	3,524	51	3,473
13*	33.0	3.00	30.0	117.4	3,523	51	3,472
14*	33.0	3.00	30.0	117.5	3,525	51	3,474

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Removal Efficiency Calculations

The removal efficiency for each test run is calculated using a mass balance approach that evaluates the mass injected into the UUF less the mass leaving the filter. The total mass of test sediment entering the filter is a weighed measurement that is the difference between the mass of test sediment placed in the auger and what is removed at the end of each test run less the mass removed for the three feed rate samples. **Table 7a and Table 7b** summarize the results of the mass removal rate calculations.

As described in Section 3.2, the initial mass of sediment used for each test run was pre-weighed in 5-gallon pails, to the nearest $1/10^{th}$ of a pound, by IAS using their certified scales. Sediment removed from the auger at the end of each test run was returned to IAS to determine the final mass remaining in the auger, which includes what was removed for sediment feed rate sampling. IAS also determined the PSD and moisture content of the sediment in each pail. The average moisture content from all the test sediment samples was 0.05%, but the moisture content from each pail was used to adjust the total mass injected by the auger. The Influent Mass (adjusted for moisture) is the difference between the total mass injected by the auger and the total feed rate sample mass, as reported in **Table 7a**.

The effluent mass for each test run is calculated from the product of the average (background) adjusted effluent concentration and effluent volume. The mass of sediment leaving the filter during the drain down period is the product of the average (background) adjusted drain down concentration and effluent volume, as reported in **Table 7b**. The total mass captured is determined from the difference between the influent mass (mass entering the filter) and the calculated sum of effluent and drain down mass (mass leaving the filter). For the initial 10 removal efficiency test runs, 64.7 lbs of test sediment was added to the filter and 64.4 lbs of test sediment was captured. Within the accuracy limit of the test, the removal efficiency of each of the test runs #1-14 and the cumulative removal efficiency of all test runs was 99.5%.

Removal efficiency of each test run was calculated as follows:

$$\text{Removal efficiency} = \frac{Mass\ Captured}{Influent\ Mass} \times 100\%$$

Where:

$$\text{Mass Captured} = Influent\ Mass - Effluent\ Mass - Draindown\ Mass$$

Influent mass $= (Inital\ mass\ in\ auger - Final\ mass\ in\ auger) \times (1 - moisture\ percent)$

Effluent mass $= Average\ adjusted\ effluent\ TSS\ concentration \times effluent\ volume$
      Average adjusted effluent TSS conc. $= Average\ Effluent\ TSS\ conc. - Average\ Background\ TSS\ conc.$
      Effluent volume $= Influent\ volume - Drain\ down\ volume$
      Influent volume $=$ Average flow rate $\times$ Sediment injection time
      Sediment injection time $= Test\ run\ duration - total\ feed\ rate\ sampling\ time$

Drain down mass $= Average\ Adjusted\ drain\ down\ TSS\ concentration \times Drain\ down\ volume$
      Average adjusted drain down TSS conc.$= Average\ drain\ down\ TSS\ conc. - Average\ Background\ TSS\ conc.$
      Drain down volume $= Measured\ during\ drain\ down$

Table 7a Influent Mass Results

Test Run	Initial Mass in Auger	Final Mass in Auger	Total Mass injected by Auger	Moisture Corrected Influent Mass	Total Feed Sample Mass	Influent Mass
	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)	(lbs)
1	51.5	44.2	7.30	7.30	0.670	6.63
2	51.4	44.2	7.20	7.20	0.666	6.53
3	52.0	44.7	7.30	7.30	0.676	6.62
4	51.3	44.2	7.10	7.10	0.668	6.43
5	50.9	43.8	7.10	7.10	0.661	6.43
6	51.3	44.2	7.10	7.10	0.674	6.42
7	51.2	44.1	7.10	7.10	0.662	6.43
8	51.1	44.1	7.00	7.00	0.661	6.33
9	52.0	44.9	7.10	7.10	0.656	6.44
10	51.7	44.6	7.10	7.10	0.657	6.44
					Total:	**64.7**
11	39.3	32.2	7.10	7.10	0.659	6.44
12	39.4	32.3	7.10	7.10	0.656	6.44
13	39.5	32.4	7.10	7.10	0.651	6.44
14	39.2	32.1	7.10	7.10	0.658	6.44
					Total:	**25.8**

Table 7b Removal Efficiency Results

Test Run	Influent Mass (lbs)	Effluent Mass (lbs)	Drain down Mass (lbs)	Mass Captured (lbs)	Test Run Removal Efficiency (%)	Cumulative Influent Mass (lbs)	Cumulative Mass Captured (lbs)	Cumulative Removal Efficiency (%)
1	6.63	0.03	0.00	6.60	99.6%	6.63	6.60	99.6%
2	6.53	0.03	0.00	6.50	99.5%	13.2	13.1	99.5%
3	6.62	0.03	0.00	6.59	99.5%	19.8	19.7	99.5%
4	6.43	0.03	0.00	6.39	99.5%	26.2	26.1	99.5%
5	6.43	0.03	0.00	6.40	99.5%	32.6	32.5	99.5%
6	6.42	0.03	0.00	6.39	99.5%	39.1	38.9	99.5%
7	6.43	0.03	0.00	6.40	99.5%	45.5	45.3	99.5%
8	6.33	0.03	0.00	6.30	99.5%	51.8	51.6	99.5%
9	6.44	0.03	0.00	6.41	99.5%	58.3	58.0	99.5%
10	6.44	0.03	0.00	6.41	99.5%	64.7	64.4	99.5%
Total:	**64.7**	**0.32**	**0.00**	**64.4**	**99.5%**			
11	6.44	0.03	0.00	6.41	99.5%	71.1	70.8	99.5%
12	6.44	0.03	0.00	6.41	99.5%	77.6	77.2	99.5%
13	6.44	0.03	0.00	6.42	99.6%	84.0	83.6	99.5%
14	6.44	0.03	0.00	6.41	99.5%	90.5	90.0	99.5%
Total:	**25.8**	**0.12**	**0.00**	**25.6**	**99.5%**			

Sediment Mass Load Test Results

The Sediment Mass Loading Capacity of the UUF was determined after the first 10 removal efficiency test runs, when the water elevation in the UUF was 2-inches less than the height of the UUF. The flow rate was reduced to 90% of the treatment flow rate or 117 gpm and an additional four test runs were completed prior to water elevations reaching 18 inches, at which point testing was stopped. The target influent concentration was increased as much as possible, which was 225 mg/L ± 10%, due to the auger feed rate limit. For all fourteen test runs, 90.5 lbs of test sediment was added to the filter and 90.0 lbs of test sediment was captured.

Water elevations in the filter were manually recorded for each test run. A plot of the maximum water elevation recorded for each of the fourteen test runs as the mass of test sediment increases in shown in **Figure 5**. A decrease in elevation was observed on the 11th test run after the flow rate was decreased by 10%. Other than this point, there is a constant increase as sediment accumulates in the filter indicating that the filter has less open area for flow to pass thorough.
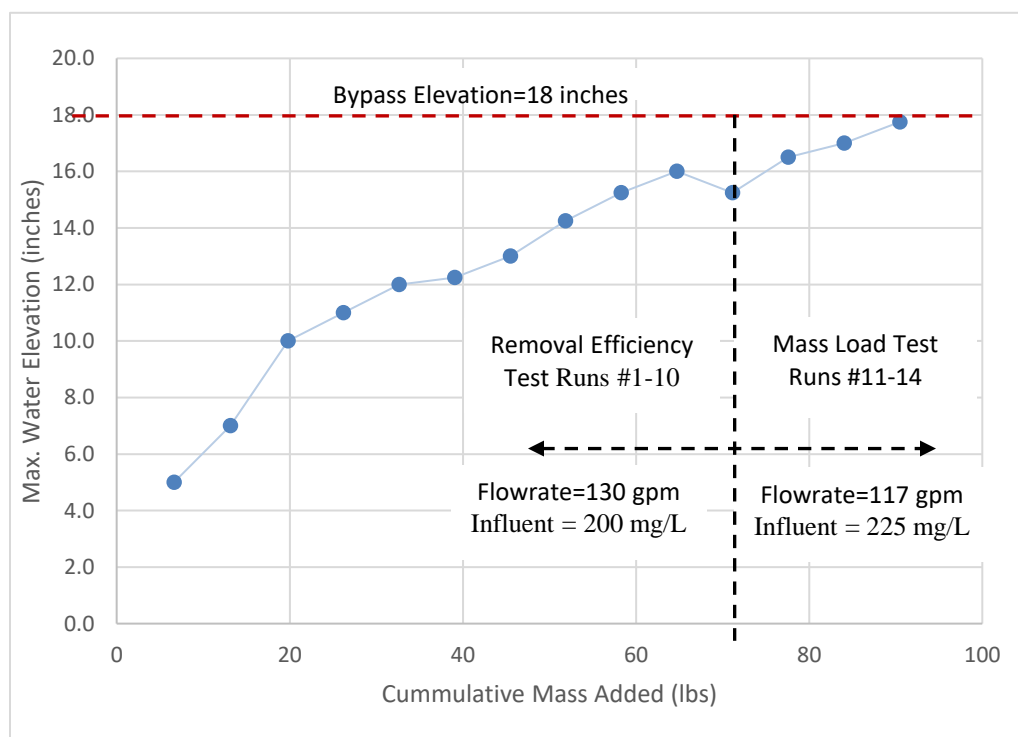

Figure 5 Influence of Mass Load on Water Elevations

Average Influent Concentrations

The average influent concentration for each test run is calculated as the quotient of the influent mass and water volume during dosing. Calculation of these quantities have been previously described and are included in **Table 8**. The influent concentrations for removal efficiency testing can vary between 180 mg/L and 220 mg/L or ±10%. With the auger injecting at its maximum capacity, and the reduced flow rate during mass load test runs #11-14, the target influent concentration during mass load test runs was 225 mg/L ±10%. Excluding the first test run, all influent concentrations are within 3.1% and are in compliance with the test protocol. Test run #1 was shorter than planned

due to available storage volume needed to keep water elevations in the supply tank constant. It was not excluded from the removal efficiency test results given all other test runs achieved greater than 99% capture and its exclusion would not have influenced the results.

Table 8 Influent Concentrations

Test Run	Influent Mass (lbs)	Influent Volume (gallons)	Avg. Influent TSS Conc. (mg/L)	Influent Variability (%)	Influent TSS Compliant (Y/N)
1	6.63	3,558	223	11.5%	N
2	6.53	3,912	200	0.00%	Y
3	6.62	3,907	203	1.50%	Y
4	6.43	3,915	197	1.50%	Y
5	6.43	3,908	197	1.50%	Y
6	6.42	3,923	196	2.00%	Y
7	6.43	3,913	197	1.50%	Y
8	6.33	3,911	194	3.00%	Y
9	6.44	3,917	197	1.50%	Y
10	6.44	3,913	197	1.50%	Y
Total:	**64.7**	**39,172**			
		Average:	**200**	**0.04%**	**Y**
11	6.44	3,526	219	3.00%	Y
12	6.44	3,524	219	3.00%	Y
13	6.44	3,523	219	3.00%	Y
14	6.44	3,525	219	3.00%	Y
Total:	**25.8**	**14,098**			
		Average:	**219**	**3.00%**	**Y**

5.2   Scour Testing Results

As described in Section 3.2, scour testing was completed to determine the maximum on-line flow rate. Results from three sequential test runs are shown in **Tables 9a**, **9b**, and **9c**. Each test run was 33 minutes in duration and included a 5-minute ramp-up period used to reach the target flow rate. The average flow rate and COV does not include the first two flow readings.

Given the maximum water elevation recorded during the last mass load test run #14, which was only slightly below the bypass weir, the flow rate for the first scour test remained the same, at 130 gpm. Very little bypass or sediment was observed in the effluent during the first scour test. Consequently, a second scour test run was attempted at 200% of the MTFR, or 260 gpm, but was terminated due to insufficient flow capacity needed to maintain constant head on the supply pump. Following some changes to the lab set-up, the scour test at 260 gpm was repeated. Given potable water was used for scour tests and previous tests indicated background concentrations < 1 mg/L, no samples were taken during this test run. Results show that the fifteen discrete effluent concentrations for scour test three were all less than 20 mg/L, with an average 7.5 mg/L, demonstrating minimal re-suspension at 200% of the MTFR.

Table 9a Scour Test #1 – 130 gpm

Sample	Time	Flow Rate					Max. Temp	Quality Check ≤80F	Effluent TSS	Back-ground TSS	Adj. Effluent TSS	Quality Check ≤20 mg/L
		Target	Actual	Mean	Std. Dev.	COV						
	(min:sec)		(gpm)				(°F)	(Y/N)		(mg/L)		(Y/N)
	1:00	26	26						No samples taken during ramp up per protocol			
	3:00	78	78.4	Ramp-up Period								
1	5:00	130	130.1	130.3	0.384	0.003	59.5	Y	<1	<1	<1	Y
2	7:00	130	130.4						<1		<1	Y
3	9:00	130	130.3						<1	<1	<1	Y
4	11:00	130	130.1						<1		<1	Y
5	13:00	130	131.3						<1	<1	<1	Y
6	15:00	130	130.3						<1		<1	Y
7	17:00	130	129.8						<1	<1	<1	Y
8	19:00	130	130.5						<1		<1	Y
9	21:00	130	130.4						<1	<1	<1	Y
10	23:00	130	130.5						<1		<1	Y
11	25:00	130	130.1						<1	<1	<1	Y
12	27:00	130	129.7						<1		<1	Y
13	29:00	130	130.3						<1	<1	<1	Y
14	31:00	130	129.9						<1		<1	Y
15	33:02	130	130.6						<1	<1	<1	Y

Table 9b Scour Test #2 – 260 gpm

Sample	Time	Flow Rate Target	Flow Rate Actual	Flow Rate Mean	Flow Rate Std. Dev. (SD)	Flow Rate COV (SD/mean)	Max. Temp	Quality Check ≤80F	Effluent TSS	Back-ground TSS	Adjusted Effluent TSS	Quality Check ≤20 mg/L
	(min:sec)		(gpm)				(°F)	(Y/N)		(mg/L)		(Y/N)
	1:00	52	54.0						No samples taken during ramp up per protocol			
	3:00	156	156.0	Ramp-up Period								
1	5:00	260	260.0						<1	<1	<1	Y
2	7:00	260							<1		<1	Y
3	9:00	260							<1	<1	<1	Y
4	11:00	260							<1		<1	Y
5	13:00	260	Test Terminated due to pump#2 not operating > ~220 gpm Water elevation dropped in supply tank No Flow Data Available after 5 minutes.				59.5	Y	Test Terminated Pump#2 Exceed Capacity No samples taken after 11 minutes.			
6	15:00	260										
7	17:00	260										
8	19:00	260										
9	21:00	260										
10	23:00	260										
11	25:00	260										
12	27:00	260										
13	29:00	260										
14	31:00	260										
15	33:00	260										

Table 9c Scour Test #3 – 260 gpm

Sample	Time	Target	Actual	Mean	Std. Dev.	COV	Max. Temp	Quality Check ≤80F	Effluent TSS	Back-ground TSS*	Adjusted Effluent TSS	Quality Check ≤20 mg/L
	(min:sec)		(gpm)				(°F)	(Y/N)		(mg/L)		(Y/N)
	1:00	52	48.4	Ramp-up Period					No samples taken during ramp up per protocol			
	3:00	156	155.0									
1	5:00	260	257.8						2	0	2	Y
2	7:00	260	262.8						<1		1	Y
3	9:00	260	261.2						5	0	5	Y
4	11:00	260	262.3						1		1	Y
5	13:00	260	261.1						7	0	7	Y
6	15:00	260	260.0	260.6	1.22	0.005	59.5	Y	4		4	Y
7	17:00	260	260.5						6	0	6	Y
8	19:00	260	259.9						17		17	Y
9	21:00	260	260.3						6	0	6	Y
10	23:00	260	259.9						15		15	Y
11	25:00	260	260.7						16	0	16	Y
12	27:00	260	260.0						8		8	Y
13	29:00	260	261.4						14	0	14	Y
14	31:00	260	261.5						3		3	Y
15	33:02	260	259.4						8	0	8	Y

*No background samples taken since all previous BG samples < 1 mg/L.

6.   Maintenance

Maintaining the UUF DI 304-150M catch basin filter inserts is required for sustaining hydraulic performance and pollutant removals. It does require planning but is intended to be very simple and inexpensive. All drop-in filter inserts are installed (suspended) in catch basin structures from a collar that is placed under the inlet grate. Once the grate has been removed, there will be full access to trash, sediment or debris that has been captured in the filter insert. Following removal of captured materials, the grate is replaced, and the materials disposed as required by local authorities or regulations. No confined space entry is necessary, and no internal components need to be removed or replaced. Materials captured by the filter that are allowed to dry during long dry periods may harden, which can cause the filter to partially blind if not properly maintained. Should the filter blind and cleaning beyond simple removal of material be required, the UUF filter insert can be removed from the catch basin and cleaned above grade. The frequency of maintenance will vary and if possible, should be determined by inspections that are part of a larger stormwater drainage systems' maintenance program.

Planning Considerations

Safety is the most important consideration before inspecting and removing pollutants from the UUF. Urban stormwater drainage structures are often installed along roadside curbs or in parking lots with limited space. Consider plans for:

- Safety clothing and gear – reflective vests, glasses, steel-toed shoes, gloves
- Allowing personnel space to remove and temporarily store surface grates
- Maneuvering and parking maintenance vehicles
- Equipment for directing traffic and pedestrians - safety cones or barriers and use of appropriate signage
- Equipment for removing the grates (Example: Grate Lifter)
- Tools to loosen consolidated sediment and debris covering the grate
- Storing and disposal of pollutants

Inspection Procedures

1. Locate the catch basins to inspect and refer to the planning considerations listed above.
2. Remove and dispose of any materials blocking the grate openings.
3. Using a light if needed or remove the surface grate to:
   - Take photographs
   - Observe & record the depth of accumulated sediment, trash and debris
4. Complete an inspection form. Record catch basin ID, depth and date.
5. Replace the surface grate if it was removed.
6. Schedule maintenance (clean out) if filter insert is more than half full.

Maintenance Procedures

1. Refer to planning considerations and ideally, only clean out when it is not raining.
2. Contact AbTech Industries for an authorized service provider.
3. Remove surface grate.

4. Use equipment, like a Vactor Truck that can power wash and vacuum.
5. Power wash surface area around the inlet and in the filter to loosen any consolidated sediment and debris.
6. Using the vacuum, suck out trash, foliage and sediment.
7. Pressure wash the sides and bottom of the filter insert to remove captured materials.
8. Repeat steps 6 & 7 until the all the captured materials have been removed.
9. Replace the grate and ensure it is flush with the finished grade.

7. Scaling

Based on the verified test results and loading rate of 13.3 gpm/ft^2, a "Normal" filter height of 18-inches, or "Half" filter height of 10-inches, and total screen filtration treatment area, other model size examples are provided in **Table 10.**

Table 10 UUF DI 304-150M Filter Models

	Model*	Filter Dimensions (inches)			Total Screen Surface Area	Sediment Storage Depth	Treatment Flow Rate	Loading Rate
		L	W	H	ft^2	inches	gpm	gpm/ft^2
Shallow	DI 1212H-304-150M	12	12	10	4.33	3	58	13.3
	DI 1414H-304-150M	14	14	10	5.25	3	70	13.3
	DI 1420H-304-150M	14	20	10	7.50	3	100	13.3
	DI 1616H-304-150M	16	16	10	6.22	3	83	13.3
	DI 2020H-304-150M	20	20	10	8.33	3	111	13.3
	DI 1632H-304-150M	16	32	10	12.4	3	165	13.3
Deep	DI 1212N-304-150M	12	12	18	7.00	5	93	13.3
	DI 1414N-304-150M	14	14	18	8.36	5	111	13.3
	DI 1420N-304-150M	14	20	18	11.9	5	159	13.3
	DI 1616N-304-150M	16	16	18	9.78	5	130	13.3
	DI 2020N-304-150M	20	20	18	12.8	5	170	13.3
	DI 1632N-304-150M	16	32	18	19.6	5	260	13.3

*Not all models are shown. Custom models are available.

8. Statements

The following signed statements from the manufacturer (AbTech), third-party observer (Kimberwerks) and NJCAT are required to complete the NJCAT verification process.

AbTech

Leader of Stormwater Purification

March 18, 2020

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

RE: Manufacturers Statement of Compliance

Dear Dr. Magee,

AbTech Industries (the manufacturer) has completed verification testing for the Ultra Urban® Filter (UUF) model DI1616-304-150M at AbTech's testing facility. The performance assessment and verification included quantifying the sediment removal efficiency, the total mass of sediment captured and resulting changes in headlosses, while operating at a constant flow rate. Additionally, high flow rate tests were conducted to quantifying the effluent concentrations that are used as a measure of the filter's ability to retain previously captured sediment, also referred to as scour or washout.

Except for the specified particle size distribution, test protocols were in accordance with the, "New Jersey Department of Environmental Protection (NJDEP) Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device" (January 25, 2013). To ensure compliance with these protocols, a test plan was completed and submitted to NJCAT for review and approval, all testing and sampling collection and handling was witnessed by an approved independent observer, Mike Kimberlain, P.E. of Kimberwerks, and all analytics were performed by a certified laboratory, IAS Laboratories (IAS), located in Phoenix Arizona.

Please accept this letter as the manufacturers statement of compliance. Specifically, AbTech has followed all procedures to ensure that the results and performance claims presented in this verification report are in compliance with the standards set forth in the test protocol.

Sincerely,

David A. Scott, CPSWQ
Program Development Manager
AbTech Industries

KimberWerks, Inc.
P.O. Box 7198
Rancho Santa Fe, California 92067
(858) 381-6209

March 19, 2020

Richard S. Magee Sc.D., P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental Systems
Stevens Institute of Technology
Castle Point on Hudson
Hoboken, NJ 07030
973-879-3056 (M)
rsmagee@rcn.com

Re: **Statement of Third-Party Observer**
Performance Verification of the AbTech Industries, Inc. Ultra Urban Filter
Model UUF DI1616N-304-150M

Dr. Magee,

KimberWerks, Inc. has been engaged by AbTech Industries, Inc. (AbTech) to act as the third-party observer for the Performance Verification Testing of their Ultra Urban Filter Model UUF DI1616N-304-150M Filtration Manufactured Treatment Device. Performance Verification testing was performed by AbTech personnel under the direction of Mr. David Scott, Program Development Manager, and began on February 17th and ended on February 21st. The Performance Verification was performed at AbTech's facility located at 3610 East Southern Avenue, Suite 2, Phoenix, Arizona 85040.

I was personally on site to observe the testing and I remained on site to observe the testing for its full duration. It is my professional opinion that the Performance Verification Testing conducted by AbTech meets or exceeds the requirements of the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device (January 25, 2013)* with the noted exception in the report regarding the intentional deviation from the Protocol Section 5.B. (Test Sediment) Particle Size Distribution. In addition, I have personally reviewed the data sets, calculations, and conclusions associated with the Removal Efficiency and Scour Testing in the *NJCAT TECHNOLOGY VERIFICATION: Ultra-Urban® Filter Model UUF DI1616N-304-150M* report by AbTech Industries dated March 2020 and hereby state they conform to my observations while acting as third-party observer.

Please let me know should you have any questions or need any clarification to these statements.

Sincerely,

Michael Kimberlain, P.E., CPSWQ
mkimberlain@kimberwerks.com
(858) 381-6209

KimberWerks, Inc.
P.O. Box 7198
Rancho Santa Fe, California 92067
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March 19, 2020

Richard S. Magee Sc.D., P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology
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Castle Point on Hudson
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Re: **Third-Party Observer Statement of Disclosure / Disclosure Record**

Dr. Magee,

In accordance with the *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology (January 25, 2013), Section 4. B Conflict of Interest* KimberWerks, Inc. would like to inform NJCAT that we have no disclosures that would represent a conflict of interest. KimberWerks, Inc. has no personal, professional, or financial interest in the outcome of the Performance Verification Testing performed by AbTech Industries, Inc. and has no personal, professional, or financial interest in AbTech Industries, Inc.

KimberWerks, Inc. is a privately owned Engineering Consulting company that regularly performs work in the areas of Civil Engineering, Storm Water, Waste Water, and Potable Water and as such has in the past engaged with various Storm Water MTD Manufactures including but not limited to: AbTech, Industries, Inc., Prinsco, Hydro International, Advanced Drainage Systems, Forterra Building Products, OldCastle Stormwater Solutions, Lane Enterprises, AquaShield, and Jensen Stormwater Systems. None of these engagements present a personal, professional, or financial conflict of interest as the engagements did not include (and are not limited to):

- having an ownership stake in any of the companies;
- receiving commission for selling a MTD for a manufacturer;
- having a licensing agreement with the manufacturer; or
- receiving funding or grants not associated with a testing program from the manufacturer.

Please let me know should you have any questions or need any clarification to these statements.

Sincerely,

Michael Kimberlain, P.E., CPSWQ
mkimberlain@kimberwerks.com
(858) 381-6209

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

March 25, 2020

Mr. David Scott
Program Development Manager
AbTech Industries
4110 N. Scottsdale Rd., Suite 235
Scottsdale, AZ 85251

Dear Mr. Scott,

Based on my review, evaluation and assessment of the testing conducted on AbTech's Ultra Urban® Filter (UUF) model DI 1616N-304-150M at the company's testing facility in Phoenix, Arizona, under the third party oversight of Kimberwerks, the test protocol requirements contained in the *"New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device"* (NJDEP Filter Protocol) were met with one exception: the sediment test particle size distribution (PSD) was coarser than specified in the NJDEP protocol. Consequently, the verification report does not qualify for NJDEP certification.

Test Sediment Feed – The particle size distribution used for this performance assessment was coarser than what is specified in the NJDEP test protocol but may be considered suitable for the intended application depending on the water quality objectives. In general, the test sediment was larger than 53 microns and less than 300 microns and the average d_{50} was 117µm. In comparison, the d_{50} for the test sediment specified in the protocol is 75 microns and 45% is between 2µm and 50µm and about 10% between 300µm and 1,000µm

Removal Efficiency Testing – The tested UUF DI 1616N-304-150M achieved an overall removal efficiency of 99.5% TSS with a PSD between 53 microns and 300 microns, with average d_{50}=117µm for all test runs.

Tested Treatment Flow Rate - The UUF Model UUF DI1616N-304-150M, with Effective Filtration Treatment Area (EFTA) area of 9.78 ft^2, has a MTFR 130 gpm (loading rate 13.3 gpm/ft^2).

Sediment Mass Loading Capacity - The sedimentation mass loading capacity of the UUF DI 1616N-304-150M, was determined to be 90.5 lbs.

On-line/Off-line Applications - Scour testing results showed the average effluent concentration (7.5 mg/L) not to exceed 20 mg/L for flow rates up to 200% of the treatment flow rate, or 260 gpm.

All other criteria and requirements of the NJDEP Filter Protocol were met. These include: flow rate measurements COV <0.03; test sediment influent concentration COV <0.10; test sediment influent concentration within 10% of the targeted value of 200 mg/L (or 400 mg/L); influent background concentrations <20 mg/L; and water temperature <80 ºF.

Sincerely,

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

9.   References

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

2.   NJDEP 2013b. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device. January 25, 2013.

3.   ASTM D422-63(2007). Standard Test Method for Particle-Size Analysis of Soils.

4.   ASTM D3977-97(2019). Standard Test Methods for Determining Concentrations in Water Samples.

5.   ASTM D4959-16. Standard Test Method for Determination of Water Content of Soil by Direct Heating.