NJCAT TECHNOLOGY VERIFICATION

UT SAFL Baffle Stormwater Treatment Unit

Upstream Technologies, Inc.

October 2023

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1. Description of Technology

The SAFL Baffle by Upstream Technologies (UT) is a hydrodynamic separator that removes suspended solids from stormwater runoff. It is installed in a standard, precast concrete sump structure.

Research at the University of Minnesota's St. Anthony Falls Laboratory (SAFL) discovered that standard sump structures are effective at capturing suspended solids in stormwater, under typical or low flows. However, high flows caused a vortex to form in the sump that scoured the previously collected sediment and washed it out of the sump (Howard, et. al., 2011).

The SAFL Baffle is installed in the sump, where it distributes the flow across the width of the manhole. This reduces flow velocity and prevents the vortex during high flows, eliminating washout of the sediment collected in the sump during low and typical flow storms. **(Figure 1)**

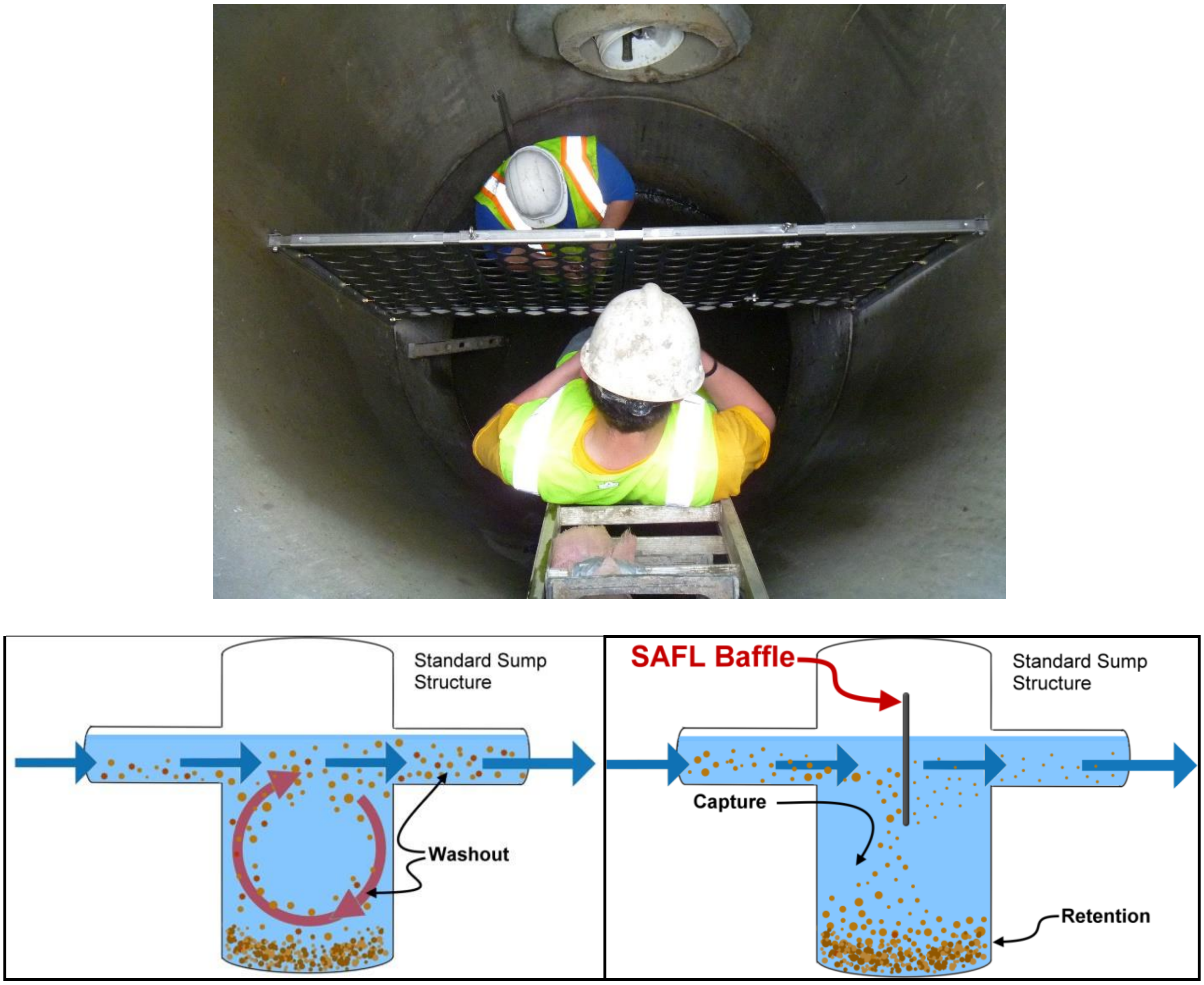

Figure 1 SAFL Baffle Internal Flow Paths

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 performed during late winter and spring 2022 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 2021, (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.

The unit was tested in accordance with the Canadian ETV testing protocol prior to initiating the NJDEP test program. The removal curve was used to estimate the initial 100% MTFR of 110 gpm. Additional tests were conducted to refine the curve within the range of the NJDEP target flows and select the final MTFR of 120 gpm.

2.1 Test Setup

The UT SAFL Baffle test unit is a 5-ft diameter x 8-ft high stormwater treatment device containing an internal SAFL Baffle, which is designed to facilitate the settling of sediment particles. The baffle, which consisted of multiple perforated panels, was installed in the center of the tank and oriented perpendicular to the inlet pipe. The baffle invert was located one foot below the inlet and outlet pipe inverts, 4 ft above the tank floor and is 3 ft high. The unit was configured with 14 inch I.D. inlet and outlet pipes, with the pipe invert elevations at 5 ft above the unit floor. The inlet and outlet pipes were oriented on-center with 1% slopes. Flow entering the unit contacts the perforated baffle, which is then conveyed through the perforations or under the baffle before entering the outlet pipe. A drawing of the design is shown on **Figure 2**. A false floor was installed at the 50% sump depth of 18 inches for the hydraulic and removal efficiency testing. The floor height was reduced to 14 inches for the scour testing to allow the addition of 4 inches of sediment. The test tank diameter of 5 ft was used for all related area calculations. Photographs showing the test unit installed in the test loop and the installed 60" wide by 36" high SAFL Baffle (two 18" panels and a single 24" panel) are shown in **Figure 3.**

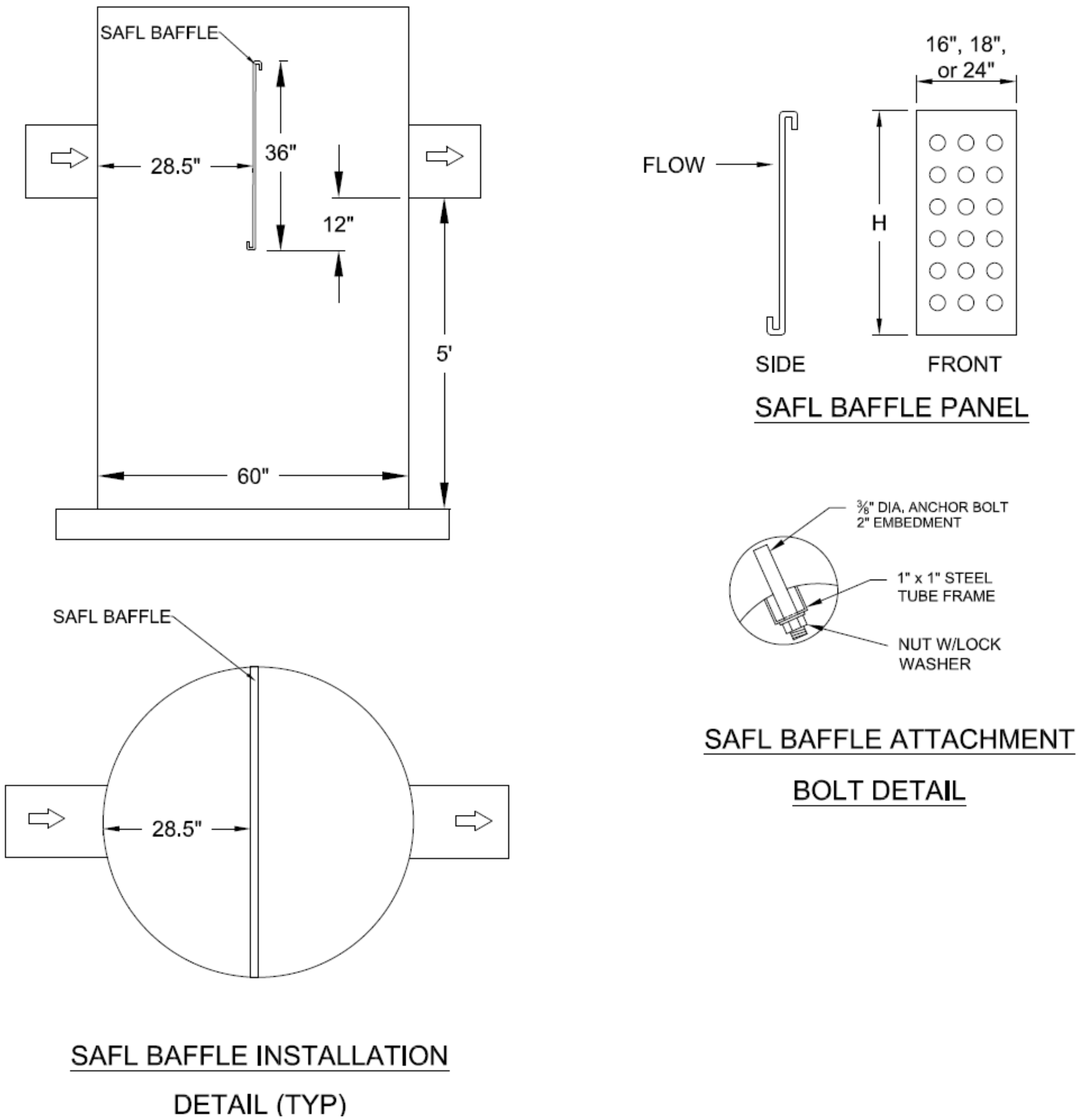

Figure 2 Drawing of the SAFL Baffle Treatment Unit

Figure 3 SAFL Baffle Test Unit Installed in Alden Flow Loop

The SAFL Baffle 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) ft of straight 14 inch pipe conveyed the metered flow to the unit. Eight (8) ft of straight 14 inch effluent piping returned the test flow back to the supply sump as a free discharge. The influent and effluent pipes were set at 1% slopes. A 12 inch tee was located 3 ft upstream of the test unit for injecting the test sediment into the crown of the influent pipe. Sediment injection was accomplished with the use of a volumetric screw feeder. The end-of-pipe grab sampling methodology was used for the scour test. The mass capture methodology was used for the removal efficiency testing. An iso-kinetic sampler was installed in the upstream vertical riser pipe for collection of the background samples.

Filtration of the supply sump to reduce background concentration was performed with an inline filter wall containing 1-micron filter bags.

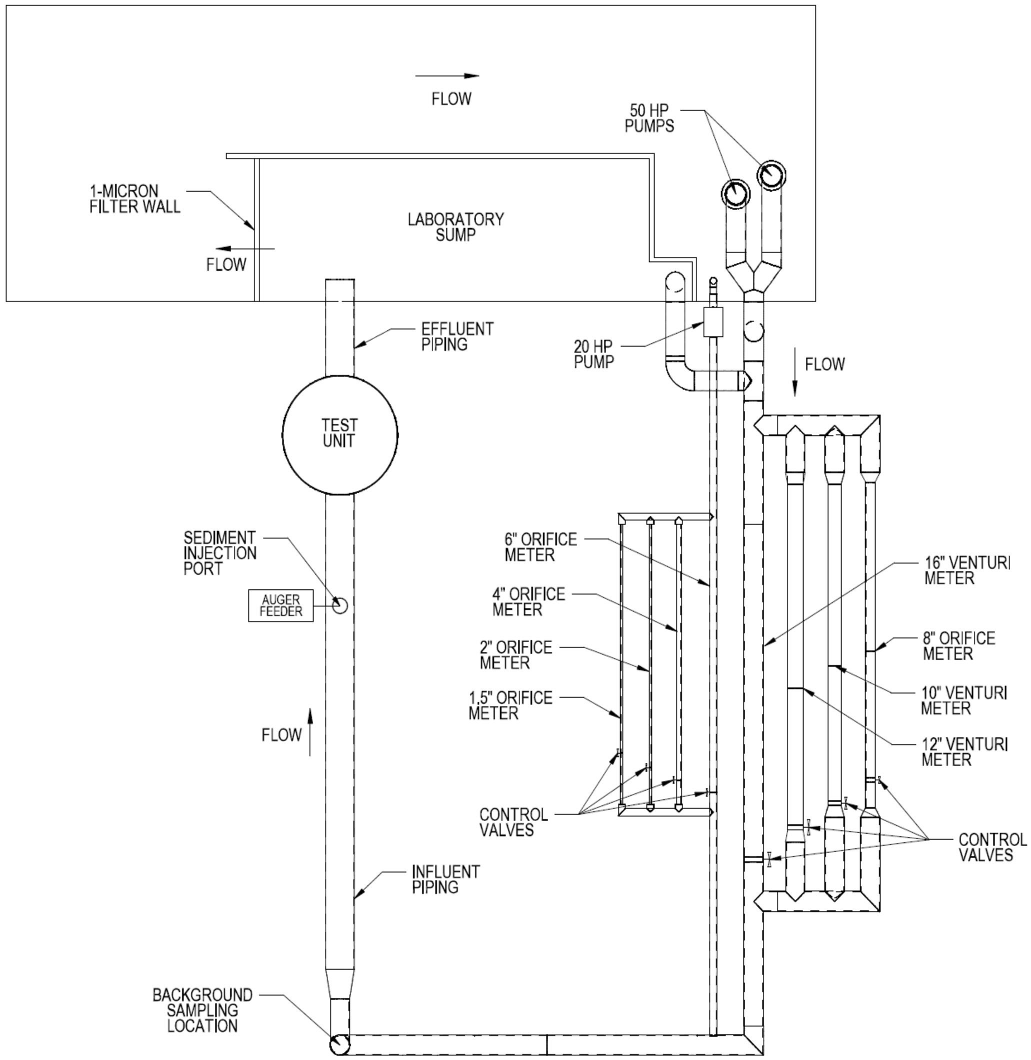

Figure 4 Plan View of Alden Flow Loop

2.2 Hydraulic Testing

The SAFL Baffle was tested with clean water to determine its hydraulic characteristic curves. Flow and water level measurements were recorded at steady-state flow conditions using a computer data-acquisition system, which included a data collect program, 0-250” Rosemount® differential pressure cell, and Omegadyne 0-2.5 psi pressure transducer. The pressure cell was mounted at an elevation of 2.597 ft below the outlet pipe invert. This datum value was subtracted from all recorded measurements to calculate the water height above the invert. The system energy loss across the unit was determined by adding the velocity head to the elevations at the inlet and outlet pipes.

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 5 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 one pipe-diameter upstream and downstream of the unit, as well as within the treatment tank.

2.3 Removal Efficiency Testing

Removal testing was conducted on a clean unit utilizing the mass capture testing methodology. A false floor was installed at the 50% collection sump sediment storage depth of 18 inches. All tests were run with clean water containing a background suspended sediment concentration (SSC) of ≤ 20 mg/L.

Seven sediment removal efficiency tests were conducted at flows ranging from 16% to 161% of the final Maximum Treatment Flow Rate (MTFR).

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 (**Table 1).** Sediment batches 1-1000-micron were prepared by Alden to meet the protocol specifications using commercially-available silica products. A random sample from each test batch was analyzed in accordance with ASTM D6913/D7928, by GeoTesting Express, an AALA ISO/IEC 17025 accredited independent laboratory. The specified less-than (%-finer) values of the sample average were within the 2 percentage-point tolerance listed in the protocol. 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.

The target influent sediment concentration was 200 mg/L (±20 mg/L) for all tests. The concentration was verified by collecting a minimum of eight timed dry samples at the injector and correlating the data with the measured flow rate. Each sample volume was a minimum of 0.1 liter, 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 D2216 (2019) "Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass", for each test conducted. The allowed supply water maximum temperature of 80 degrees F was met for all tests conducted.

A minimum of 8 background samples of the supply water were collected at evenly spaced intervals throughout each test. Samples were collected every hour for any test ≥ 8 hours in duration. Collected samples were analyzed for Suspended Sediment Concentration (SSC) using ASTM D3977-97 (2019) "Standard Test Methods for Determining Sediment Concentration in

Water Samples".

After completion of a selected test, the unit was decanted over a period not exceeding 30 hours. The remaining water and sediment were collected from the tested treatment unit and dried in designated pre-weighed nonferrous trays in compliance with ASTM D2216 (2019).

Table 1 NJDEP Target Test Sediment Particle Size Distribution

	TSS Removal Test PSD	Scour Test Pre-load PSD
Particle Size (Microns)	Target Minimum % Less Than[2]	Target Minimum % Less Than[3]
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

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.
2. A measured value may be lower than a target minimum % less than value by up to two percentage points, provided the measured d_{50} value does not exceed 75 microns.
3. This distribution is to be used to pre-load the MTD's sedimentation chamber for off-line and on-line scour testing.

2.4 Scour Testing

A sediment scour test was conducted to evaluate the ability to retain captured material during high flows. Four inches of 50-1000-micron sediment was pre-loaded in the collection sump to the 50% capacity level. All test sediment was evenly distributed and levelled prior to testing.

The unit was filled with clean water (< 20 mg/L background) to the dry-weather condition 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 test was conducted at a minimum of 200% MTFR for online certification. Testing consisted of conveying the selected target flow through the unit and collecting 15 time-stamped effluent samples (every 2 minutes) for SSC analysis, with the first sample being collected 1 minute after initiating the flow. A minimum of 8 evenly-spaced time-stamped background samples were collected throughout the test. The target flow was reached within 3 minutes of commencement of the test. Flow data was continuously recorded every 3 seconds throughout the test and correlated with the samples.

Each effluent grab sample for sediment concentration analysis was collected from the end of the effluent pipe by sweeping a 1-liter wide-mouth bottle 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 (1.5", 2", 4", 6" or, 8"). Each meter was fabricated per ASME guidelines and calibrated in Alden's Calibration Department. Flows were set with a control valve and the differential head from the meter was measured using a Rosemount® 0 to 250-inch differential pressure cell, also calibrated at Alden. The test flow was averaged and recorded every 3 to 30 seconds (flow dependent) throughout the duration of the test using an in-house computerized data acquisition program. The accuracy of the flow measurement is ±1%. The maximum allowable Coefficient of Variance (COV) for flow documentation was 0.03. A photograph of the flow meter array is shown on **Figure 5.**

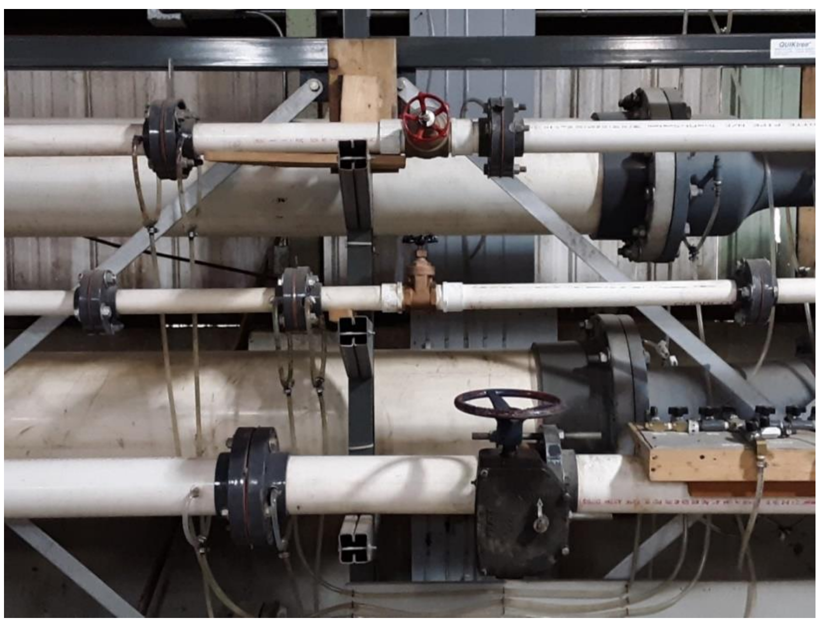

Figure 5 Photograph Showing Laboratory Flow Meters

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 laboratory prior to testing. The temperature measurement was documented at the start, middle and end of each test, to assure an acceptable testing temperature of ≤ 80 degrees F.

Pressure Head

Pressure head measurements were recorded at multiple locations using piezometer taps and an Omegadyne PX419, 0 - 2.5 psi pressure transducer, calibrated at Alden prior to testing. Accuracy of the readings is ± 0.001 ft. The cell was installed 2.597 ft below the outlet invert, 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, under steady-state flow conditions. A photograph of the pressure 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 Feeders LTD® volumetric screw feeder, model VF-1, shown on **Figure 7**. The feed screws used in testing ranged in size from 0.5 to 1 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 pre-test calibration, as well as test verification of the sediment feed was accomplished by collecting 1-minute (maximum) timed dry samples and weighing them on a calibrated Ohaus® 4000g x 0.1g, model SCD-010 digital scale. The allowable COV for sediment feed was ≤ 0.10.

Figure 7 Photograph Showing Variable-Speed Auger Feeder

Sample Collection

Background concentration samples were collected from the center of the vertical riser pipe upstream of the test unit inlet pipe, with the use of a 0.75 inch isokinetic sampler, shown on **Figure 8**. The sampler was calibrated for each test flow. All effluent grab samples were collected from the free-discharge at the end of the effluent pipe, using 1-L wide-mouth bottles. All collected samples were a minimum of 0.5 L in volume.

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 (Re-approved 2019), “Standard Test Methods for Determining Sediment Concentration in Water Samples”. Alden has assigned a Non-Detection Limit (NDL) of 1.0 mg/L. To be conservative, all concentrations below the NDL were assigned a value of 0.5 mg/L.

Mass Capture Analysis

A mass capture test methodology, in which the influent and captured sediment mass is quantified, was used to determine the sediment removal efficiency for each test flow. The mass of injected sediment was determined by weighing the prepared test batch prior to testing and subtracting the remaining mass at the conclusion of the test. All captured material was collected in designated pre-weighed non-ferrous trays and dried in a Binder® laboratory oven; model ED-400, in accordance with ASTM D2216. Depending on collected mass, each tray was weighed on either an Ohaus® 2200g x 0.1g; model SPX2201, or Ohaus® 30kg x 0.0001kg; model RD-30LS digital scale.

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 board was used to convert the voltage signal from the pressure cells. 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. The 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 liter 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 (2019) analytical method. Gross sample weights were measured using a 2200g x 0.1g calibrated digital scale. The dried sample weights were measured with a calibrated 30g x 0.0001g AND® 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 0.13 mg/L.

The ASTM SSC analysis method is not currently included as part of Alden's 17025 accreditation. Analytical accuracy was verified by preparing two blind control samples (~20 mg/L and ~50 mg/L), using the test sediment and processing according to the ASTM method. The final calculated values were within 6% of the theoretical sample concentrations, as shown in **Table 2**. The lower processed sample concentrations were within expected values, as the %-finer value of the 1.5-micron size (filter porosity) was approximately 5%.

Table 2 Results of Processed Blind Control Concentration Samples

	Sample 1	Sample 2
	mg/L	mg/L
Prepared Concentration	52.3	23.0
Processed Concentration	51.8	21.6
Delta %	-0.9%	-5.8%

3. Performance Claims

The following performance claims for the Upstream Technologies SAFL Baffle are based on the independent laboratory testing conducted in accordance with the NJDEP testing protocol.

Total Suspended Solids (TSS) Removal Efficiency

The SAFL Baffle Stormwater Treatment Unit achieved removal efficiencies ranging from 38.6% to 62.8%, using the NJDEP 1-1000 micron sediment PSD. The NJDEP weighted removal efficiency based on an MTFR of 120 gpm, was 50.3%, which meets the 50% NJDEP certification criterion.

Maximum Treatment Flow Rate (MTFR)

The effective treatment sedimentation area of the tested unit was 19.6 ft^2. The 100% MTFR is 120 gpm (0.27 cfs), with a corresponding surface loading rate of 6.1 gpm/ft^2.

Maximum Sediment Storage Depth and Volume

The maximum sediment storage depth of the test unit was 36 inches (60 inches – 24 inches), which equates to a sediment storage volume of 58.8 ft^3. The 50% storage depth was 18 inches, corresponding to a storage volume of 29.4 ft^3.

Online / Offline Installation

A 1015% MTFR online sediment scour test was performed with the collection sump preloaded to 50% of the capture capacity (18 inches), using the NJDEP protocol 50-1000-micron sediment PSD. The test resulted in an average unadjusted effluent concentration of 2.5 mg/L, and adjusted concentration of 0.1 mg/L, which meets the online installation NJDEP certification criterion.

System Loss

Hydraulic testing was conducted at flows ranging from 50 to 2500 gpm. The system loss was not measurable at flows below 1100 gpm. The maximum recorded loss was 0.37 ft at 2500 gpm.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013) 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 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 provided by AGSCO Corp., a QAS International ISO-9001 certified company. Sediment batches were prepared by Alden to meet the 1-1000-micron PSD removal efficiency testing protocol specifications. A random sample from each test batch was analyzed in accordance with ASTM D6913/D7928, by GeoTesting Express, an AALA ISO/IEC 17025 accredited independent laboratory. 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 30-35 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 3** and the corresponding curves are shown on **Figure 9.**

Table 3 Removal Efficiency Test Sediment Particle Size Distribution

Test Batch	Bucket 15	Bucket 10	Bucket 7	Bucket 1	Bucket 11	Bucket 8	Bucket 13			QA / QC Compliant
	19.3 gpm	**38.6 gpm**	**55 gpm**	**96.4 gpm**	**110 gpm**	**138 gpm**	**192.8 gpm**	**Average**	**NJCAT**	
(micron)	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	%-Finer	
1000	100	100	100	100	100	100	100	**100**	**100**	Y
500	96	96	96	96	96	96	96	**96**	**95**	Y
250	89	89	88	89	89	89	88	**89**	**90**	Y
150	73	74	73	74	74	73	73	**73**	**75**	Y
100	62	61	61	61	61	62	59	**61**	**60**	Y
75	55	53	53	54	54	54	52	**54**	**50**	Y
50	46	46	44	45	44	44	44	**45**	**45**	Y
20	37	37	35	37	35	33	34	**36**	**35**	Y
8	24	22	23	26	20	22	21	**23**	**20**	Y
5	16	15	16	17	15	16	16	**16**	**10**	Y
2	8	8	9	9	7	7	8	**8**	**5**	Y
D_{50}	61	64	66	64	65	64	68	**65**	**75**	Y

The sediment particle size distribution (PSD) used for removal efficiency testing is finer than the NJDEP PSD sediment specifications (**Table 1**) across the entire distribution. The median (D_{50}) of 65 microns was less than the required 75 microns.

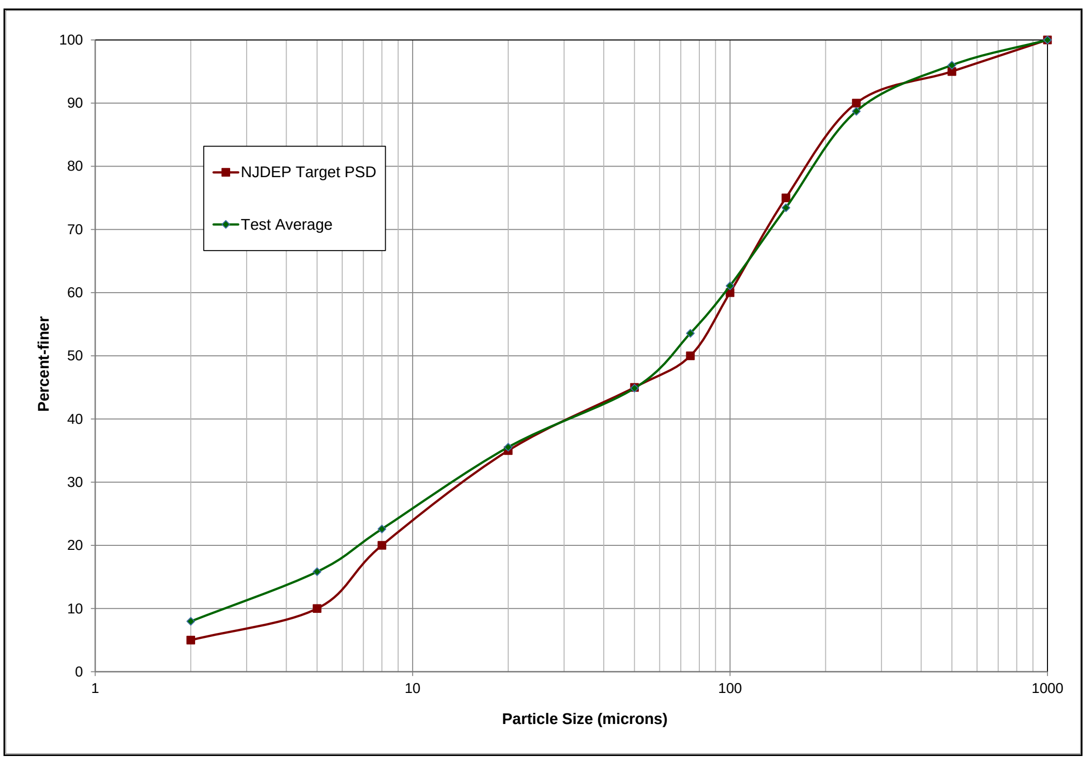

Figure 9 Average Removal Efficiency Test Sediment PSD

4.2 Removal Efficiency Testing

Testing Summary

Removal efficiency tests were conducted at 7 flows ranging from 16% to 161% MTFR. The 100% MTFR was 120 gpm. The target influent sediment concentration was 200 mg/L.

The measured flow, temperature and background data are shown in **Table 4** and the injected sediment data summary is shown in **Table 5**.

Table 4 Test Flow and Temperature Summary

Measured Flow gpm	Flow Measurement COV	Maximum Temperature Deg. F	Maximum Background mg/L	QA / QC Compliant	Removal Efficiency
19.3	0.002	65.4	1.9	Y	**62.8%**
38.6	0.002	66.8	5.1	Y	**55.9%**
55.2	0.002	74.3	2.5	Y	**54.4%**
96.4	0.001	65.4	7.9	Y	**44.3%**
110.1	0.002	68.6	7.8	Y	**44.5%**
137.8	0.002	67.8	9.3	Y	**42.7%**
193.2	0.002	65.8	10.4	Y	**38.6%**

Table 5 Injected Sediment Summary

Flow gpm	Target Concentration mg/L	Injector Wts. Concentration mg/L	Injector Measurements COV	Mass/Volume Concentration mg/L	Total Injected Mass Lbs.	QA / QC Compliant
19.3	200	198	0.06	**202**	**27.31**	**Y**
38.6	200	196	0.05	**195**	**26.06**	**Y**
55.2	200	200	0.01	**191**	**24.77**	**N**
96.4	200	206	0.04	**207**	**28.09**	**Y**
110.1	200	200	0.01	**201**	**26.81**	**Y**
137.8	200	200	0.01	**199**	**26.35**	**Y**
193.2	200	200	0.03	**197**	**25.91**	**Y**

Removal Efficiency Summary

At the end of each test run, the captured sediment was collected and quantified. For all runs there was zero sediment in the inlet pipe. The removal efficiency was determined by dividing the sediment captured in the SAFL Baffle sump by the injected sediment mass:

$$\% \textit{Removal} = \frac{\textit{Captured Sediment Mass}}{\textit{Injected Sediment Mass}} \, x\, 100$$

The removal efficiencies of the tested flows ranged from 38.6% to 62.8%. The test data was plotted, and a 3rd-order polynomial curve and equation was applied. The R^2 value of the curve equation was 0.986, exceeding the 0.95 criterion. The equation was used to select the 100% MTFR (120 gpm, 6.12 gpm/ft^2) and calculate the NJDEP weighted removals for the 25%, 50%, 75%, 100% and 125% flows. The calculated MTFR removal summary is shown in **Table 6**. The removal curve and corresponding equation using the 7 test data points are shown on **Figure 10**. The weighted removal at the target MTFR flows using the curve equation was 50.3%.

Table 6 Removal Efficiency Summary

MTFR	Flow (gpm)	Removal	Annual Weighting Factor	Weighted Removal
25%	30	59.3%	0.25	14.8%
50%	60	51.7%	0.3	15.5%
75%	90	46.6%	0.2	9.3%
100%	120	43.4%	0.15	6.5%
125%	150	41.3%	0.1	4.1%
				50.3%

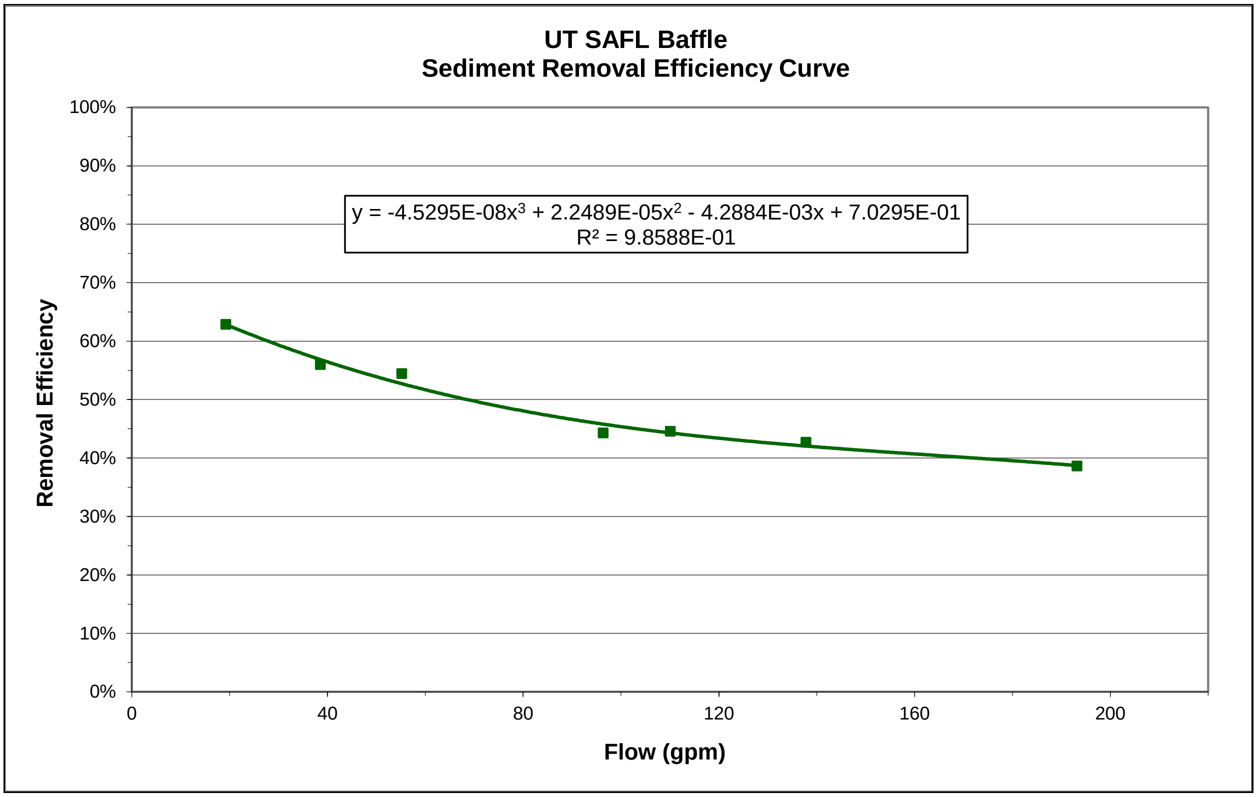

Figure 10 Upstream Technologies SAFL Baffle Removal Efficiency Curve

16% MTFR (19 gpm)

Although this test was above the 10% MTFR flow, it was low enough to allow interpolation of the 25% weighted removal point and therefore, deemed acceptable. The test was conducted at 19.3 gpm over a period of 14.5 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 19.3 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 64.8 to 65.4 degrees F.

The injection feed rate of 14.6 g/min was verified by collecting timed weight samples from the injector every 30 minutes. The calculated influent injection concentrations for the full test ranged from 181 mg/L to 218 mg/L, with a mean of 198 mg/L and COV of 0.06. The total mass injected into the unit was 27.31 lbs. The calculated mass/volume concentration for the test was 202 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 11**.

Sixteen (16) background concentrations samples were collected throughout the test and ranged from 0.5 to 1.9 mg/L. The background curve is shown on **Figure 12**.

The total mass collected from the unit was 17.16 lbs, resulting in a removal efficiency of 62.8%.

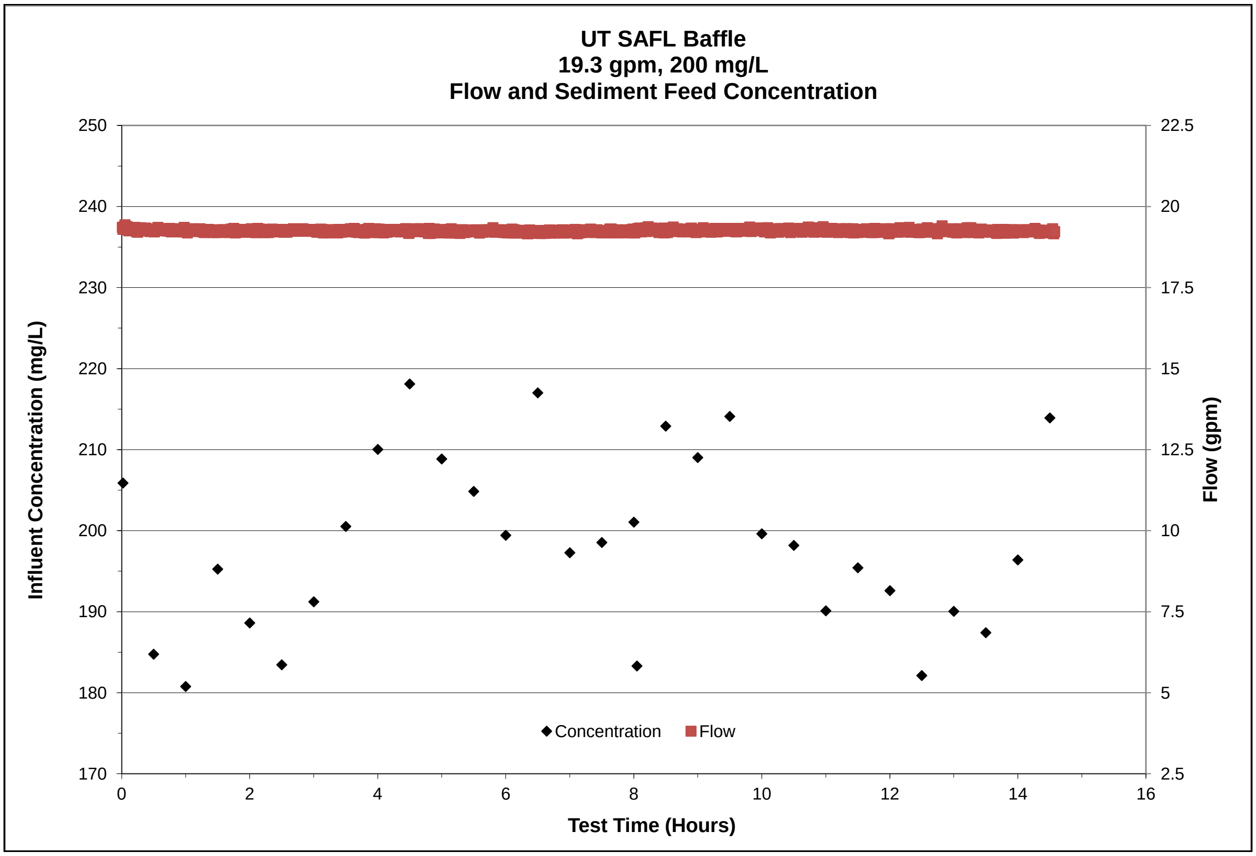

Figure 11 19 gpm Measured Flow and Influent Concentrations

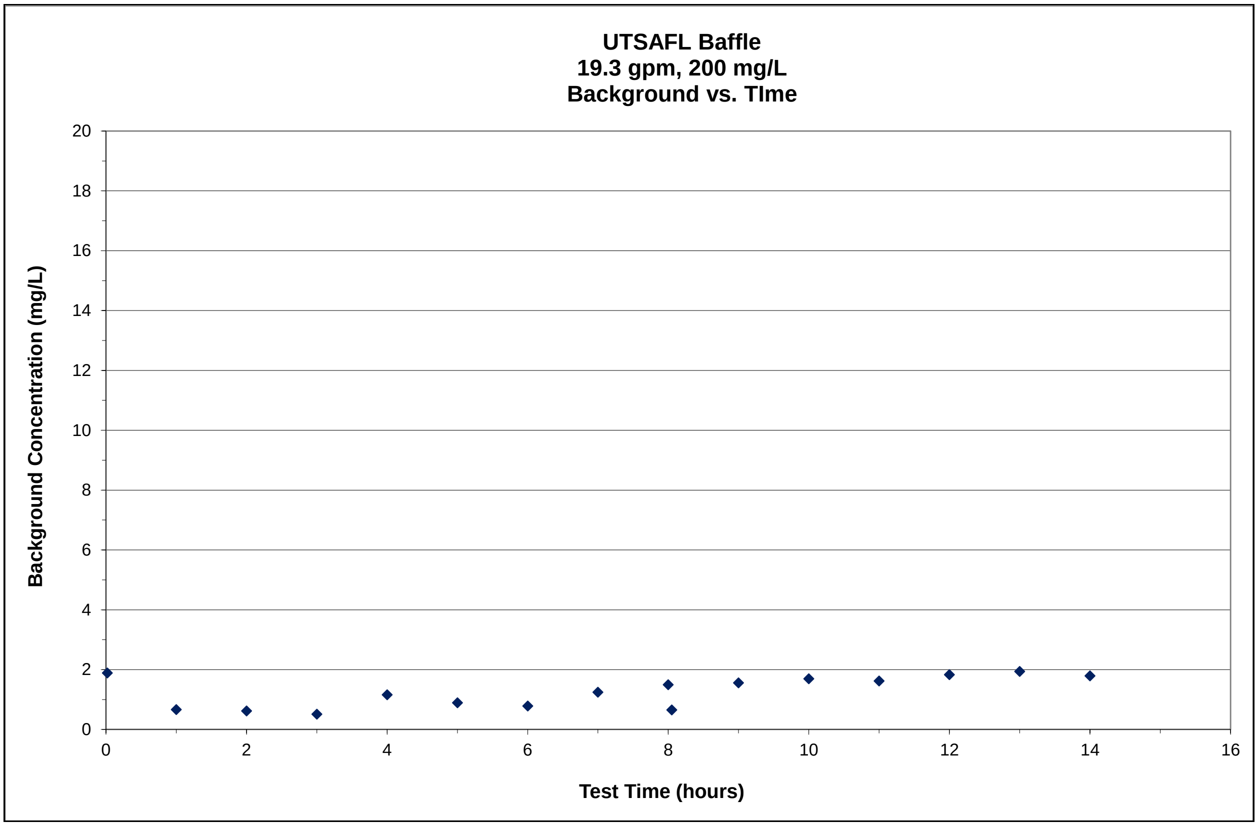

Figure 12 19 gpm Measured Background Concentrations

32% MTFR (39 gpm)

The test was conducted at 39 gpm over a period of 7 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 38.6 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 66.3 to 66.8 degrees F.

The injection feed rate of 29.2 g/min was verified by collecting timed weight samples from the injector every 30 minutes. The calculated influent injection concentrations for the full test ranged from 181 mg/L to 218 mg/L, with a mean of 196 mg/L and COV of 0.05. The total mass injected into the unit was 26.06 lbs. The calculated mass/volume concentration for the test was 195 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 13**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 2.2 to 5.1 mg/L. The background curve is shown on **Figure 14**.

The total mass collected from the unit was 14.58 lbs, resulting in a removal efficiency of 55.9%.

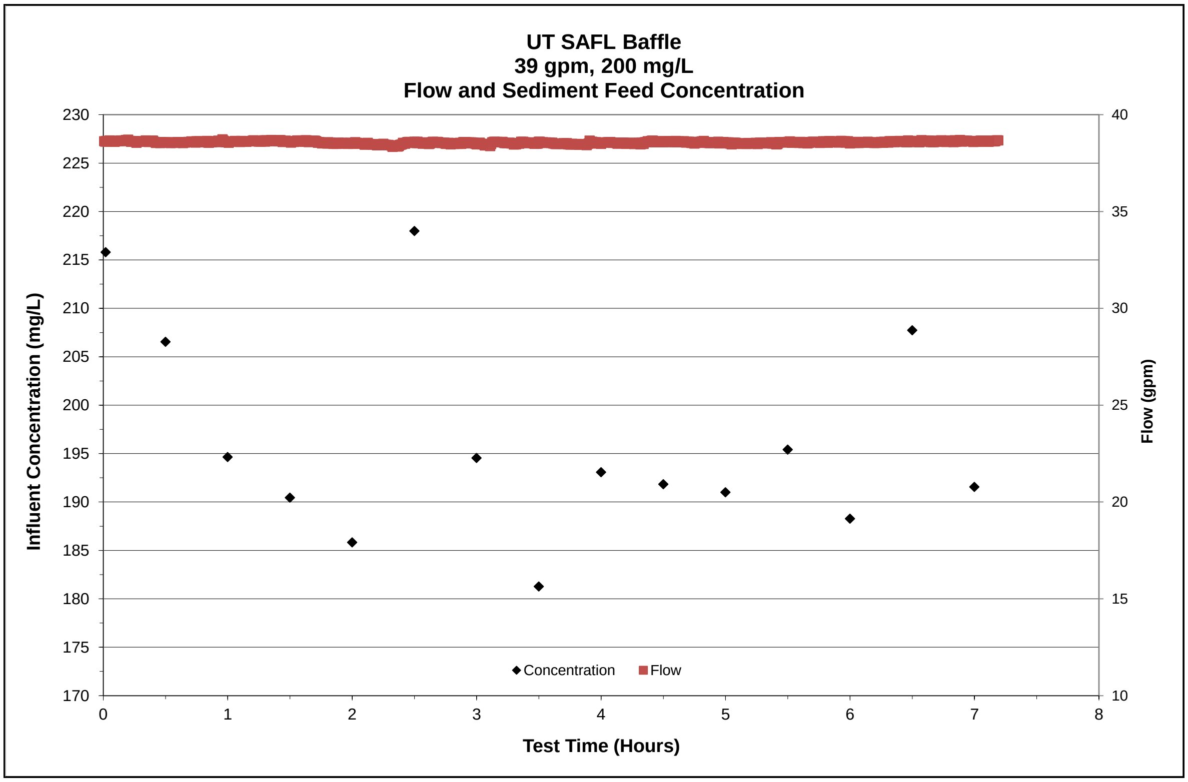

Figure 13 39 gpm Measured Flow and Influent Concentrations

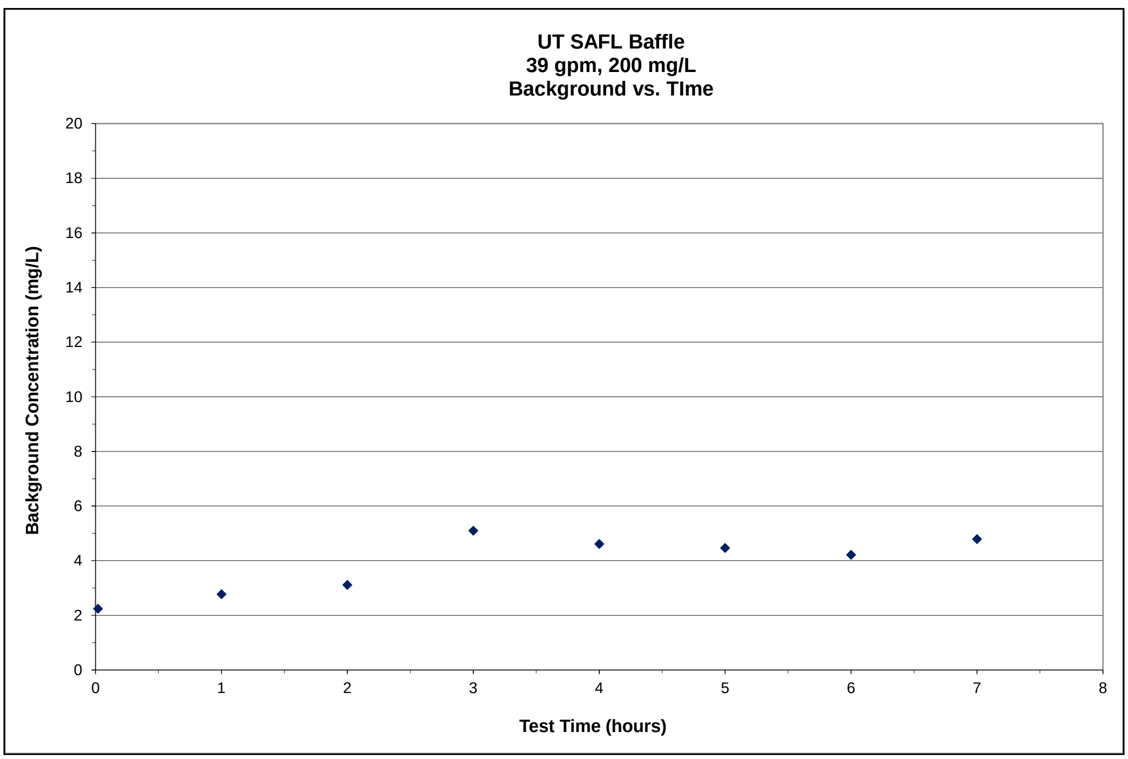

Figure 14 39 gpm Measured Background Concentrations

46% MTFR (55 gpm)

The test was conducted at 55 gpm over a period of approximately 5 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 55.2 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 73.8 to 74.3 degrees F.

The injection feed rate of 41.7 g/min was verified by collecting timed weight samples from the injector every 40 minutes. The calculated influent injection concentrations for the full test ranged from 197 mg/L to 202 mg/L, with a mean of 200 mg/L and COV of 0.01. The total mass injected into the unit was 24.77 lbs, <1% of the required 25 lbs. (To be protocol compliant this was increased to 25.00 lbs for removal efficiency calculations, reducing the removal efficiency percentage 0.5%). The calculated mass/volume concentration for the test was 191 mg/L, which accounted for the injected mass being low. The measured flow and influent concentration data for the complete test is shown on **Figure 15**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.4 to 2.5 mg/L. The background curve is shown on **Figure 16**.

The total mass collected from the unit was 13.60 lbs, resulting in a removal efficiency of 54.4%.

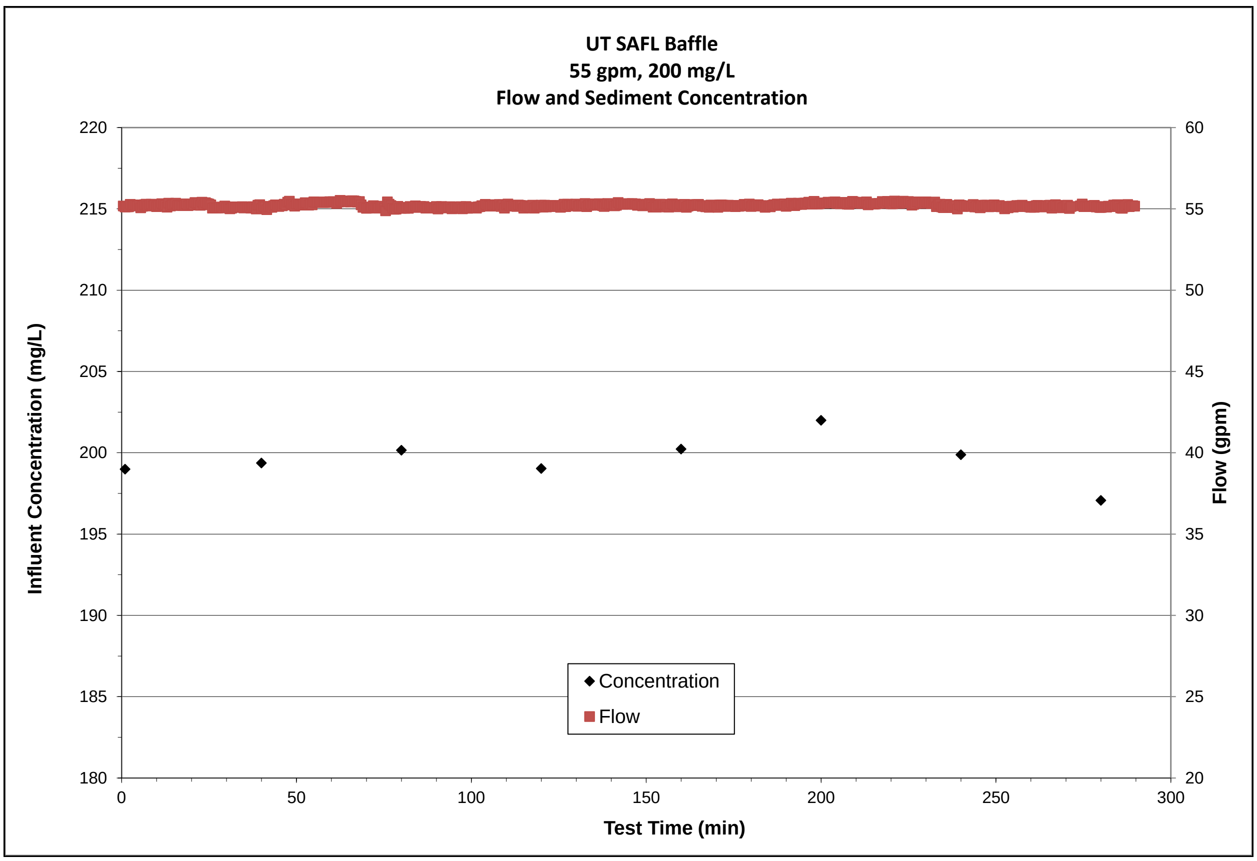

Figure 15 55 gpm Measured Flow and Influent Concentrations

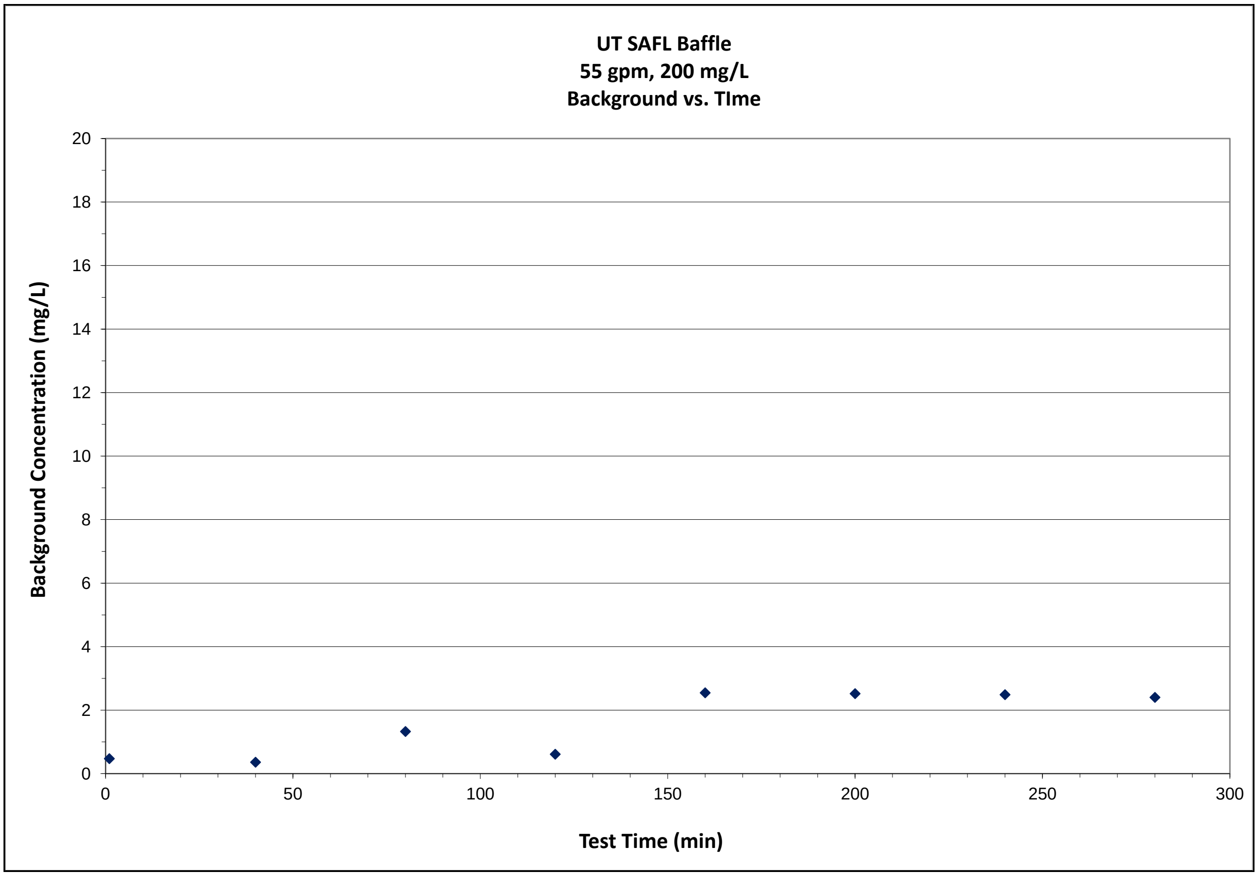

Figure 16 55 gpm Measured Background Concentrations

80% MTFR (96 gpm)

The test was conducted at 96 gpm over a period of approximately 3 hours. The test flow was averaged and recorded every 30 seconds throughout the test. The average recorded test flow was 96.4 gpm, with a COV of 0.001. The recorded temperature for the full test ranged from 65.3 to 65.4 degrees F.

The injection feed rate of 73.0 g/min was verified by collecting timed weight samples from the injector every 25 minutes. The calculated influent injection concentrations for the full test ranged from 190 mg/L to 216 mg/L, with a mean of 206 mg/L and COV of 0.04. The total mass injected into the unit was 28.09 lbs. The calculated mass/volume concentration for the test was 207 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 17**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.3 to 7.9 mg/L. The background curve is shown on **Figure 18**.

The total mass collected from the unit was 12.43 lbs, resulting in a removal efficiency of 44.3%.

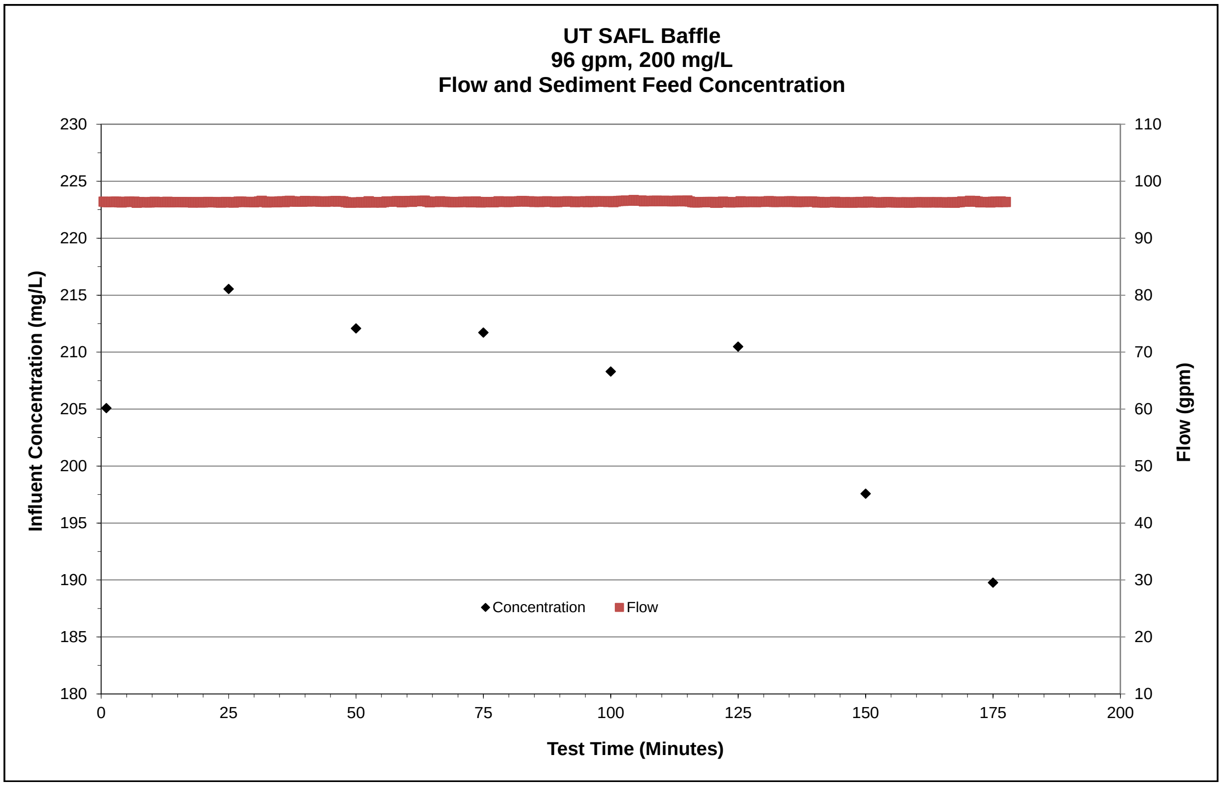

Figure 17 96 gpm Measured Flow and Influent Concentrations

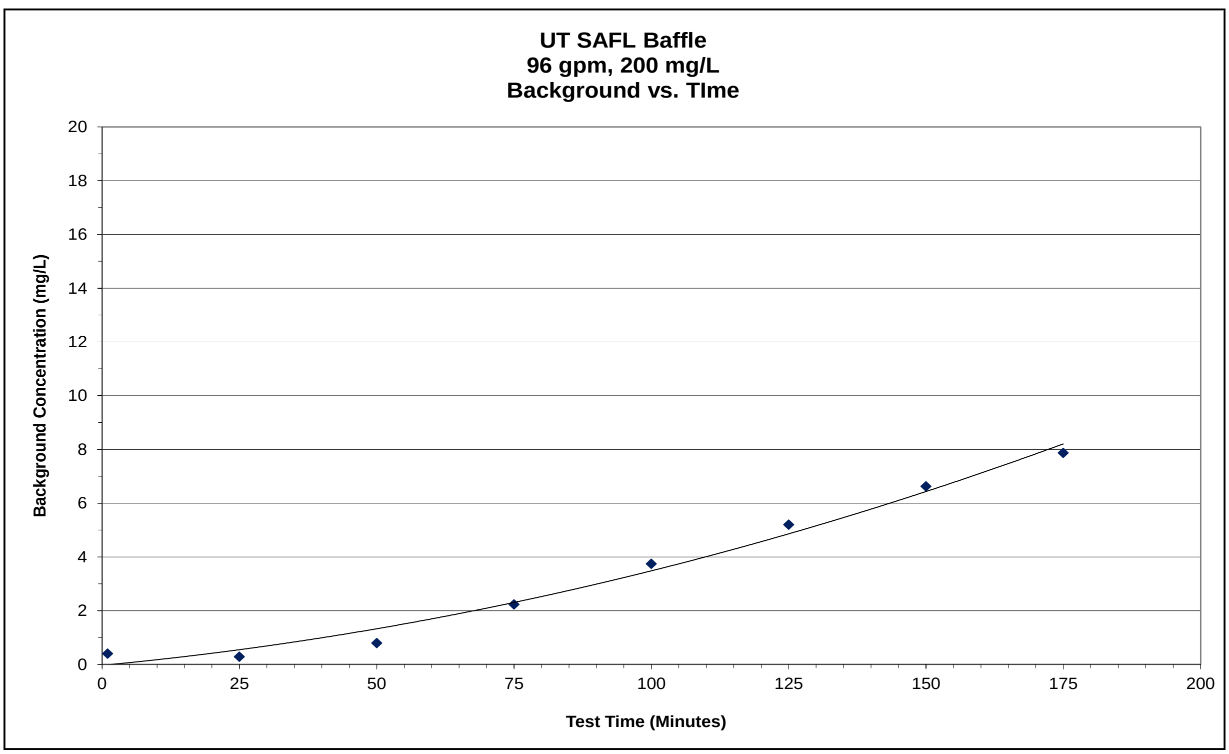

Figure 18 96 gpm Measured Background Concentrations

92% MTFR (110 gpm)

The test was conducted at 96 gpm over a period of approximately 2.5 hours. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 110.1 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 68.4 to 68.6 degrees F.

The injection feed rate of 83.3 g/min was verified by collecting timed weight samples from the injector every 21 minutes. The calculated influent injection concentrations for the full test ranged from 197 mg/L to 203 mg/L, with a mean of 200 mg/L and COV of 0.01. The total mass injected into the unit was 26.81 lbs. The calculated mass/volume concentration for the test was 201 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 19**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.8 to 7.8 mg/L. The background curve is shown on **Figure 20**.

The total mass collected from the unit was 11.94 lbs, resulting in a removal efficiency of 44.5%.

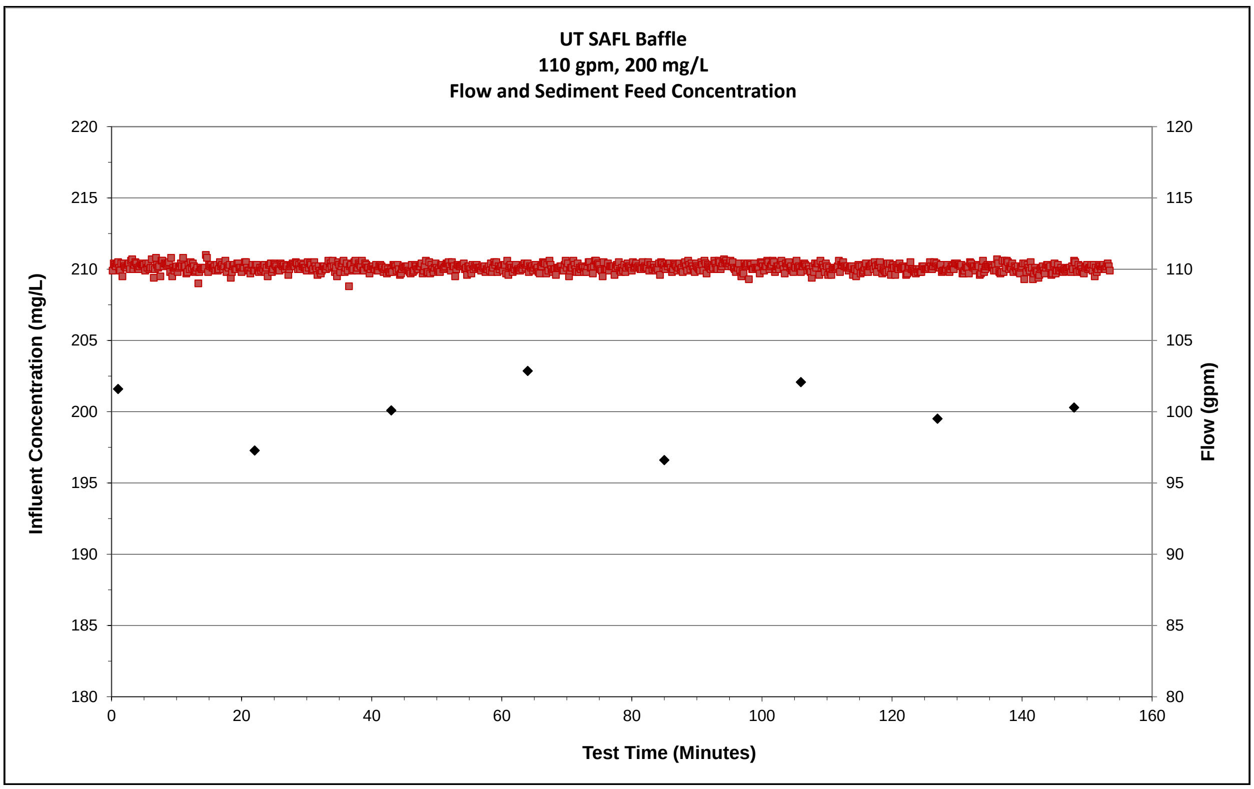

Figure 19 110 gpm Measured Flow and Influent Concentrations

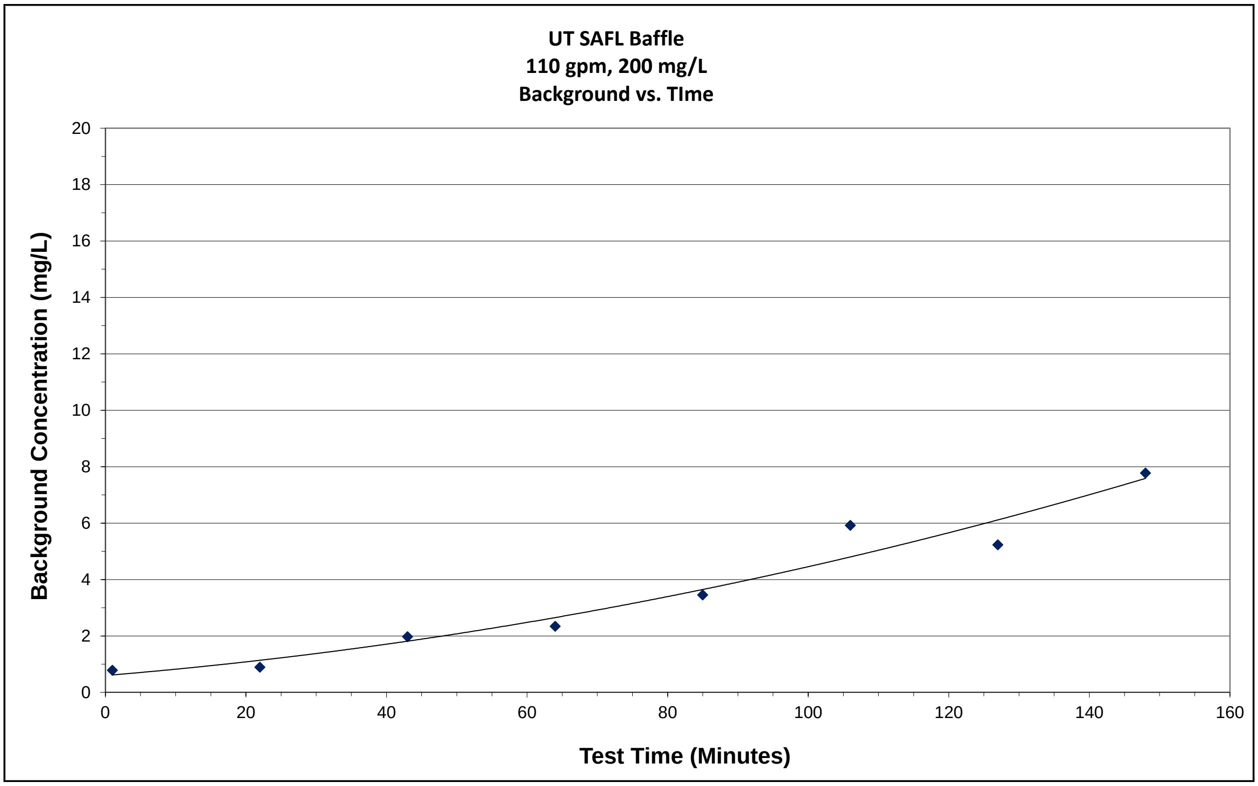

Figure 20 110 gpm Measured Background Concentration

115% MTFR (138 gpm)

The test was conducted at 138 gpm over a period of 2 hours. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 137.8 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 67.7 to 67.8 degrees F.

The injection feed rate of 104.1 g/min was verified by collecting timed weight samples from the injector every 17 minutes. The calculated influent injection concentrations for the full test ranged from 194 mg/L to 203 mg/L, with a mean of 200 mg/L and COV of 0.01. The total mass injected into the unit was 26.35 lbs. The calculated mass/volume concentration for the test was 199 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 21**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.3 to 9.3 mg/L. The background curve is shown on **Figure 22**.

The total mass collected from the unit was 11.24 lbs, resulting in a removal efficiency of 42.7%.

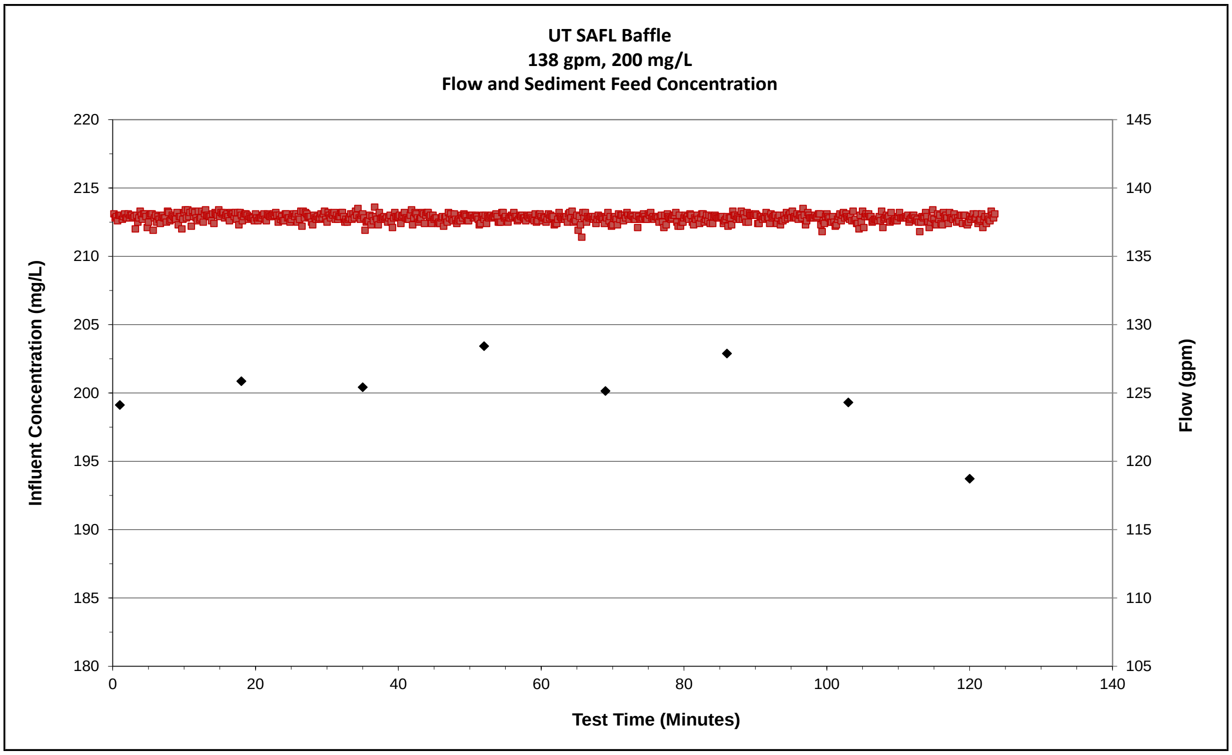

Figure 21 138 gpm Measured Flow and Influent Concentrations

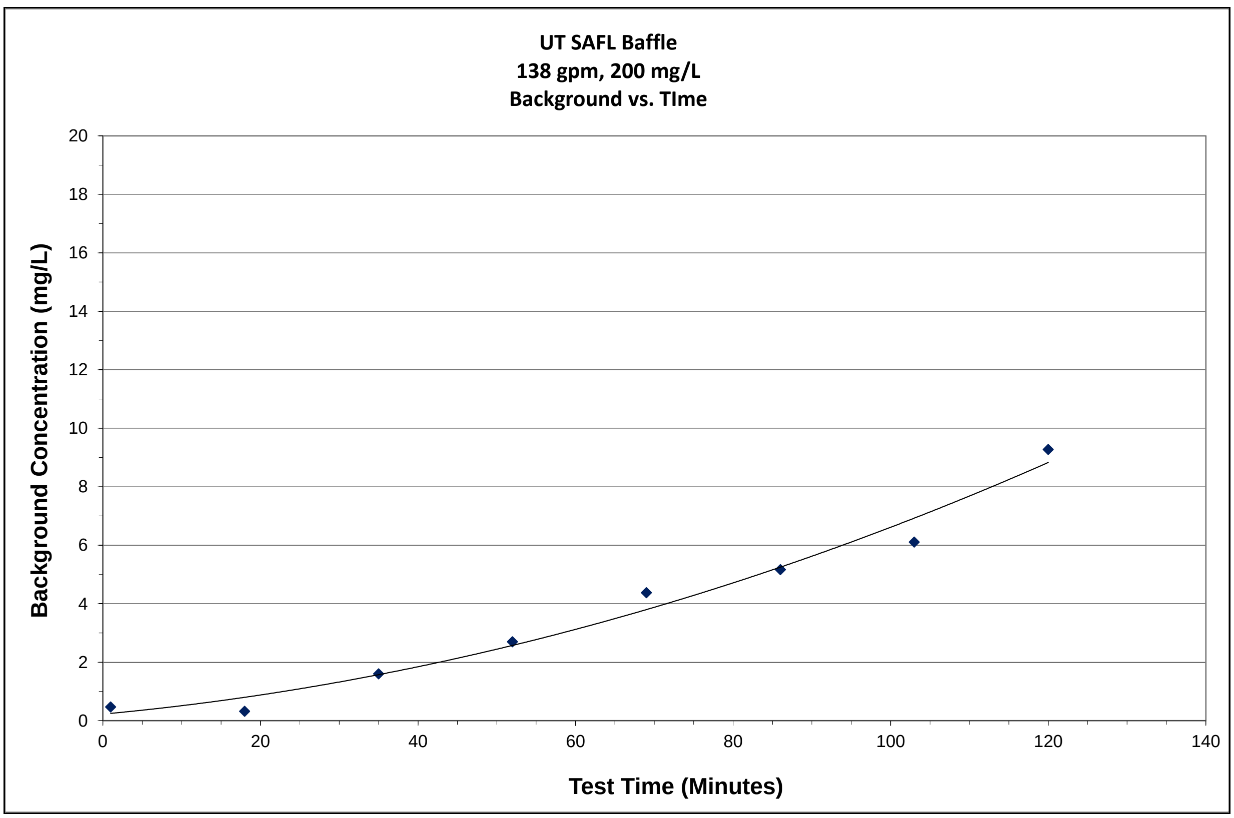

Figure 22 138 gpm Measured Background Concentrations

161% MTFR (193 gpm)

The test was conducted at 193 gpm over a period of 90 minutes. The test flow was averaged and recorded every 10 seconds throughout the test. The average recorded test flow was 193.2 gpm, with a COV of 0.002. The recorded temperature for the full test ranged from 65.7 to 65.8 degrees F.

The injection feed rate of 145.9 g/min was verified by collecting timed weight samples from the injector every 13 minutes. The calculated influent injection concentrations for the full test ranged from 193 mg/L to 208 mg/L, with a mean of 200 mg/L and COV of 0.03. The total mass injected into the unit was 25.91 lbs. The calculated mass/volume concentration for the test was 197 mg/L. The measured flow and influent concentration data for the complete test is shown on **Figure 23**.

Eight (8) background concentrations samples were collected throughout the test and ranged from 0.5 to 10.4 mg/L. The background curve is shown on **Figure 24**.

The total mass collected from the unit was 10.00 lbs, resulting in a removal efficiency of 38.6%.

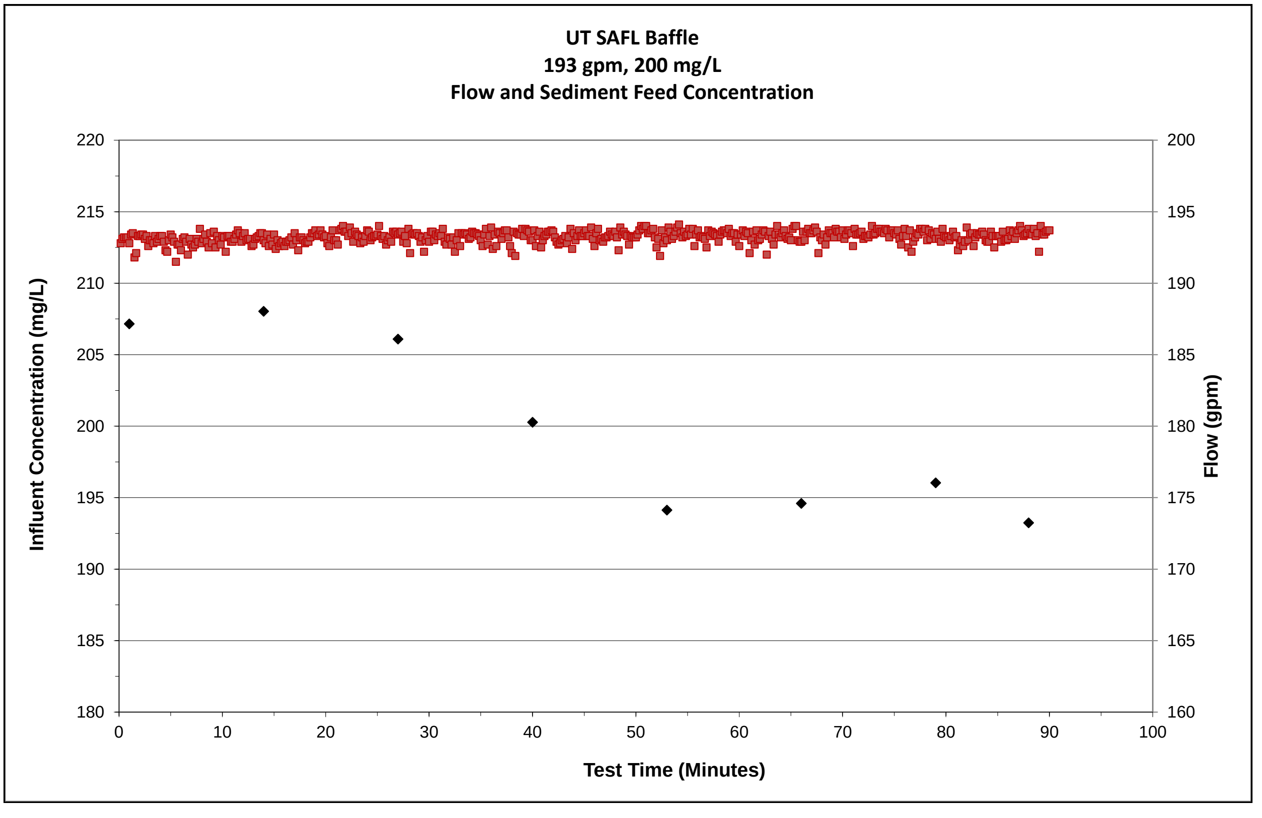

Figure 23 193 gpm Measured Flow and Influent Concentrations

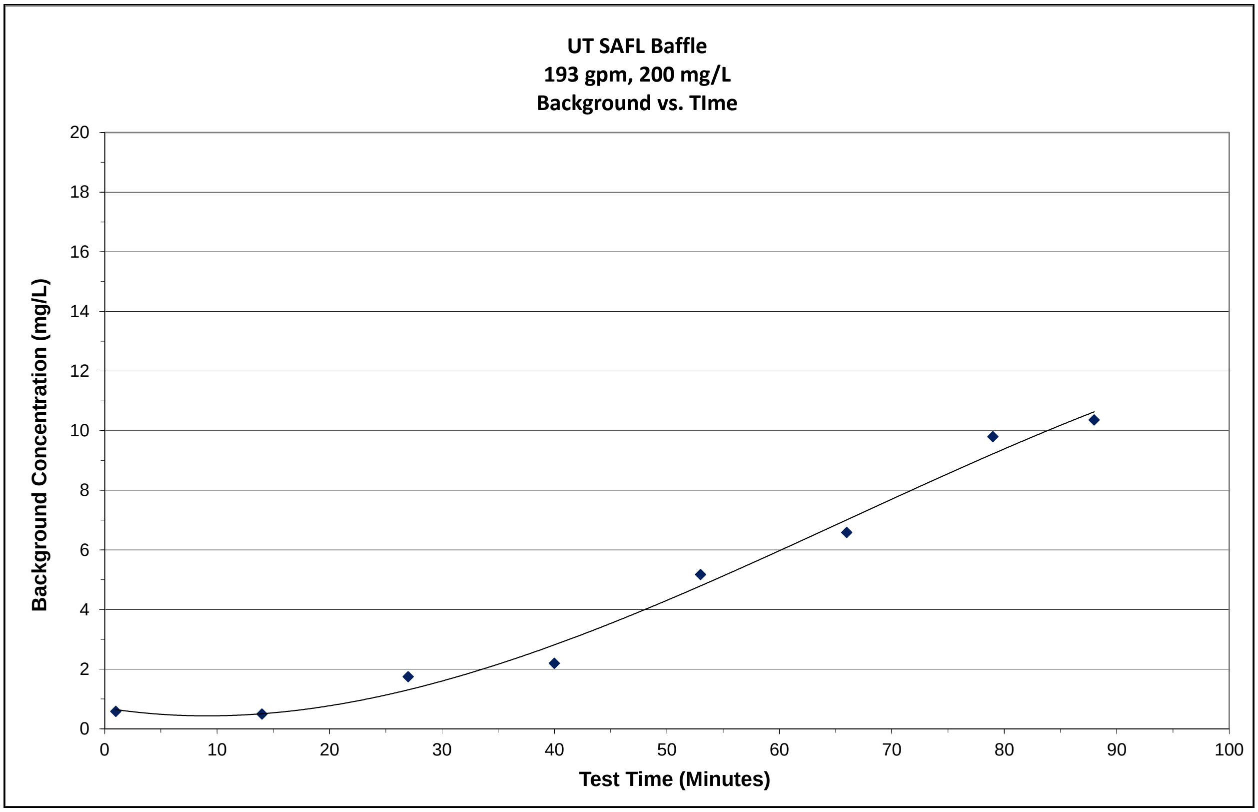

Figure 24 193 gpm Measured Background Concentrations

4.3 Scour Test

The commercially-available AGSCO NJDEP50-1000 certified sediment mix was utilized for the scour test. Three samples of the batch mix were analyzed in accordance with ASTM D422-63 (2019), 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** of **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 7** and the corresponding curves, including the initial AGSCO in-house analysis, are shown on **Figure 25**.

Table 7 PSD Analyses of AGSCO NJDEP 50-1000 Batch Mix

Particle size (µm)	NJDEP %-Finer Specifications	Test Sediment Particle Size (%-Finer)			
		Sample 1	Sample 2	Sample 3	Average
1000	100	100	100	100	**100**
500	90	95	95	95	**95**
250	55	58	58	59	**58**
150	40	41	41	42	**41**
100	25	23	23	23	**23**
75	10	10	10	11	**10**
50	0	1	1	1	**1**

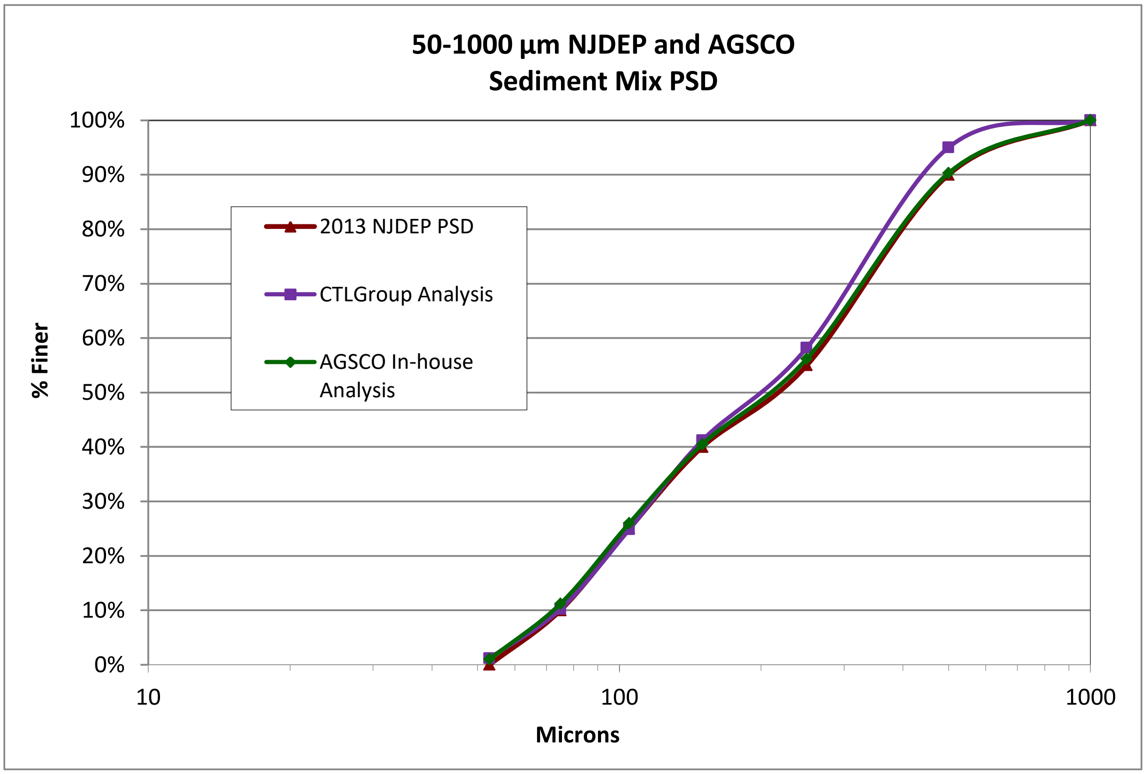

Figure 25 Scour Sediment PSD Curves

The scour test was conducted with the unit preloaded with 4 inches of sediment to the 50% capacity level. The false floor was lowered 4 inches to allow for the addition of the test sediment.

The test was conducted at 1218 gpm, which is equal to 1015% MTFR. This flow was selected by UT based on previously conducted tests. The flow data was recorded every 3 seconds throughout the test and is shown on **Figure 26.** The target flow was reached within 3 minutes of initiating the test. The average recorded steady-state flow was 1218 gpm, with a COV of 0.002. The recorded water temperature was 75.8 degrees F.

Eight background samples were collected throughout the duration of the test. The measured concentrations ranged from 2.5 to 3.0 mg/L, with an average concentration of 2.8 mg/L.

A total of 15 effluent samples were collected throughout the test. The calculated concentrations, adjusted for background, ranged from 0 to 1.7 mg/L, with an average concentration of 0.1 mg/L. The effluent and background concentration data are shown in **Table 8** and on **Figure 27**.

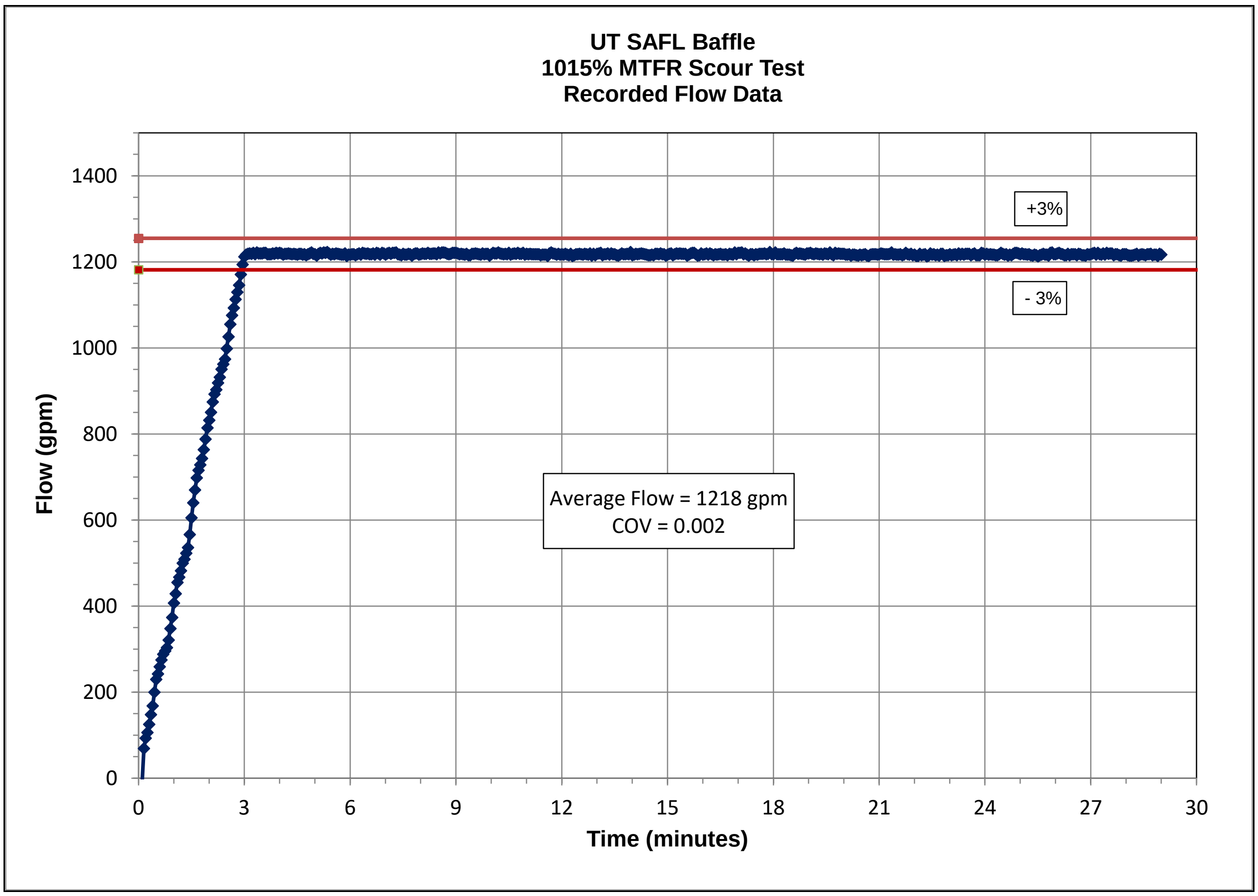

Figure 26 1015% MTFR Scour Test Recorded Flow Data

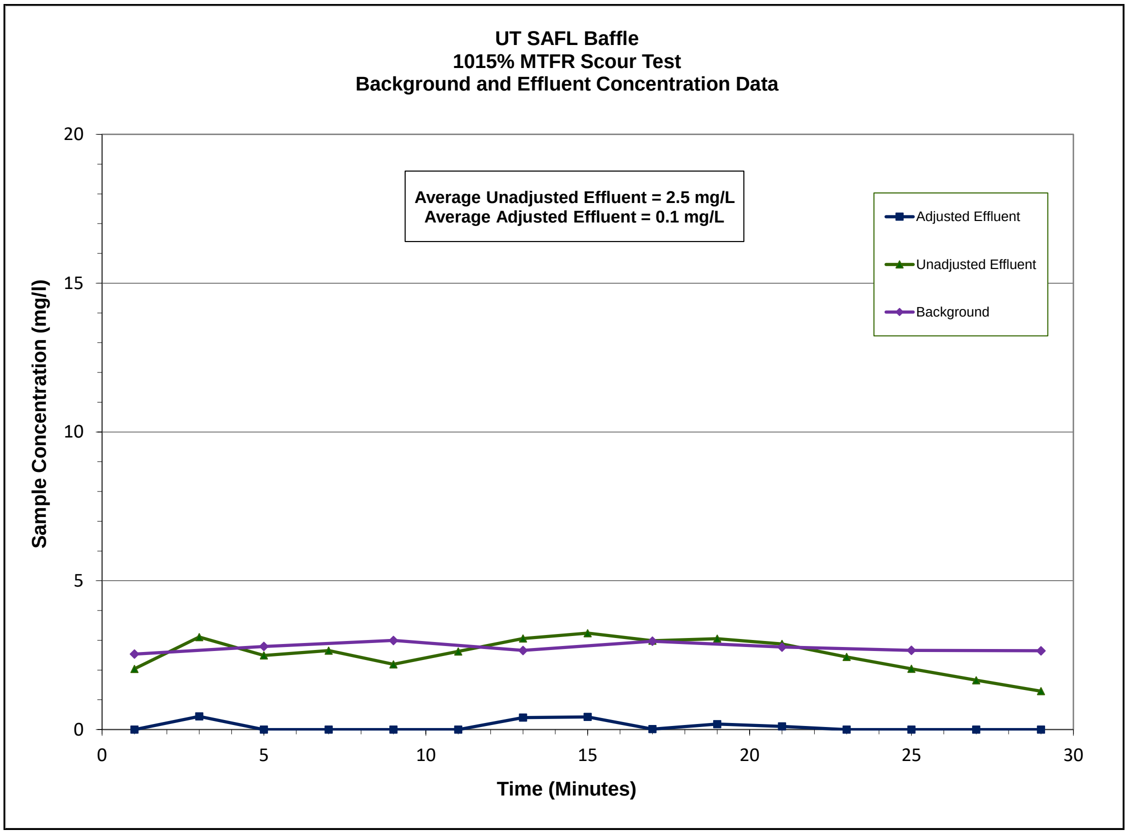

Figure 27 1015% MTFR Measured Background and Effluent Concentrations

Table 8 1015% MTFR Effluent Concentration Data

Sample ID	Timestamp (minutes)	Effluent Concentration (mg/L)	Background Concentration (mg/L)	Adjusted Effluent Concentration (mg/L)
EFF 1	1	2.04	2.54	0.00
EFF 2	3	3.11	2.67	0.44
EFF 3	5	2.49	2.79	0.00
EFF 4	7	2.65	2.89	0.00
EFF 5	9	2.19	3.00	0.00
EFF 6	11	2.62	2.83	0.00
EFF 7	13	3.06	2.66	0.40
EFF 8	15	3.24	2.81	0.42
EFF 9	17	2.99	2.97	0.02
EFF 10	19	3.05	2.87	0.18
EFF 11	21	2.88	2.77	0.11
EFF 12	23	2.44	2.72	0.00
EFF 13	25	2.04	2.66	0.00
EFF 14	27	1.66	2.66	0.00
EFF 15	29	1.29	2.65	0.00
	Average	**2.52**	**2.79**	**0.10**

4.4 Hydraulics

Piezometer taps were installed in the inlet and outlet pipe inverts and test tank, as described in **Section 2.2**. Flow (gpm) and water level (ft) within the system were measured for 15 flows ranging from 50 gpm to 2500 gpm (5.6 cfs). The recorded elevation data and system loss are shown in **Table 9** and on **Figure 28.** The pressure data for the inlet and outlet pipes were corrected for energy (velocity head). The greatest calculated loss of 0.37 ft was measured at the highest flow.

Table 9 Recorded Flow and Elevation Data

Flow	Inlet El. (A')	Outlet El. (C')	System Energy Loss
gpm	Corrected for V-head	Corrected for V-head	A'-C'
	ft	ft	ft
50.9	0.188	0.186	0.002
100.3	0.250	0.261	-0.011
201.7	0.359	0.370	-0.010
301.9	0.444	0.454	-0.010
404.1	0.519	0.531	-0.012
486.0	0.573	0.585	-0.013
599.1	0.640	0.656	-0.016
754.7	0.727	0.742	-0.014
901.6	0.803	0.811	-0.008
1118.0	0.911	0.914	-0.004
1303.0	1.021	0.998	0.023
1500.0	1.162	1.087	0.075
1754.7	1.344	1.199	0.145
2004.3	1.524	1.311	0.213
2497.7	1.925	1.555	0.370

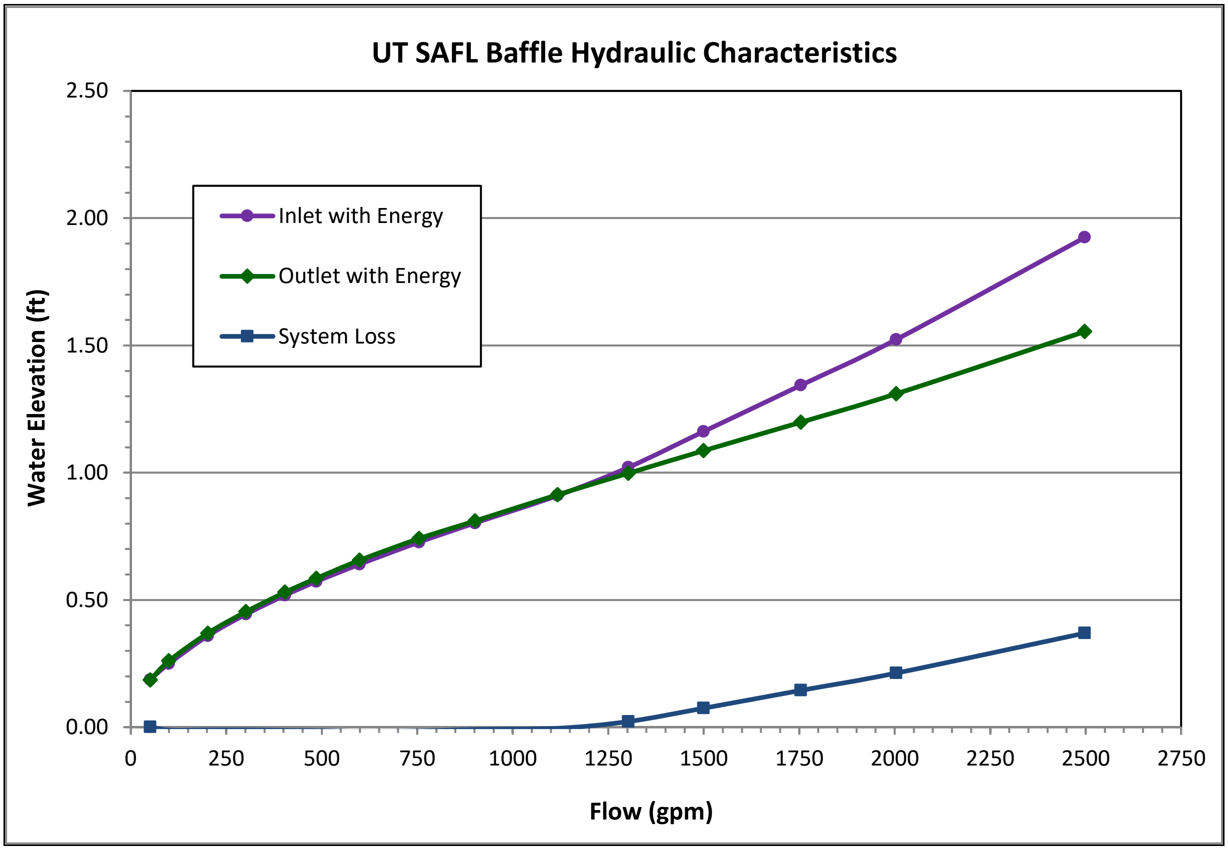

Figure 28 Measured Flow vs Water Elevations

5. Design Limitations

Upstream Technologies, Inc. has engineers to assist with submittals for every project. This includes selecting the correct SAFL Baffle model to meet the project requirements. Many factors impact the SAFL Baffles performance including inlet pipe diameter, slope of the inlet pipe, slope of the site, drainage area contributing to the SAFL Baffle, impervious area draining to the SAFL Baffle, infiltration rate of the pervious areas, and particle size distribution of the sediment. The following is a discussion of design limitations for the SAFL Baffle.

Slope

The SAFL Baffle performs optimally with inlet pipe slopes from near 0% to 3%. At slopes above 3%, the performance will be impacted and may require increasing the size of the unit to meet project requirements. Upstream Technologies engineers can assist with questions on pipe slope and whether a larger size unit is needed.

Maximum Flow Rate

The SAFL Baffle is available in 6 models to achieve the required treatment rate. In addition, multiple SAFL Baffles can be installed on larger sites (see bulleted items below). The SAFL

Baffle is designed to be installed online. At high flows exceeding the MTFR, the SAFL Baffle will retain previously captured sediment in the sump but capture of additional sediment will be reduced.

- Multiple SAFL Baffles can be used if they are installed in parallel. An example of a parallel installation is when a site has more than one branch (separate pipe runs) on the storm sewer system. One SAFL Baffle can be used per branch or pipe run.

- Do not install multiple SAFL Baffles in series. For example, two SAFL Baffle structures placed downstream to each other on the same storm sewer pipe near the outlet of the storm sewer will not work. The upstream SAFL baffle structure will perform all the sediment capture and any remaining sediment will be too fine to be captured in the downstream SAFL Baffle.

In some cases, maximum flow rate will be governed by structural capacity of the SAFL Baffle. A bracing kit is available to allow the SAFL Baffle to withstand higher flows, and the Upstream Technologies website contains guidance on maximum flows for unbraced and braced SAFL Baffles at: https://www.upstreamtechnologies.us/docs/SAFL-Baffle-Bracing-Detail.pdf.

Installation Limitations

The SAFL Baffle is installed in a standard precast concrete manhole purchased locally. It is shipped in a flat box, and all parts fit through a 24-inch inside diameter manhole casting. It can be installed before the top slab is placed on the manhole, after the manhole is constructed, or even after pavement is in place. SAFL Baffles can also be retrofitted into existing sump manholes. The retrofit must adhere to the sizing tables in the Verification Appendix. Installation instructions are shipped in the box with each SAFL Baffle.

The invert elevation of the outlet pipe must be at or no more than 6 inches below the invert elevation of the inlet pipe. The SAFL Baffle does not work properly with a larger drop between the inlet and outlet.

The SAFL Baffle is installed perpendicular to the inlet pipe. Make sure ladder rungs are in a location where they will not interfere with the installation of the SAFL Baffle. Upstream Technologies engineers are available to review a proposed SAFL Baffle structure and provide a drawing of the orientation/installation of the SAFL Baffle.

Load Limitations

The SAFL Baffle is installed in a standard, locally sourced precast structure. The required load rating or DOT standard needs to be identified on the storm sewer drawings for the project. It is the responsibility of the contractor to supply a structure that meets the load rating or DOT standard provided on the project plans and specifications.

Accessibility

The SAFL Baffle must be installed in a location that can be accessed by a vacuum truck. The depth of the structure must not exceed the reach of the hose on the vacuum truck that will be used for maintenance.

6. Maintenance

The SAFL Baffle is a stainless steel baffle installed in a concrete structure to capture sediment from stormwater runoff, and to retain the sediment in the structure during high flows. Once installed, the SAFL Baffle requires maintenance to perform properly. There are two major maintenance activities as detailed in the Upstream Technologies SAFL Baffle O&M manual at:

https://www.upstreamtechnologies.us/docs/SAFL_Baffle_Operations_and_Maintenance_Manual_NJDEP.pdf.

- Visual Inspection
- Sump Cleaning

Tools Needed

- Vacuum truck with jet power washer.
- Measuring tape with attached flat disk.
- Rake or broom.

Visual Inspection

Visual inspection needs to take place to ensure the SAFL Baffle is functioning properly and should take place 3 times per year for the first two years, then once each following year. Key inspection questions:

- Previous Inspections – When was the last time this structure was inspected?
- Access – Is the structure accessible? If not, remove the obstruction.
- Debris - Is trash or vegetation in the structure? If so, what types of trash or vegetation are present? Is there so much debris that it is difficult to see water? If so, sump cleaning is required.
- Structural Integrity – Push and pull on top of Baffle to insure it is still solidly anchored to the walls. Are there pieces of the Baffle that have become dislodged? Do any parts of the Baffle appear weak, damaged or loose? If so, retighten as needed. If parts are needed, contact Upstream Technologies at 651-237-5123.
- Clogging - Is anything clogging the Baffle? If so, what is causing the clogging? Attempt to remove debris stuck to the Baffle with a rake or broom.
- Sediment Accumulation – Several measurements should be taken to generate an average sediment depth. If average sediment depth is at or above 18 inches from the sump floor, the sump needs to be cleaned out. Sump depth is measured from the pipe invert to the sump floor.

Sump Cleaning

Sump cleaning needs to take place to ensure maximum capture of sediment from stormwater and should be performed at minimum once per year. The structure may need more frequent sump cleaning if sediment depth is consistently more than 18 inches above the sump floor. Sump depth is measured from the pipe invert to the sump floor. Sump cleaning involves:

- Vacuum water, debris, and sediment.
- Jet wash debris from Baffle.
- Jet wash any remaining debris and sediment towards vacuum hose.

7. Statements

The following signed statements from the manufacturer (Upstream Technologies, 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.

5201 East River Road, Suite 303
Fridley, MN 55421
July 27, 2022

Dr. Richard Magee, Sc.D., PE, 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 SAFL Baffle

Dear Dr. Magee,

Upstream Technologies Inc. has tested the SAFL Baffle 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 2021. 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 2021. The testing conducted at Alden Research Laboratory met or exceeded this protocol. Mr. James Mailloux oversaw and conducted all water quality tests of our 60x36 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,

Arthur Schwidder

Arthur Schwidder
Chairman & CTO

ALDEN
Solving flow problems since 1894

July 25, 2022

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 Upstream Technologies, Inc.

Protocol Compliance Statement

Alden performed the verification testing on the Upstream Technologies SAFL Baffle treatment system. The Technical Report and all required supporting data documentation has been submitted to NJCAT as required by the protocol.

Testing performed by ALDEN on the Upstream Technologies SAFL Baffle 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 1, 2021). One test was below the specified injected mass by 1% and was identified in the technical report.

James T. Mailloux

Principal Engineer
Alden Research Laboratory
jmailloux@aldenlab.com

(508) 829-6000 x6446

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

August 20, 2023

Gabriel Mahon, Chief
Bureau of NJPDES Stormwater Permitting & Water Quality Management
Division of Watershed Protection and Restoration
New Jersey Department of Environmental Protection
P.O. Box 420 Mail Code 501-02A
Trenton, NJ 08625-0420

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on the Upstream Technologies SAFL Baffle Stormwater Treatment Unit (SAFL Baffle) - Model 60 x 36, 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 1, 2021)"* (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 microns); the test sediment D_{50} was 65 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 SAFL Baffle 5-ft. diameter commercially available unit, to establish the ability of the SAFL Baffle to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the selected

MTFR (120 gpm). The tested SAFL Baffle demonstrated 50.3% 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 10.4 mg/L).

Scour Testing

To demonstrate the ability of the SAFL Baffle to be used as an online treatment device, scour testing was conducted at 1015% of the MTFR. The scour tests were conducted with the unit preloaded with 4" of sediment to the 50% capacity level (18"). The average unadjusted and adjusted background sediment concentrations were 2.5 mg/L and 0.1 mg/L. respectively. These results confirm that the SAFL Baffle meets the criteria for online use.

Maintenance Frequency

The predicted maintenance frequency for all SAFL Baffle models is 65 years.

Sincerely,

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

8. References

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ASTM (2019), *"Standard Test Methods for Determining Sediment Concentration in Water Samples"*, Annual Book of ASTM Standards, D3977-97, Vol. 11.02.

ASTM (2019), *"Standard Test Methods for Determination of Water (Moisture) Content of Soil by Direct Heating"*, Annual Book of ASTM Standards, D2216, Vol. 04.08.

ASTM (2021), *"Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis"*, Annual Book of ASTM Standards, D7928-21e1, Vol. 4.09.

Howard, Mohseni, Gulliver, and Stefan, *Assessment and Recommendations for the Operation of Standard Sumps as Best Management Practice for Stormwater Treatment (Volume 1)*, Minnesota Department of Transportation Research Services, Office of Policy Analysis, Research, and Innovation. February 2011.

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

NJDEP (2021). *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device.* Trenton, NJ. January 1, 2021.

VERIFICATION APPENDIX

Introduction

- Manufacturer – Upstream Technologies Inc. 5201 East River Road, Suite 303, Fridley, MN 55421. www.upstreamtechnologies.us 651-237-5123.
- Upstream Technologies SAFL Baffle verified models are shown in **Table A-1** and **Table A-2**.
- TSS Removal Rate – 50%
- Online or offline installation

Detailed Specification

- NJDEP sizing table and physical dimensions of the SAFL Baffle 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 60 x 36 SAFL Baffle model has a maximum treatment flow rate (MTFR) of 0.27 cfs (120 gpm), which corresponds to a surface loading rate of 6.1 gpm/ft^2 of sedimentation area.
- The maximum recommended sediment depth prior to cleanout is 50% of the maximum sediment storage depth shown in **Table A-2**.
- SAFL Baffle Operations and Maintenance Manual is at: https://www.upstreamtechnologies.us/docs/SAFL_Baffle_Operations_and_Maintenance_Manual_NJDEP.pdf
- The sediment removal interval for all the SAFL Baffle models is 65 years.
- Under N.J.A.C. 7:8-5.5, NJDEP stormwater design requirements do not allow a hydrodynamic separator such as the SAFL Baffle 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 SAFL Baffle Models

Model	Diameter (ft)	Maximum Treatment Flow Rate[1] (cfs)	Treatment Area (ft^2)	Hydraulic Loading Rate (gpm/ft^2)	50% Sediment Storage Capacity[3] (ft^3)	Sediment Removal Interval[2] (years)
60 x 36	5	0.27	19.6	6.1	29.4	65
72 x 36	6	0.39	28.3	6.1	42.5	65
84 x 46	7	0.53	38.5	6.1	57.8	65
96 x 46	8	0.69	50.3	6.1	75.5	65
108 x 46	9	0.87	63.6	6.1	95.4	65
120 x 57	10	1.08	78.5	6.1	117.8	65

1. Based on a verified loading rate of 6.1 gpm/ft^2 for test sediment with a D50 of 66 µm and an annualized weighted TSS removal of at least 50% using the methodology in the current NJDEP HDS protocol.
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.
3. 50% Sediment Storage Capacity is equal to the manhole area x (0.5 x sediment storage depth) shown in Table A-2.

Table A-2 Standard Dimensions for SAFL Baffle Models

Model	SAFL Baffle Width[5] (in)	SAFL Baffle Height[6] (in)	SAFL Baffle Open Area (%)	Minimum Inlet/Outlet Pipe Dia.[7] (in)	Chamber Depth[1] (in)	Sediment Storage Depth[2] (in)	Effective Treatment Depth[3] (in)	Aspect Ratio[4]
60 x 36	60	36	41.8	15	60	36	42	0.70
72 x 36	72	36	41.4	18	60	36	42	n/a
84 x 46	84	46	43.2	21	60	36	42	n/a
96 x 46	96	46	41.8	24	76	36	58	0.60
108 x 46	108	46	42.9	27	84	36	66	0.61
120 x 57	120	57	44.3	30	90	36	72	0.60

1. Inlet invert to chamber bottom.
2. Sediment storage depth for all SAFL Baffle Models is 3 ft. Upstream Technologies recommends removing accumulated sediment from the sump when it is at 50% of the sediment storage depth.
3. Effective treatment depth is defined as the chamber depth minus ½ the sediment storage depth (18”).
4. Aspect ratio is defined as the ratio of the effective treatment depth to manhole diameter. Larger models (> 250% MTFR, i.e., 0.65 cfs) of the unit tested must be geometrically proportionate to the test unit. A variance of ± 15% is allowable (0.595 to 0.805).
5. SAFL Baffle width = diameter of the precast structure.
6. SAFL Baffles come in three heights (36”, 46”, 57”). The bottom of the baffle must be installed at least 1 foot below the invert elevation of the inlet pipe. (Note it can be installed more than the 12” below the invert as long as the depth from the bottom of the baffle to the sediment storage depth is at least 12”.) Best practice is to have the top of the SAFL Baffle at least 6” above the inside top of the inlet pipe. It is acceptable for the top of the SAFL Baffle to extend more than 6” above the inside top of the pipe. Under no circumstances shall the top of the SAFL baffle be below the inside top of the pipe.
7. The ratio of pipe diameter to structure diameter is 0.25 for each SAFL Baffle model. A larger ratio of pipe diameter to structure diameter may influence SAFL Baffle model performance. This is true of all HDS.

Table A-3 SAFL Baffle Model Details[1]

Model	Number of Panels		18-inch Panels		24-inch Panels		Model Baffle Open Area (%)
	18-inch	24-inch	Width (in)	Height (in)	Width (in)	Height (in)	
60 x 36	2	1	18	36	24	36	41.8
72 x 36	0	3	-	-	24	36	41.4
84 x 46	2	2	18	46	24	46	43.2
96 x 46	0	4	-	-	24	46	41.8
108 x 46	2	3	18	46	24	46	42.9
120 x 57	0	5	-	-	24	57	44.3

1. When the SAFL Baffle is scaled up, the width and height increases. This provides more panel area and increases the number of holes. The hole diameter remains the same for each panel width, and the number of holes is increased as the height increases to maintain essentially the same percent open area.