NJCAT TECHNOLOGY VERIFICATION

StormVault BioFiltration (SVBF)

with Sierra Blend

Jensen Water Resources

April 2020

Table of Contents

List of Figures

List of Tables

1. Description of Technology

The ***StormVault BioFiltration (SVBF)*** unit is a Manufactured Treatment Device (MTD) which utilizes bioretention and gravity filtration for stormwater treatment. Through filtration and sedimentation, the ***SVBF*** unit removes stormwater pollutants including total suspended solids (TSS), trash and debris. The ***SVBF*** unit consists of a precast concrete vault filled with Jensen Water Resources' (formerly Jensen Stormwater Systems) engineered ***Sierra Blend***.

A mulch layer and inlet rip rap bay on top of the media help capture larger trash and debris, while also protecting the media from erosion and scour under high flow conditions. The system's underdrain consists of a coarse gravel layer and perforated effluent pipe beneath the media. The ***SVBF*** unit can be deployed with either an internal or external bypass, allowing excess flows to continue downstream of the unit without exceeding its treatment capacity.

The ***SVBF*** unit is primarily a bio-filtering system consisting of the following, layered from bottom to top: 4, 6 or 8-inch diameter perforated underdrain piping surrounded by stone, 6-inches of bridging stone, 18-inches of ***Sierra Blend*** bio-soils media, 3-inches of mulch, and 6-inches of ponding depth with at least 6-inches of freeboard. An apron of 4 to 6-inch diameter stone is placed beneath the inflow point as rip rap for erosion control. The overall unit configuration with descriptions of the treatment flow path process is shown in **Figure 1**.

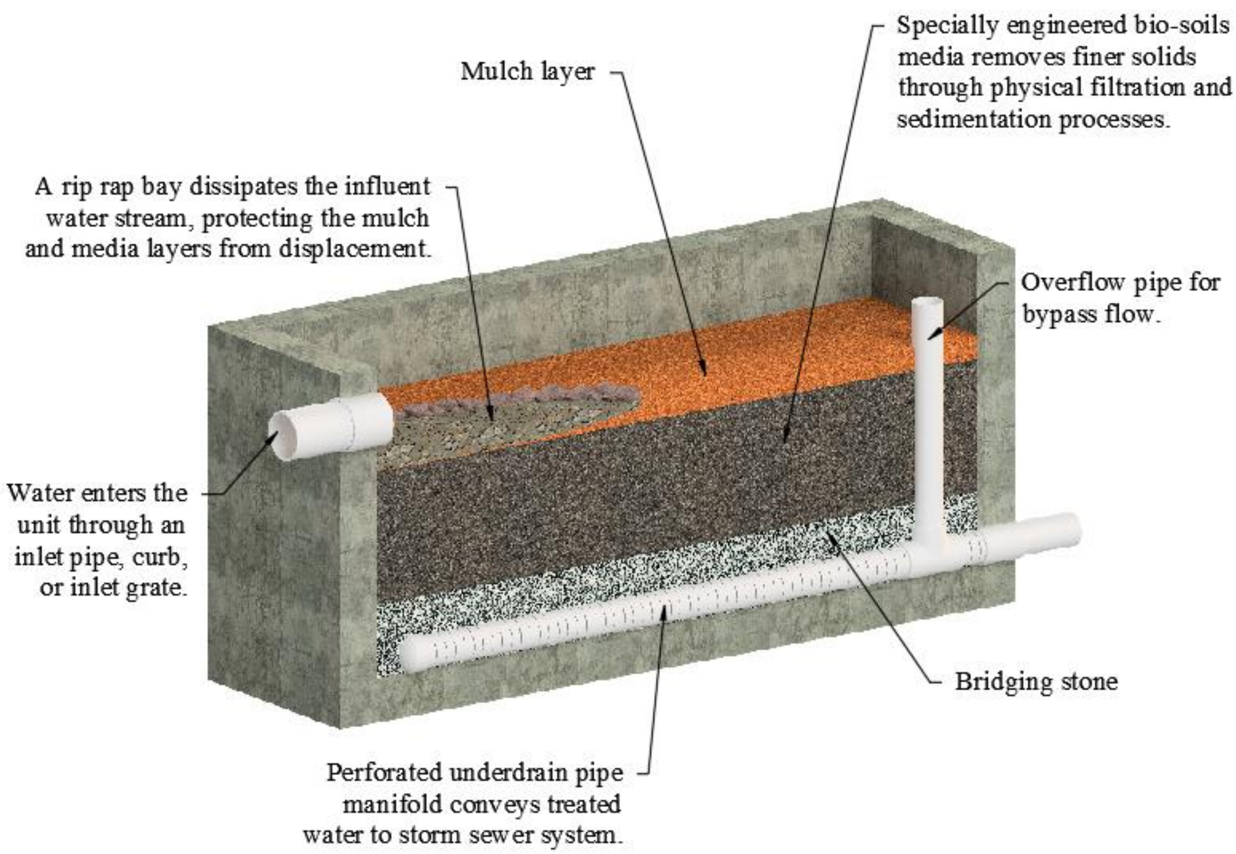

Figure 1 Flow of Typical "Online" SVBF Unit

The ***SVBF*** unit is available in several configurations, allowing Jensen to offer multiple solutions for any project. Units may also be deployed as open top planter boxes for shrubs and other smaller plants, or as grated tree boxes. The ***SVBF*** unit may also be configured as an underground treatment vault fed by a subsurface inlet pipe. All unit configurations can be deployed with block outs to facilitate groundwater infiltration. The default design uses plugged block outs. A commercial unit drawing of the ***SVBF*** can be seen in **Figure 2**.

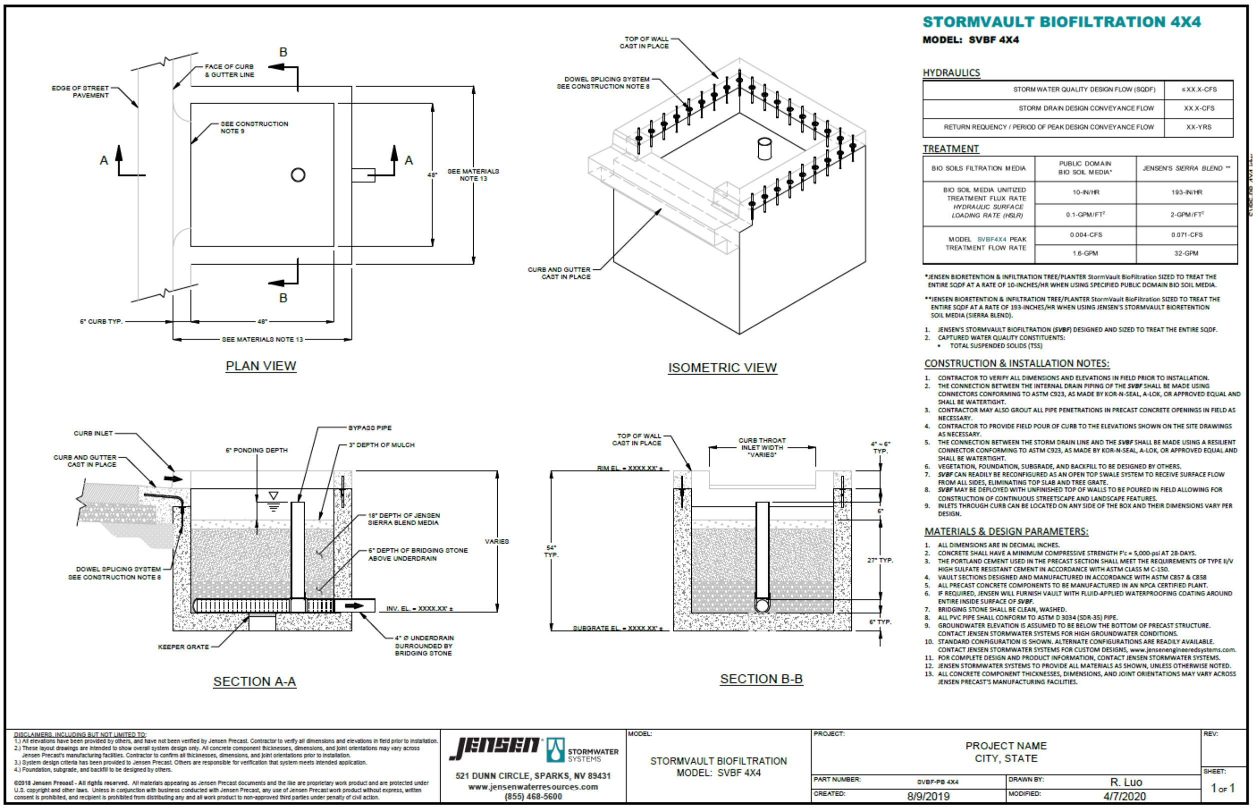

Figure 2 Commercial *StormVault Biofiltration* Unit Drawing

2. Laboratory Testing

Laboratory testing was performed to independently verify that the ***StormVault BioFiltration*** (***SVBF***) stormwater treatment unit is eligible for certification by the New Jersey Department of Environmental Protection (NJDEP) as an 80% Total Suspended Solids (TSS) removal Manufactured Treatment Device (MTD).

The ***SVBF*** unit was tested in accordance with the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Filtration Manufactured Treatment Device* (NJDEP, 2013). Testing was conducted at Jensen's outdoor stormwater testing facility in Sparks, Nevada.

Performance tests were conducted under the direct supervision of Professor Keith Dennett, Ph.D., P.E., and Professor Mark Hausner, Ph.D. Professor Dennett is an Associate Professor in the

Department of Civil and Environmental Engineering, University of Nevada, Reno. Professor Hausner is an Assistant Research Professor of Hydrology in the Division of Hydrologic Sciences, Desert Research Institute. Professor Dennett and Professor Hausner served as the independent third-party observers of all tests on the ***SVBF*** unit. Due to scheduling restraints, these two third-party observers were used to ensure that all testing could be completed in a reasonable time period. Employment of these two third-party observers was approved by NJCAT.

2.1 Test Unit

The test unit was a full-scale, commercially available ***StormVault BioFiltration*** Model ***SVBF4x4***. This test unit had all the same internal components and dimensions of the commercially available unit, but it was housed in a constructed plywood vault rather than a precast concrete vault. This made transporting and supporting the test unit more feasible for a laboratory setting. The design specifications for the ***SVBF4x4*** are provided in **Table 1.**

Table 1 SVBF4x4 Dimensions and Treatment Flow Rate

Maximum Treatment Flow Rate (MTFR)		Internal Dimensions (LxWxD)	Sediment Storage	Effective Treatment Area	Loading Rate
cfs	gpm	ft	lbs	ft^2	gpm/ft^2
0.07	32	4x4x4	176.7	16	2

2.2 Test Setup

The testing facility is a closed loop, re-circulating system with fine membrane filtration in the recirculation piping from the return to the supply tanks (**Figure 3**). The piping into and out of the test unit is 6-in and 4-in PVC, respectively. The calibrated electromagnetic flow meters attached to the supply pumps served as the primary flow measuring devices.

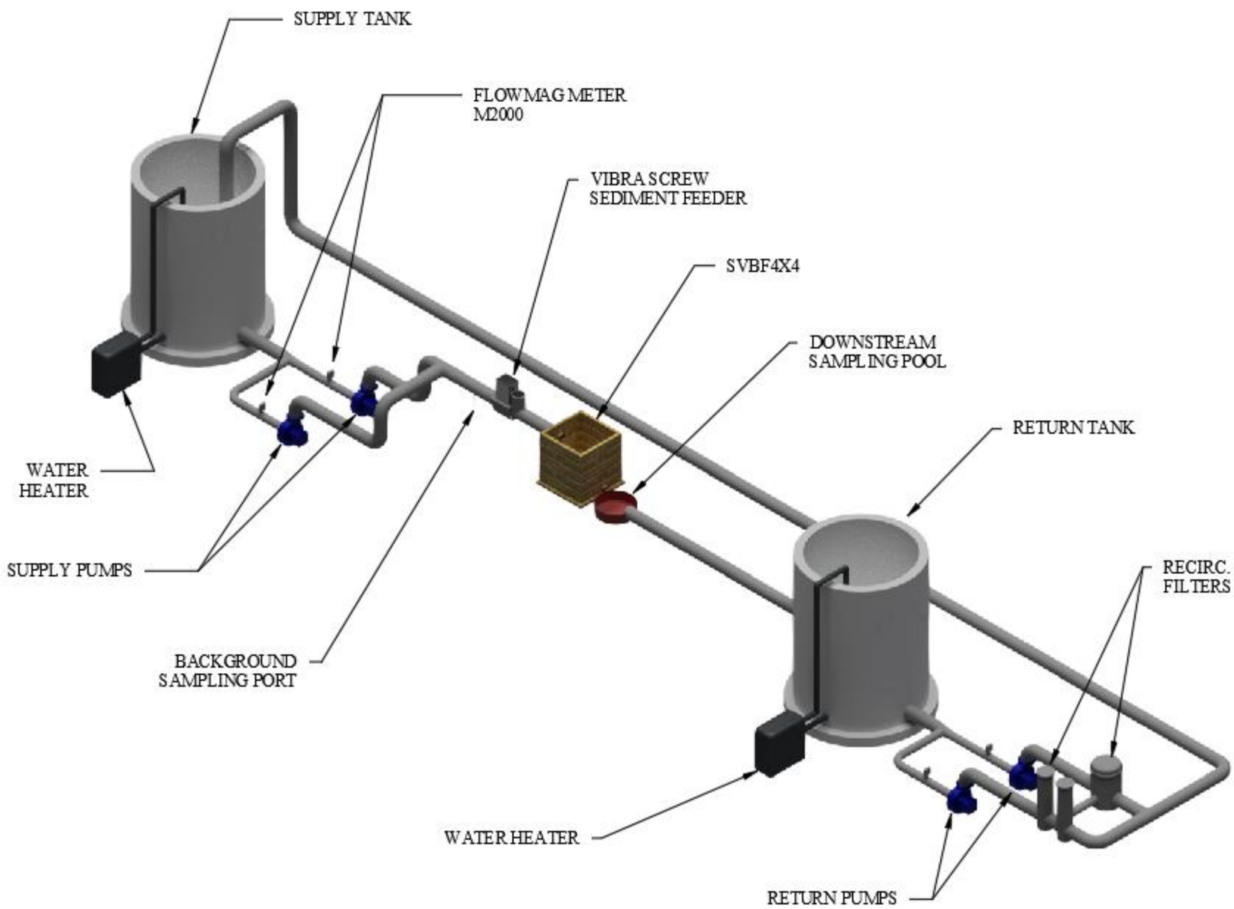

Figure 3 Lab Setup Schematic

Water Flow and Measurement

Flow can be pumped from both supply and return tanks using one of two Grundfos Model LC pumps (250 and 700-gpm capacity). The 700-gpm capacity pump was closed off and bypassed only allowing the 250-gpm capacity pump to be in operation throughout testing. A ModMag M2000 electromagnetic flow meter (**Figure 4**) measured flow throughout the duration of the test which was controlled through a variable frequency drive (VFD). For quality assurance purposes, flow meters were calibrated by Micro Precision Calibration, a third-party entity, using Dynasonics ultrasonic flow meters.

Figure 4 ModMag M2000 Electromagnetic Flow Meters

Sediment Feeding

Test sediment was fed through the crown of a 6-in PVC tee, located 30-in upstream of the ***SVBF*** unit, using a Vibra-Screw volumetric screw feeder with a vibratory hopper. A screw diameter of ½-inch allowed for the precise addition of sediment at both the 200 and 400-mg/L target concentrations.

Sample Collection

Flow exited the ***SVBF*** unit and entered the downstream sampling pool in a free discharge approximately 32-in from the unit (**Figure 5**). Grab samples were collected by hand using wide-mouthed 1-Liter (L) high-density polyethylene (HDPE) sample bottles in a sweeping motion through the free spilling effluent stream.

Figure 5 Effluent Grab Samples from the Effluent Stream

Background water samples were collected in 1-L bottles through a sampling port located 7.5-ft, upstream from the ***SVBF*** unit inlet. The ½-in sampling port was controlled manually using a ball valve (**Figure 6**). The sampling port was opened a few seconds before each sampling time to allow water stored in the sample pipe to be displaced by influent water.

Figure 6 Background Sampling Port

Other Instrumentation and Measurements

Water temperature was collected every minute using a Campbell Scientific temperature probe located downstream and recorded with a Campbell Scientific CR3000 Data-Logger.

Test duration and sampling times were recorded using a stopwatch (Apple iOS).

Sediment feed samples were collected in 500-milliliter (mL) glass beakers and weighed using a Tree Electronic Precision Balance to a milligram.

Water level within the ***SVBF*** unit was measured using a Campbell Scientific CS451 Pressure Transducer housed within a slotted standpipe and recorded with a Campbell Scientific CR3000 Data-Logger.

2.3 Test Sediment

As described in the previous section, test sediment was fed through the crown of a 6-in PVC tee located 30-in upstream from the ***SVBF*** unit using a Vibra-Screw volumetric screw feeder with vibratory hopper. Sediment was dropped at the centerline through a 6-in pipe connected to the tee.

Since the testing facility is outdoors, a windshield and tent were put in place to eliminate wind effects on sediment loading (**Figures 7 and 8**).

Figure 7 Vibra Screw Sediment Feed

Figure 8 Vibra Screw Sediment Feeder with Windshield

Appropriate sediment was purchased in bulk from a variety of suppliers and vendors. Jensen blended these sediments to meet the particle size distribution (PSD), requirements explicitly listed in **Table 2**, set forth by the New Jersey Department of Environmental Protection (NJDEP). A batch of test sediment was prepared for TSS Removal Efficiency and Sediment Mass Loading Capacity testing. Three 1-Liter samples were composited throughout the blending process in order to achieve a representative sample. All three test sediment samples from the entire batch of test sediment had a median particle size (d_{50}) of less than 75-microns (µm), as required. The d_{50} of the test sediment was approximately 48 µm. The sediment samples have a specific gravity of 2.65.

Samples were sent to Lumos & Associates, Sparks, NV, an independent material testing laboratory, for analysis using ASTM D422-63 (Reapproved 2007), *Standard Test Method for Particle Size Analysis of Soils.* Results of Particle Size Distribution (PSD) analyses for the test sediment were plotted against the NJDEP limiting PSD curves and are provided in **Figure 9.**

Table 2 Test Sediment Particle Size Distribution

SVBF Test Sediment Particle Size Distribution for Removal Efficiency and Mass Loading Tests							
NJDEP PSD		Sample 1	Sample 2	Sample 3	Average	NJDEP CONDITION	QA/QC Compliance
SSCTEST		PSD1	PSD2	PSD3	PSD_{avg}		
Particle Size micron [µm]	Percent Finer Required (%)	Percent Finer (%)	Percent Finer (%)	Percent Finer (%)	Percent Finer (%)		
1000	100	100.0	100.0	100.0	100.0	≥ 98%	OK
500	95	96.3	96.3	96.3	96.3	≥ 93%	OK
250	90	95.0	95.1	95.1	95.1	≥ 88%	OK
150	75	92.8	92.8	92.8	92.8	≥ 73%	OK
100	60	70.2	70.5	70.5	70.4	≥ 58%	OK
75	50	53.5	54.1	53.9	53.8	≥ 48%	OK
50	45	50.7	51.2	51.1	51.0	≥ 43%	OK
20	35	38.4	38.0	39.8	38.7	≥ 33%	OK
8	20	19.4	19.1	19.7	19.4	≥ 18%	OK
5	10	12.5	12.1	12.1	12.2	≥ 8%	OK
2	5	4.7	4.4	4.4	4.5	≥ 3%	OK
d_{50}		48-µm	48-µm	47-µm	48-µm	≤ 75-µm	OK

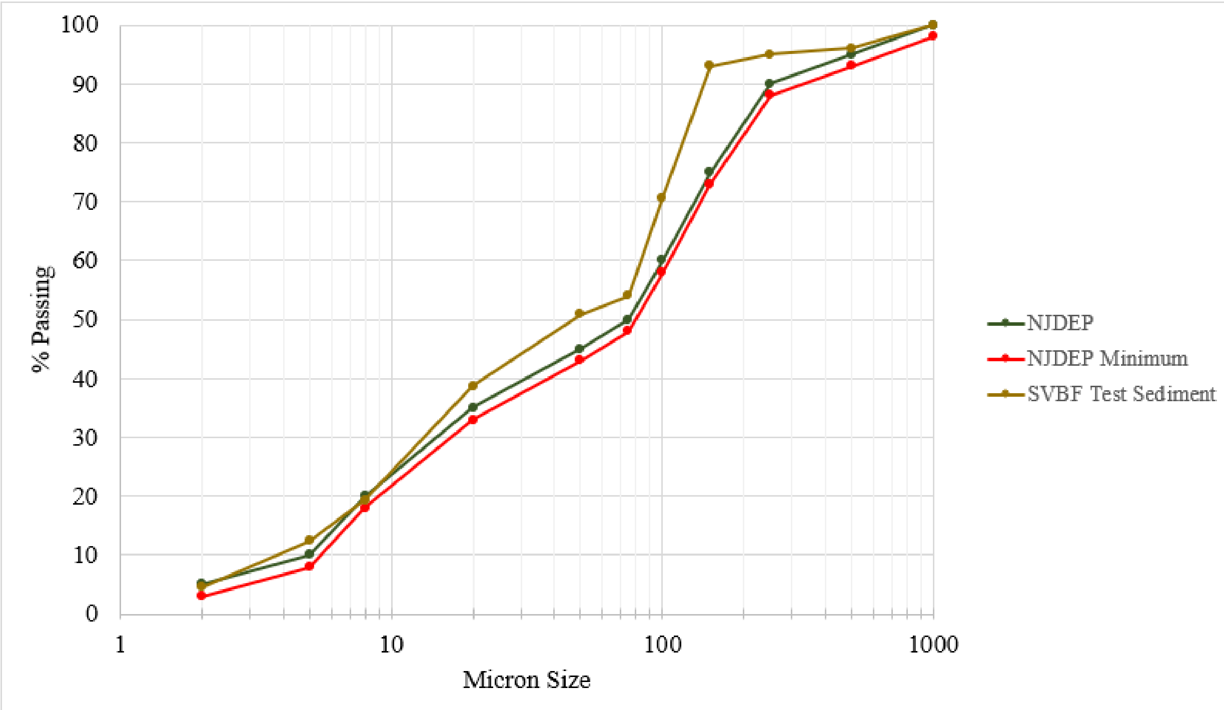

Figure 9 Test Sediment Particle Size Distribution

2.4 Removal Efficiency Testing Procedure

Removal Efficiency testing was performed in accordance with Section 5 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)*. Fifteen (15) test runs were performed at the unit's Maximum Treatment Flow Rate (MTFR). Upon completion of these tests, results were used to calculate the removal efficiency for the ***SVBF4x4***.

Testing began with clean layers of filter media, mulch, rip rap and underdrain to simulate a newly installed unit. The test sediment mass was fed into the influent flow stream 30-in upstream of the ***SVBF*** unit using the Vibra-Screw vibratory auger at a constant rate. Sediment was introduced at a feed rate within ±10% of the target influent concentration of 200-mg/L. Feed rate calibration samples were taken throughout the duration of removal efficiency testing to ensure compliance with NJDEP protocols.

Three calibration samples were collected from the sediment injection point during each removal efficiency test. Clean 500-mL glass beakers were used to collect these sediment feed samples, which measured a minimum of 0.1-L or until a maximum of one-minute sampling time occurred, whichever came first. These calibration sediment feed samples were collected at evenly spaced intervals (beginning, middle, end) over the 90-minute duration of each test and timed such that no sediment sampling time exceeded 1-minute in duration, rounded to the nearest second. These samples were weighed to the nearest milligram using a calibrated Tree® Model HRB623 electronic balance. This data was used to confirm that the Coefficient of Variance (COV) of sediment feed rate was below the limit of 0.10 as required by the protocol.

The average influent TSS concentration used for determining removal efficiency was calculated using the total mass of the test sediment injected into the water divided by the volume of water that flowed through the test unit during injection (**Equation 1**), as defined by the protocol. The mass extracted for calibration samples was subtracted from the total mass injected from the screw feeder for the removal efficiency calculation. The total volume of water for each test was calculated by multiplying the average flow rate by the time of sediment injection only.

$$\textbf{Average Influent Concentration} = \frac{\text{Total mass added}}{\text{Total volume of water flowing through the MTD during addition of test sediment}}$$

Equation 1 Calculation for Average Influent Sediment Concentration

Background water samples were taken from a sampling port located 7.5-ft upstream from the ***SVBF*** unit by the grab sampling method using 1-L HDPE bottles. Background samples were taken in correspondence with every odd effluent sample, for a total of three background samples per test. When samples were not taken, background concentrations were interpolated between previous and subsequent results. Effluent sampling was also done using the grab sampling method. Samples were taken from the ***SVBF*** effluent pipe using 1-L HDPE bottles, approximately 32-in downstream of the ***SVBF*** unit.

Effluent grab sampling began after at least three MTD detention times had passed. When the sediment feed was interrupted during feed rate sampling, the following effluent sample was taken after another three MTD detention times had passed. At the end of each test run, when flow into the unit ceased, two evenly spaced drawdown samples were taken at the effluent sample location. Drawdown samples were taken at two thirds and one third of the water level within the SVBF unit at the end of each test run. A total of 6 effluent samples, 3 background samples, 3 sediment samples, and 2 drawdown samples were collected during each test run.

The background solids concentration data were used to adjust the effluent samples for background concentration. The ***SVBF*** removal efficiency for each test run was calculated per **Equation 2** as follows:

$$\text{Removal Efficiency (\%)} = \frac{\left(\begin{array}{c}\text{Average Influent}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Test Water}\end{array}\right) - \left(\begin{array}{c}\text{Adjusted Effluent}\\ \text{TSS Concentration x}\\ \text{Total Volume of}\\ \text{Effluent Test Water}\end{array}\right) - \left(\begin{array}{c}\text{Average}\\ \text{Drawdown Flow}\\ \text{TSS Concentration x}\\ \text{Total Volume}\\ \text{of Drawdown Water}\end{array}\right)}{\text{Average Influent TSS Concentration x Total Volume of Test Water}} \text{ x } 100$$

Equation 2 Equation for Calculating Removal Efficiency

All samples were analyzed by Western Environmental Testing Laboratory (WETLAB), Sparks, Nevada in accordance with ASTM D 3977-97, (re-approval 2007) *Standard Test Methods for Determining Sediment Concentrations in Water Samples*.

M2000 electromagnetic flow meters attached to the supply pumps measured flow throughout the duration of each test run. These flows were controlled by the VFD and recorded once per minute by the Data-Logger in order to calculate total water volume and average flow rate during the test. During test runs, the allowable variation of flow was within ±10% of the target flow rate with a COV of less than or equal to 0.03. The water temperature was also recorded by the Data-Logger at one-minute intervals.

2.5 Sediment Mass Loading Capacity Testing Procedure

Sediment Mass Loading Capacity Testing was performed as a continuation of Removal Efficiency Testing. The test procedure remained the same as the Removal Efficiency Testing Procedure described above in Section 2.4 of this report except for an increase in the sediment concentration of the influent from 200-mg/L to 400-mg/L. Sediment Mass Loading Capacity Testing began after 15 runs of Removal Efficiency Testing were completed. Thirteen (13) Sediment Mass Loading Capacity tests were conducted.

2.6 Scour Testing Procedure

For minimum conforming scouring testing, the test unit was pre-loaded to at least 50% of its maximum sediment storage capacity. A total of 193.4-lbs was loaded into the unit during TSS Removal and Sediment Mass Loading Capacity Testing. For Scour Testing, the unit was loaded with 109.8-lbs of sediment, slightly more than the required 50% load. To achieve this, sediment was fed into the test ***SVBF*** unit at its MTFR of 0.07-cfs (32.0-gpm) at a concentration of 400-mg/L. Mass balance calculations were used to determine how long the unit needed to be loaded at these conditions until just over 50% of its sediment storage capacity was reached. The unit was loaded for a total of 17.5-hrs spread out over a 4-day period to ensure 50% loading was met or exceeded. After loading, the unit was left undisturbed for 21-hours before scour testing began.

Using the VFD, test flow was brought up to 0.14-cfs (64-gpm), the target 200% of the ***SVBF*** unit's MTFR of 0.07-cfs (32-gpm) within 5-min of beginning the test. The flow rate was measured using M2000 electromagnetic flow meters attached to the supply pumps and recorded once per minute by the CR3000 Data-Logger. Once testing commenced, effluent samples were collected using a 1-L wide-mouthed bottle every 2-minutes, while background samples were collected during every odd-numbered effluent sample. A total of 15 effluent samples and 8 background samples were collected during scour testing.

All Scour Testing samples were analyzed by WETLAB, Sparks, Nevada in accordance with ASTM D3977-B (re-approval 2007) *Standard Test Methods for Determining Sediment Concentrations in Water Samples*.

3. Performance Claims

In compliance with the NJCAT verification process, the ***StormVault BioFiltration*** (***SVBF***) Model ***SVBF4x4*** performance claims are cited below.

Total Suspended Solids Removal Rate

For the particle size distribution specified by the NJDEP Filtration MTD protocol, the ***SVBF4x4*** at an MTFR of 0.07-cfs (32-gpm) will achieve at least 80% cumulative mass TSS removal efficiency.

Maximum Treatment Flow Rate (MFTR)

The MTFR for the ***SVBF4x4*** was demonstrated to be 0.07-cfs (32-gpm), which corresponds to a surface area loading rate of 2-gpm/ft^2 of Sierra Blend bio-soil media.

Sediment Mass Loading Capacity

The sediment mass loading capacity for the ***SVBF4x4*** is 11.0-lb/ft^2 with a maximum sediment storage capacity of 176.7-lb and an effective treatment area of 16-ft^2.

Effective Treatment Area

The effective treatment area of the ***SVBF*** models varies with model size, as it corresponds to the surface area of the ***SVBF*** unit. The tested ***SVBF4x4*** model has an effective treatment surface area of 16-ft^2.

Detention Time and Volume

The detention time of the ***SVBF*** depends on flow rate and model size. The tested ***SVBF4x4*** has a wetted volume of 17.6-ft^3. At the MTFR of 0.07-cfs, the ***SVBF4x4*** has a detention time of 248 seconds.

Online or Offline

Based on the results of the Scour Testing included in Section 4.3 of this report, the ***SVBF4x4*** qualifies for online installation of flows up to 200% MTFR.

4. Supporting Documentation

The NJDEP Procedure (NJDEP, 2013a) for obtaining verification of an MTD from NJCAT requires that copies of the laboratory test reports including all collected and measured data, all data from performance test runs, all pertinent calculations, etc., be included in this section. It is the understanding of Jensen that this was discussed with NJDEP and it was agreed that, so long as such documentation was made available to NJCAT, it would not be necessary to include all such supporting documentation in verification reports.

4.1 Removal Efficiency Testing

In accordance with the NJDEP Filtration MTD Protocol, sediment removal efficiency testing was conducted on the ***SVBF4x4*** unit in order to establish the ability of the ***SVBF*** unit to remove the specified test sediment at 100% of the target MTFR with the goal of demonstrating at least 80% cumulative mass sediment removal efficiency after 10 runs. The target MTFR was 0.07-cfs (32-gpm).

Two Removal Efficiency tests (Run 4 and Run 9, **Table 3**) exceeded the flow COV limit of 0.03. At the beginning of these two tests, the VFD read a flow rate of 0-gpm for the first 4-minutes, followed by a flow spike for another minute, after which the flow stabilized to the MTFR flow rate of 0.07-cfs (32-gpm). Though the VFD read 0-gpm, water was flowing into the ***SVBF4x4*** test unit, which was verified by Dr. Keith Dennett, the third-party observer present, for these two tests. This was determined to be caused by water freezing in the pipes overnight, which constricted the flow and resulted in abnormal VFD readings for the first several minutes until the icing in the piping cleared. This issue was resolved by assuring all pipe valves and drain plugs were left open at the end of each remaining testing day to allow water to drain from the supply piping.

Table 3 Flow Rate and Water Temperature for TSS Removal Efficiency Testing

Run	Runtime (min)	Target Flow (gpm)	Actual Flow (gpm)	Percent Difference (%)	COV	QA/QC Compliance (COV≤0.03)	Max. Water Temperature (◦F)	QA/QC Compliance (T≤80°F)
1	90	32	31.60	-1.250	0.023	PASS	64.79	PASS
2	90	32	31.49	-1.597	0.018	PASS	66.85	PASS
3	90	32	31.11	-2.778	0.019	PASS	67.58	PASS
4*	90	32	32.36	1.111	0.262	FAIL	65.21	PASS
5	90	32	31.78	-0.694	0.018	PASS	67.73	PASS
6	90	32	31.10	-2.813	0.019	PASS	72.14	PASS
7	90	32	32.67	2.083	0.015	PASS	64.77	PASS
8	90	32	32.92	2.882	0.008	PASS	69.61	PASS
9*	90	32	31.39	-1.910	0.221	FAIL	67.82	PASS
10	90	32	32.82	2.569	0.013	PASS	70.11	PASS
11	90	32	31.61	-1.215	0.016	PASS	70.27	PASS
12	90	32	32.94	2.951	0.007	PASS	72.76	PASS
13	90	32	31.69	-0.972	0.015	PASS	72.89	PASS
14	90	32	31.13	-2.708	0.018	PASS	71.13	PASS
15	90	32	31.53	-1.458	0.018	PASS	64.03	PASS

*Run failed flow rate QA/QC for COV. These runs are not included in calculation of cumulative removal efficiency but are included in cumulative mass captured summation.

Table 4 Sediment Feed Rate for TSS Removal Efficiency Testing

Run	Run Time (min)	Weight (g)	Duration (s)	Feed Rate (g/min)	Average Concentration [mass balance] (mg/L)	QA/QC Compliance [180-220 mg/L] [COV≤0.1]	Run	Run Time (min)	Weight (g)	Duration (s)	Feed Rate (g/min)	Average Concentration [mass balance] (mg/L)	QA/QC Compliance [180-220 mg/L] [COV≤0.1]
1	0	23.522	60	23.522	182.7	PASS	9	0	24.965	60	24.965	189.1	PASS
	45	22.486	60	22.486				45	24.809	60	24.809		
	90	22.783	60	22.783				90	24.873	60	24.873		
			COV	0.023						**COV**	0.003		
2	0	23.525	60	23.525	217.1	PASS	10	0	25.523	60	25.523	198.0	PASS
	45	22.841	60	22.841				45	24.637	60	24.637		
	90	22.834	60	22.834				90	24.923	60	24.923		
			COV	0.017						**COV**	0.018		
3	0	23.475	60	23.475	197.6	PASS	11	0	25.098	60	25.098	218.2	PASS
	45	22.353	60	22.353				45	24.739	60	24.739		
	90	22.001	60	22.001				90	24.976	60	24.976		
			COV	0.034						**COV**	0.007		
4	0	22.407	60	22.407	180.4	PASS	12	0	25.854	60	25.854	204.5	PASS
	45	22.068	60	22.068				45	26.872	60	26.872		
	90	21.715	60	21.715				90	25.829	60	25.829		
			COV	0.016						**COV**	0.023		
5	0	25.562	60	25.562	211.7	PASS	13	0	25.052	60	25.052	217.2	PASS
	45	24.183	60	24.183				45	25.199	60	25.199		
	90	24.155	60	24.155				90	25.876	60	25.876		
			COV	0.033						**COV**	0.017		
6	0	25.176	60	25.176	209.9	PASS	14	0	24.083	60	24.083	203.8	PASS
	45	24.854	60	24.854				45	24.754	60	24.754		
	90	25.023	60	25.023				90	24.188	60	24.188		
			COV	0.006						**COV**	0.015		
7	0	23.95	60	23.950	208.4	PASS	15	0	24.772	60	24.772	206.1	PASS
	45	24.74	60	24.740				45	24.512	60	24.512		
	90	26.068	60	26.068				90	25.305	60	25.305		
			COV	0.043						**COV**	0.016		
8	0	25.884	60	25.884	210.2	PASS							
	45	25.087	60	25.087									
	90	25.762	60	25.762									
			COV	0.017									

Table 5 Drawdown Analysis for TSS Removal Efficiency Testing

Run	Water Level at End of Run (in)	Drawdown Water Volume (L)	Drawdown Sample 1 (mg/L)	Drawdown Sample 2 (mg/L)	Average Drawdown TSS Concentration (mg/L)	Total Sediment Loss (g)
1	8.65	184.6	22	52	37.0	6.83
2	11.40	243.3	21	59	40.0	9.73
3	11.64	248.3	21	68	44.5	11.05
4	9.95	212.3	17	45	31.0	6.58
5	12.32	262.8	19	55	37.0	9.72
6	12.20	260.3	19	56	37.5	9.76
7	13.15	280.5	17	41	29.0	8.14
8	13.62	290.6	17	41	29.0	8.43
9	13.29	283.6	18	40	29.0	8.22
10	13.67	291.7	17	41	29.0	8.46
11	12.96	276.6	18	42	30.0	8.30
12	13.39	285.7	18	45	31.5	9.00
13	13.02	277.8	18	55	36.5	10.14
14	12.40	264.5	22	231	126.5	33.45
15	12.82	273.5	18	50	34.0	9.30

Table 6 Background and Effluent Concentrations for TSS Removal Efficiency Testing

Run	TSS Concentration (mg/L)[1]									QA/QC Compliance (background TSS ≤20 mg/L)
	Run Time (min)	15	30	45	60	75	90	Average	Average Adjusted Effluent Concentration (mg/L)	
1	Background[2]	2.5		2.5		2.5		2.5	20.3	PASS
	Effluent	27	23	22	22	22	21	22.8		
2	Background[2]	2.5		2.5		2.5		2.5	18.3	PASS
	Effluent	23	21	21	20	20	20	20.8		
3	Background[2]	2.5		2.5		2.5		2.5	17.8	PASS
	Effluent	22	20	20	20	20	20	20.3		
4	Background[2]	2.5		2.5		2.5		2.5	15.5	PASS
	Effluent	22	17	17	17	18	17	18.0		
5	Background[2]	2.5		2.5		2.5		2.5	17.8	PASS
	Effluent	22	20	20	20	20	20	20.3		
6	Background[2]	2.5		2.5		2.5		2.5	16.7	PASS
	Effluent	21	19	19	19	18	19	19.2		
7	Background[2]	2.5		2.5		2.5		2.5	15.7	PASS
	Effluent	21	18	18	18	17	17	18.2		
8	Background[2]	2.5		2.5		2.5		2.5	15.3	PASS
	Effluent	20	18	16	18	18	17	17.8		
9	Background[2]	2.5		2.5		2.5		2.5	15.8	PASS
	Effluent	21	18	18	17	18	18	18.3		
10	Background[2]	2.5		2.5		2.5		2.5	16.0	PASS
	Effluent	20	19	18	18	18	18	18.5		
11	Background[2]	2.5		2.5		2.5		2.5	17.3	PASS
	Effluent	24	20	19	19	18	19	19.8		
12	Background[2]	2.5		2.5		2.5		2.5	16.8	PASS
	Effluent	24	19	18	18	19	18	19.3		
13	Background[2]	2.5		2.5		2.5		2.5	17.0	PASS
	Effluent	21	20	19	19	19	19	19.5		
14	Background[2]	2.5		2.5		2.5		2.5	18.3	PASS
	Effluent	26	20	20	19	20	20	20.8		
15	Background[2]	2.5		2.5		2.5		2.5	15.3	PASS
	Effluent	24	20	19	19	20	20	20.3		

1. Reporting Limit is 5-mg/L.
2. When background TSS concentration values were below the 5-mg/L reporting limit, a background concentration value of 2.5-mg/L was used, which is half the 5-mg/L, conforming to accepted standard practice of adjusting sample concentrations.

TSS Removal Efficiency Results

Table 7 TSS Removal Efficiency Results

Run	Average Influent TSS (mg/L)	Adjusted Effluent TSS (mg/L)	Total Water Volume (L)	Average Drawdown TSS (mg/L)	Volume of Drawdown Water (L)	Run Removal Efficiency (%)	Mass of Sediment Loaded (lbs.)	Mass of Captured Sediment (lbs.)	Cumulative Mass Removal Efficiency (%)
1	182.7	20.3	10407	37.0	185	88.5	4.19	3.71	88.5
2	217.1	18.3	10370	40.0	243	91.1	4.96	4.52	89.8
3	197.6	17.8	10246	44.5	248	90.4	4.46	4.04	90.0
4*	182.4	15.5	10542	31.0	212	90.4	4.24	3.86	90.0
5	211.7	17.8	10465	37.0	263	91.1	4.89	4.45	90.3
6	209.9	16.7	10242	37.5	260	91.6	4.74	4.34	90.6
7	208.4	15.7	10758	29.0	281	92.1	4.94	4.55	90.8
8	210.2	15.3	10842	29.0	291	92.3	5.02	4.64	91.0
9*	189.1	15.8	10337	29.0	284	92.3	4.31	3.93	91.0
10	198.0	16.0	10809	29.0	292	91.5	4.72	4.32	91.1
11	218.2	17.3	10411	30.0	277	91.7	5.01	4.59	91.2
12	204.5	16.8	10850	31.5	286	91.4	4.89	4.47	91.2
13	217.2	17.0	10436	36.5	278	91.7	5.00	4.58	91.2
14	203.8	18.3	10253	126.5	264	89.4	4.61	4.12	91.1
15	206.1	17.8	10385	34.0	274	90.9	4.72	4.29	91.1
Sediment Mass Loaded (lbs)							70.70		
Sediment Mass Captured (lbs)								64.42	
Cumulative Mass Removal Efficiency (%)									91.1

*Run failed flow rate QA/QC for COV. These runs are not included in calculation of cumulative removal efficiency but are included in cumulative mass captured summation.

4.2 Sediment Mass Loading Capacity Testing

Sediment Mass Loading Capacity testing was conducted as a continuation of TSS Removal Efficiency Testing in accordance with Section 5 of the NJDEP Filtration MTD Protocol. The goal of this test was to load the unit to failure more quickly so that its maximum sediment storage capacity may be determined. All testing procedures remained the same except for the sediment feed rate, which was increased from 200-mg/L to 400-mg/L of TSS.

A total of thirteen (13) test runs were performed and are denoted as Runs 16-28. Data for flow rate, sediment feed rates, drain down losses, and TSS removal efficiency were collected as was done for TSS Removal Efficiency Testing. This data is presented in **Table 8** through **Table 12**.

The ***SVBF4x4*** sediment storage capacity was determined to be 176.7-lbs with a cumulative mass removal efficiency of 91.3%. The total sediment mass loaded into the system was 193.4 lbs. The relationship between removal efficiency and sediment mass loading is illustrated in **Figure 10.**

Prior to Run 23, the system's recirculation filter cartridges were replaced. However, the filter housings were not drained and rinsed before the new cartridges were placed and testing continued. This caused a slug of turbid water to enter the supply tank, and the first background sample of Run 23 exceeded 20-mg/L (**Table 11**). The concentration had returned to an acceptable level by the time the second background sample was collected.

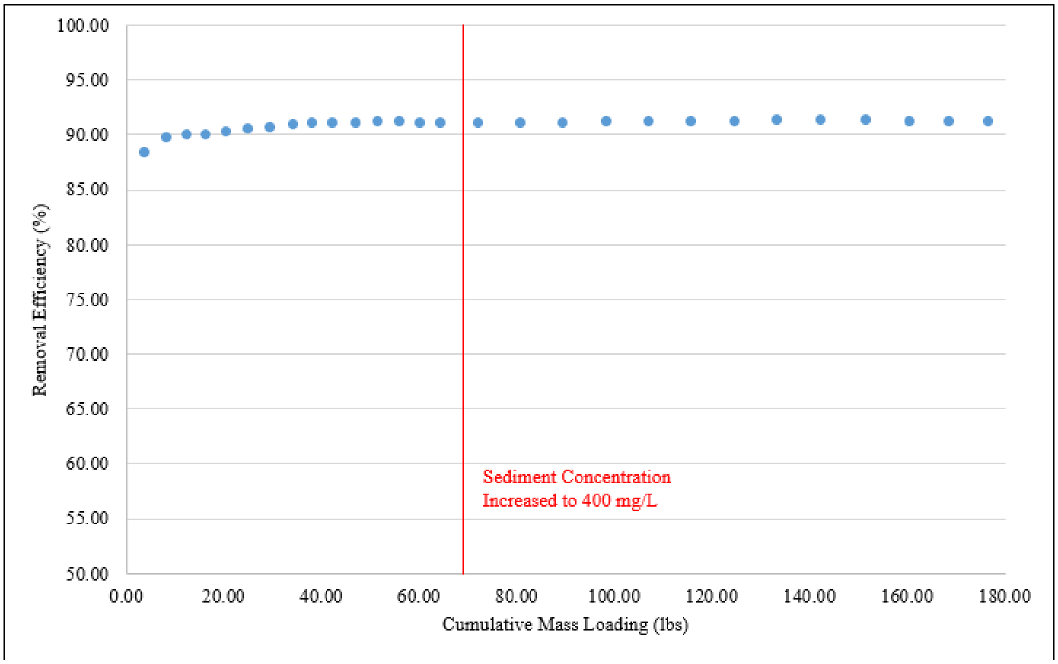

Figure 10 Removal Efficiency vs Sediment Mass Loading

Table 8 Flow Rate and Water Temperature for Sediment Mass Loading Capacity Testing

Run	Runtime (min)	Target Flowrate (gpm)	Actual Flowrate (gpm)	Percent Difference (%)	COV	QA/QC Compliance (COV≤0.03)	Max. Water Temperature (°F)	QA/QC Complian ce (T≤80°F)
16	90	32	30.97	-3.229	0.008	PASS	68.99	PASS
17	90	32	31.37	-1.979	0.025	PASS	70.77	PASS
18	90	32	32.73	2.292	0.018	PASS	67.51	PASS
19	90	32	31.27	-2.292	0.019	PASS	71.78	PASS
20	90	32	32.12	0.382	0.018	PASS	70.97	PASS
21	90	32	32.04	0.136	0.010	PASS	70.42	PASS
22	90	32	32.96	2.988	0.008	PASS	72.59	PASS
23	90	32	31.99	-0.035	0.010	PASS	71.94	PASS
24	90	32	32.94	2.951	0.008	PASS	72.67	PASS
25	90	32	32.37	1.146	0.016	PASS	73.22	PASS
26	90	32	32.93	2.917	0.009	PASS	69.78	PASS
27	90	32	32.93	2.917	0.009	PASS	71.57	PASS
28	90	32	33.01	3.160	0.007	PASS	72.81	PASS

Table 9 Sediment Feed for Sediment Mass Loading Capacity Testing

Run	Run Time (min)	Weight (g)	Duration (s)	Feed Rate (g/min)	Average Concentration [mass balance (mg/L)	QA/QC Compliance [360-440 mg/L] [COV≤0.1]
16	0	45.109	60.00	45.109	372.7	PASS
	45	45.368	60.00	45.368		
	90	46.346	60.00	46.346		
			COV	0.014		
17	0	48.443	60.00	48.443	413.9	PASS
	45	50.01	60.00	50.010		
	90	49.989	60.00	49.989		
			COV	0.018		
18	0	47.73	60.00	47.730	400.8	PASS
	45	48.362	60.00	48.362		
	90	50.557	60.00	50.557		
			COV	0.030		
19	0	50.457	60.00	50.457	422.8	PASS
	45	50.711	60.00	50.711		
	90	51.323	60.00	51.323		
			COV	0.009		
20	0	48.251	60.00	48.251	408.5	PASS
	45	48.256	60.00	48.256		
	90	50.253	60.00	50.253		
			COV	0.024		
21	0	49.985	60.00	49.985	407.0	PASS
	45	49.827	60.00	49.827		
	90	50.228	60.00	50.228		
			COV	0.004		
22	0	50.999	60.00	50.999	412.0	PASS
	45	50.001	60.00	50.001		
	90	51.385	60.00	51.385		
			COV	0.014		

Run	Run Time (min)	Weight (g)	Duration (s)	Feed Rate (g/min)	Average Concentration [mass balance] (mg/L)	QA/QC Compliance [360-440 mg/L] [COV≤0.1]
23	0	49.168	60.00	49.168	403.5	PASS
	45	49.483	60.00	49.483		
	90	52.365	60.00	52.365		
			COV	0.035		
24	0	49.766	60.00	49.766	407.1	PASS
	45	50.523	60.00	50.523		
	90	52.472	60.00	52.472		
			COV	0.027		
25	0	49.506	60.00	49.506	422.3	PASS
	45	50.957	60.00	50.957		
	90	52.112	60.00	52.112		
			COV	0.026		
26	0	50.5	60.00	50.500	411.6	PASS
	45	49.185	60.00	49.185		
	90	48.684	60.00	48.684		
			COV	0.019		
27	0	48.893	60.00	48.893	376.4	PASS
	45	46.259	60.00	46.259		
	90	47.919	60.00	47.919		
			COV	0.028		
28	0	46.469	60.00	46.469	376.4	PASS
	45	47.812	60.00	47.812		
	90	47.984	60.00	47.984		
			COV	0.017		

Table 10 Drawdown Analysis for Sediment Mass Loading Capacity Testing

Run	Water Level at End of Run (in)	Drawdown Water Volume (L)	Drawdown Sample 1 (mg/L)	Drawdown Sample 2 (mg/L)	Average Drawdown TSS Concentration (mg/L)	Total Sediment Loss (g)
16	12.57	268.2	54	66	60.0	16.09
17	12.68	270.6	37	109	73.0	19.75
18	13.76	293.6	37	85	61.0	17.91
19	13.01	277.5	39	96	67.5	18.73
20	12.83	273.8	41	90	65.5	17.93
21	12.94	276.2	37	83	60.0	16.57
22	13.48	287.6	81	37	59.0	16.97
23	13.17	280.9	44	90	67.0	18.82
24	13.61	290.4	40	87	63.5	18.44
25	13.58	289.8	42	83	62.5	18.11
26	13.74	293.2	37	68	52.5	15.40
27	13.86	295.6	33	64	48.5	14.34
28	13.93	297.2	35	62	48.5	14.42

Table 11 Background and Effluent Concentrations for Sediment Mass Loading Capacity Testing

Run	TSS Concentration (mg/L)[1]									QA/QC Compliance (background TSS ≤20 mg/L)
	Run Time (min)	15	30	45	60	75	90	Average	Average Adjusted Effluent Concentration (mg/L)	
16	Background[2]	2.5		2.5		2.5		2.5	30.8	PASS
	Effluent	35	32	33	33	33	34	33.3		
17	Background	11		9		8		9.1	31.6	PASS
	Effluent	42	40	41	40	40	41	40.7		
18	Background	7		6		6		6.3	32.6	PASS
	Effluent	41	38	38	38	39	39	38.8		
19	Background	7		7		7		7.0	31.7	PASS
	Effluent	39	38	35	40	40	40	38.7		
20	Background	7		7		7		7.0	33.5	PASS
	Effluent	43	40	40	40	40	40	40.5		
21	Background	8		8		8		8.0	31.5	PASS
	Effluent	41	35	39	44	39	39	39.5		
22	Background	7		8		7		7.3	32.2	PASS
	Effluent	42	39	39	39	39	39	39.5		
23	Background	27		14		18		18.9	28.4	PASS
	Effluent	58	47	45	44	44	46	47.3		
24	Background	12		9		7		8.9	32.9	PASS
	Effluent	45	42	41	40	41	42	41.8		
25	Background	7		8		5		6.5	35.2	PASS
	Effluent	44	39	43	40	41	43	41.7		
26	Background[2]	6		2.5		2.5		3.4	35.3	PASS
	Effluent	44	39	37	36	40	36	38.7		
27	Background[2]	2.5		2.5		2.5		2.5	33.2	PASS
	Effluent	39	35	36	34	35	35	35.7		
28	Background[2]	2.5		2.5		2.5		2.5	34.0	PASS
	Effluent	39	36	35	35	37	37	36.5		

1. Reporting Limit is 5-mg/L
2. When background TSS concentration values were below the 5-mg/L reporting limit, a background concentration value of 2.5-mg/L was used, which is half the 5-mg/L, conforming to accepted standard practice of adjusting sample concentrations.

Sediment Mass Loading Capacity Results

Table 12 Sediment Mass Loading Capacity Results

Run	Average Influent TSS (mg/L)	Adjusted Effluent TSS (mg/L)	Total Water Volume (L)	Average Drawdown TSS (mg/L)	Volume of Drawdown Water (L)	Run Removal Efficiency (%)	Mass of Sediment Loaded (lbs.)	Mass of Captured Sediment (lbs.)	Cumulative Mass Removal Efficiency (%)
16	372.7	30.8	10198	60.0	268	91.3	8.38	7.65	91.1
17	413.9	31.6	10330	73.0	271	91.9	9.43	8.66	91.1
18	400.8	32.6	10780	61.0	294	91.5	9.52	8.71	91.2
19	422.8	31.7	10297	67.5	278	92.1	9.60	8.84	91.2
20	408.5	33.5	10579	65.5	274	91.4	9.53	8.71	91.2
21	407.1	31.5	10550	60.0	276	91.9	9.47	8.70	91.3
22	412.0	32.2	10853	59.0	288	91.8	9.86	9.05	91.3
23	403.5	28.4	10535	67.0	281	92.5	9.37	8.67	91.3
24	407.1	32.9	10850	63.5	290	91.5	9.74	8.91	91.4
25	422.3	35.2	10659	62.5	290	91.3	9.92	9.06	91.3
26	411.6	35.3	10846	52.5	293	91.1	9.84	8.97	91.3
27	376.4	33.2	10846	48.5	296	90.8	9.00	8.18	91.3
28	376.4	34.0	10872	48.5	297	90.6	9.02	8.17	91.3
Sediment Mass Loaded [Runs 1-28) (lbs)							193.4		
Sediment Mass Captured [Runs 1-28] (lbs)								176.7	
Cumulative Mass Removal Efficiency [Runs 1-28] (%)									91.3

4.3 Scour Testing

Scour testing was performed in accordance with Section 4 of the NJDEP Protocol. Since the ***SVBF*** unit is designed to be installed online, testing was performed at a target rate of 0.14 cfs (64-gpm), which is 200% of the specified MTFR.

Before testing began, the ***SVBF4x4*** was replaced with an identically constructed test unit and filled with new underdrain gravel, media, mulch, and rip rap. The ***SVBF*** unit was pre-loaded at its 100% MTFR with a feed rate of 400-mg/L until its 50% sediment loading capacity was exceeded. Loading occurred for 17-hrs and 30-min (1,050 min) and was spread out over 4-days. A total of 109.8-lbs was loaded into the ***SVBF4x4***. The unit was then left undisturbed for 21-hours before testing began.

For the first 4-min of sediment loading, a flow spike of approximately 200% of the MTFR occurred then quickly subsided back to the 32-gpm flow rate for the rest of the sediment mass loading. This 4-minutes of 67-gpm inflow equates to 0.38% of the total 1,050-minutes of loading time during which the inflow rate was out of range. This short duration inflow spike is not a violation of any testing protocol, nor does it create a condition that would invalidate the results of the scour test.

Table 13 Flow Rates and Water Temperatures for Scour Pre-Loading

Day	Duration (hrs)	Water Flow Rate (GPM)		Percent Difference (%)	COV	Maximum Water Temperature (°F)
		Target	Average			
1	6	32	32.42	1.30%	0.084	73.17
2	6		31.96	-0.13%	0.015	77.84
3	5		32.64	2.01%	0.017	77.86
4	0.5		32.87	2.71%	0.017	72.36

Table 14 Sediment Feed for Scour Pre-Loading

Sediment Feed Rate (g/min)			
Target	Average	Percent Difference (%)	COV
48.45	48.40	-0.10%	0.058

At the start of the test, flow rates were gradually increased to the 200% MTFR within the allotted 5-minute period. The clock started immediately after water entered the treatment unit. This flow sequence was verified by the third-party observer. Once the clock reached the 5-minute mark, testing began with effluent and background samples collected from the same locations as the Removal Efficiency testing, in accordance with the sampling frequency indicated in **Table 15**.

Table 15 Sampling Schedule - Scour Test

Time Between Effluent Sampling (s) =		120
Time [min]	**Background**	**Effluent**
0:00		
2:00	1	1
4:00		2
6:00	2	3
8:00		4
10:00	3	5
12:00		6
14:00	4	7
16:00		8
18:00	5	9
20:00		10
22:00	6	11
24:00		12
26:00	7	13
28:00		14
30:00	8	15

Water flow rate and temperature are listed in **Table 16** and shown on **Figure 11.** The shaded portion in **Figure 11** includes data points within the 5-min start-up period allotted in Section 4 of the NJDEP protocol. TSS background and effluent concentrations are shown in **Table 17** and **Table 18,** respectively**.** Adjusted effluent concentration was determined from the following:

$$Adjusted\ Effluent\ Concentration\ \left(\frac{mg}{L}\right) = Initial\ Concentration - Background\ Concentration$$

Equation 3 Calculation of Scour Adjusted Effluent Concentration

Table 16 QA/QC Water Flow Rate and Temperature - Scour Test

Test Parameter	Water Flow Rate (gpm)				Maximum Water Temperature (°F)
	Target	**Actual**	**Difference**	**COV**	
	64	62.6	-2.188%	0.008	66.13
QA/QC Limit	-	-	±10% PASS	0.03 PASS	80 PASS

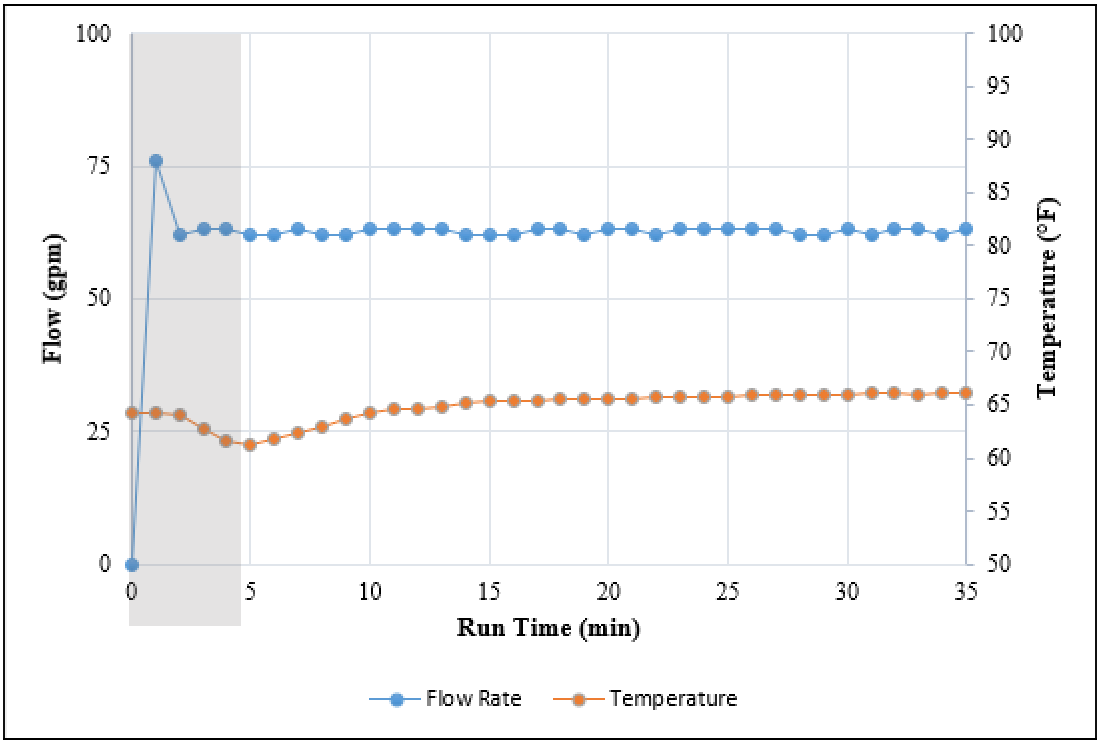

Figure 11 Scour Test Flow Rate and Water Temperature

Table 17 Background Water TSS Concentration - Scour Test

Background Water Sample Results			
Sample Number	**Sample ID**	**TSS Concentration (mg/L)[1]**	**QA / QC C ≤ 20 mg/L**
1	BW1-200[2]	2.5	PASS
2	BW2-200[2]	2.5	PASS
3	BW3-200[2]	2.5	PASS
4	BW4-200[2]	2.5	PASS
5	BW5-200[2]	2.5	PASS
6	BW6-200[2]	2.5	PASS
7	BW7-200	5	PASS
8	BW8-200	6	PASS

1. Reporting Limit is 5-mg/L
2. When background TSS concentration values were below the 5-mg/L reporting limit, a background concentration value of 2.5-mg/L was used, which is half the 5-mg/L, conforming to accepted standard practice of adjusting sample concentrations.

Table 18 Effluent Sample Results - Scour Test

Effluent Sample Results				
Sample Number	Sample ID	Effluent Concentration	Related Background Water Concentration	Adjusted Concentration
		[mg/L]	[mg/L]	[mg/L]
1	EF1-200	52	2.5	49.5
2	EF2-200	38	2.5	35.5
3	EF3-200	30	2.5	27.5
4	EF4-200	25	2.5	22.5
5	EF5-200	21	2.5	18.5
6	EF6-200	15	2.5	12.5
7	EF7-200	12	2.5	9.5
8	EF8-200	11	2.5	8.5
9	EF9-200	10	2.5	7.5
10	EF10-200	10	2.5	7.5
11	EF11-200	9	2.5	6.5
12	EF12-200	10	3.75	6.25
13	EF13-200	9	5	4
14	EF14-200	9	5.5	3.5
15	EF15-200	7	6	1
Average Adjusted Effluent Concentration (mg/L)				**14.7**
Maximum Adjusted Effluent Concentration (mg/L)				**49.5**

4.4 Filter Driving Head

For each Removal Efficiency and Mass Loading Capacity test, the maximum water level in the ***SVBF4x4*** was measured using a pressure transducer housed in a slotted standpipe within the media. The reference point for driving head is 3-inches above the discharge pipe invert, at the pipe perforations. The relationship between the maximum water level (head loss) inside of the ***SVBF4x4*** and cumulative sediment capture is illustrated in **Figure 12.**

Figure 12 displays that the maximum water levels for Removal Efficiency Tests 4 and 9 are significantly higher, due to the flow malfunction discussed in Section 4.1 of this report.

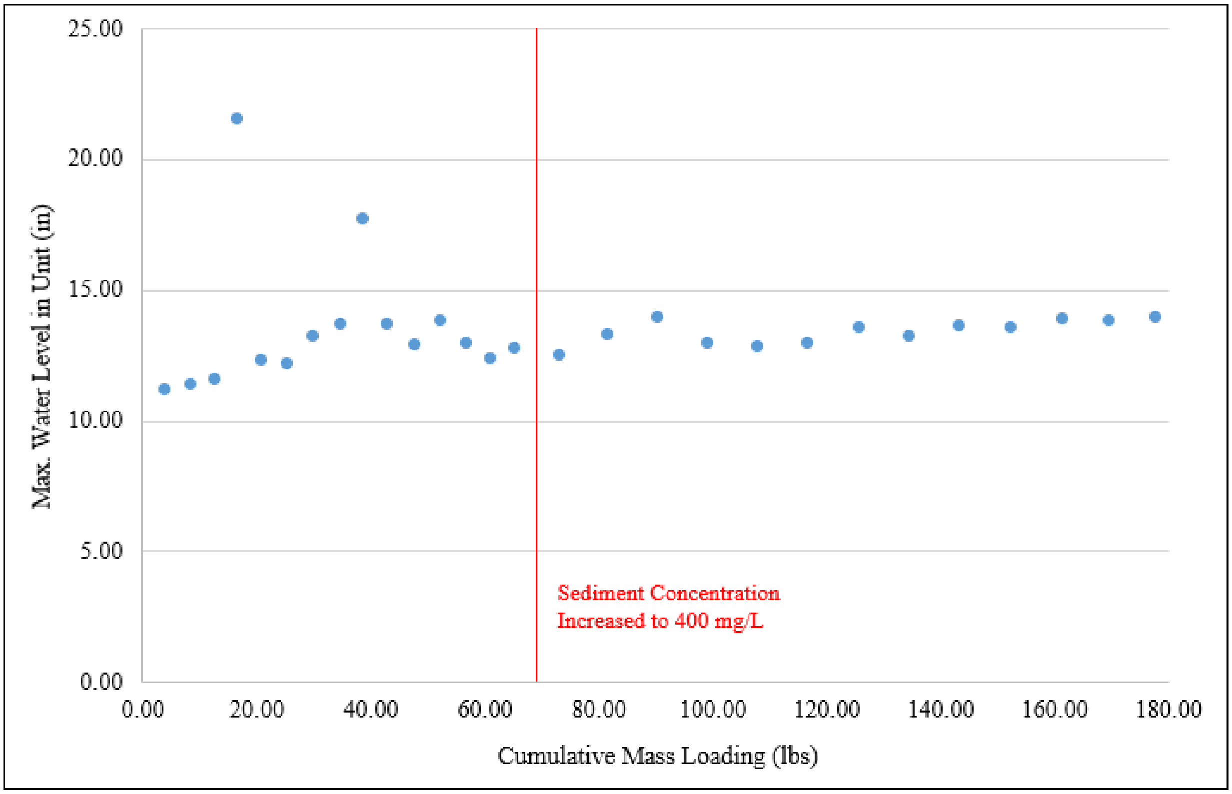

Figure 12 Head Loss vs Sediment Mass Loading

5. Design Limitations

Each ***SVBF*** unit is evaluated by Jensen and properly designed to meet site-specific conditions such as treatment and bypass flow rates, pipe elevations, and load limitations. Jensen provides engineering support to clients on all projects to ensure successful design and installation. All site and/or design constraints are addressed during the design and manufacturing processes.

Soil Characteristics

The unit can be used in all soil types. The ***SVBF*** is pre-assembled and designed to be housed in a precast concrete structure when delivered to the job site. The concrete structure is already designed to meet soil and ground water loading, as well as corrosiveness. For high traffic, railroad, or aircraft loading conditions, use of engineered rock backfill must be determined by the resident engineer. Copies of any geotechnical reports should also be reviewed for each project.

Slope of Drainage Pipe

Pipe slope to the system should follow applicable storm sewer slope design guidelines between 0.5% and 10%. Slopes more than 10% may cause force momentum concerns and possibly create a hydraulic jump at the inlet of the treatment unit, leading to scouring of already captured pollutants as well as mobilizing a portion of the upper media bed. Storm drainpipe with a supercritical slope should be considered in the design phase of the project to ensure the proper performance of the

SVBF unit. For supercritical slope conditions, energy dissipation features can be designed into the inlet of the unit.

Sub-critically sloped storm drain pipelines less than 0.5% could result in sediment accumulation in pipes immediately upstream of the ***SVBF*** unit during very low flow conditions. However, these sediment deposits are typically mobilized into the treatment area of the ***SVBF*** units during higher flow storm events. Since the ***SVBF*** unit is typically installed underground, it is not affected by slopes of the finished surface.

Jensen is prepared to provide necessary assistance with design evaluation of entrance hydraulics and velocities prior to specification.

Maximum Water Quality Treatment Flow Rate

Maximum treatment flow rate is dependent upon the ***SVBF*** model size. For the ***SVBF4x4*** used for NJCAT testing, a maximum flow rate of 0.07-cfs (32-gpm), was calculated using the design hydraulic loading rate of 2-gpm/ft^2 and a treatment area of 16-ft^2. The hydraulic loading rate of 2-gpm/ft^2 is the design specification for all ***SVBF*** units.

Maintenance Requirements

Section 6 of this report details inspection and maintenance requirements for the ***SVBF*** unit. Jensen also provides operation and maintenance manuals as well as field installation drawings and instructions for each site-specific installation.

The frequency of maintenance generally depends on site-specific conditions and is a function of the land use activities in the ***SVBF***'s catchment watershed. In general, maintenance requirements will depend upon the accumulation of trash, debris, and sediments within the system. Trash and debris should be removed during regular inspections to ensure the unit can function unobstructed. For new installations, Jensen recommends the system be checked after every runoff event for the first 30-days and at least once every 30-days during high rainfall periods.

Driving Head

Head losses will occur through each ***SVBF*** unit and will increase as more sediment loading occurs over time. A typical ***SVBF*** unit with an internal bypass has a maximum design head loss of 33-in. Site specific characteristics such as treatment flow rates, pipe sizing, and drainage slope are considered to ensure that there is enough available head for the unit to operate properly.

Installation Limitations

Jensen provides contractors with field installation notes for every ***SVBF*** installation prior to delivery. Contractors may also request on-site assistance from Jensen engineers or technicians to ensure proper installation. Maximum pick weights are also provided to every contractor to best ensure that the appropriate equipment is used when handling the system.

Configurations

The ***SVBF*** unit can be installed Online or Offline depending on site specifications. An internal bypass pipe or weir allows for the system to be installed Online without the need for an external diversion structure required for the Offline installations.

Loading

All ***SVBF*** units are precast concrete structures designed in accordance with AASHTO H-20 and ASTM C1433/C1577. Units may be designed to handle heavy vehicular traffic, railroad, aircraft, and other live loading conditions including special seismic considerations.

Pre-treatment Requirements

The ***SVBF*** unit has no pre-treatment requirements, however its performance may be optimized when paired with a pre-treatment device. MTD's that remove heavier sediment and debris loads will extend the life of the ***SVBF*** and ensure optimal treatment of target pollutants.

Depth to Seasonal High-Water Table

The ***SVBF*** unit is often designed as a closed system (when not meant to also provide for infiltration). The impermeable concrete structure and its connections to the storm drain system are sealed to the storm drain lines so that high groundwater conditions will not affect the operation of the system.

For projects requiring post-treatment infiltration, borings to determine the groundwater elevation along with percolation analysis of the in-situ soils should be performed to determine the site's suitability for infiltration.

Jensen can conduct buoyancy calculations when high ground water is a concern for specific site installation conditions. Floatation rings can be cast into vault and manhole bases if conditions merit.

Limitations on Tailwater

Tailwater conditions are project and site specific and should be addressed during the design of any ***SVBF*** system. Tail water conditions are compensated for with an increase in the diversion weir crest height, though it should be understood that there is no increase in the amount of required driving head necessary for processing flow through the unit.

Seasonal or transient tidal tailwater conditions are not significantly detrimental to unit operations though the diversion weir will need to account for these conditions. Constant high tailwater conditions are not conducive to proper filter bed operations and should be avoided.

6. Maintenance Plan

To ensure the ***SVBF*** unit performs at an optimum level, the system must be inspected and maintained at regular intervals. The frequency of maintenance is heavily dependent upon specific site conditions rather than the size of the unit. Those variable site-specific conditions may include, but are not limited to, catchment areas subject to heavy trash accumulation, unstable soils, or heavy sanding on roadways during winter conditions. Jensen has prepared an Operation and Maintenance Guide to be provided with each ***SVBF*** installation.

Inspection

Routine inspections are critical to the optimum performance of the ***SVBF*** unit. At a minimum, inspections should take place at least twice per year; however, more frequent inspections may be recommended depending on site-specific conditions. A site-specific maintenance frequency should be established within the first two to three years of operation. Jensen also recommends inspecting the unit after each major storm event during the first month of operation.

Inspection Equipment

The following is a list of equipment for the simple and effective inspection of ***SVBF*** units:

- Appropriate clothing (pants and shoes, gloves, safety vest, hard hat, etc.)
- Traffic control equipment (Traffic cones, signage, etc.)
- Manhole hook or crowbar
- Inspection & Maintenance Log (provided in the O&M Manual) or other recording method
- Flashlight
- Tape measure
- Trash grabber
- Shovel, rake, and broom
- Trash can/bag

Inspection Procedure

Inspections of the internal components can, in most cases, be accomplished through observations from the ground surface. It must be noted that closed top ***SVBF*** units can be considered confined space environments and only properly trained personnel possessing the necessary safety equipment should enter the unit to perform maintenance or inspection procedures in adherence with the requirements of a confined space entry permit. All necessary pre-inspection steps including traffic control or pedestrian detours must be carried out. Access to closed top ***SVBF*** units can be reached typically through the access hatch or grate. When the hatch or grate has been safely opened the following inspection procedure should begin:

- Record the date, time, and inspector on the day of inspection as well as the job location and model designation.
- Check the inlet structures for any unwanted objects or obstructions.
- Observe the inside of the ***SVBF*** unit for trash, debris, or displacement of the media and mulch layers.
- Observe the ***SVBF*** unit for light, medium, or heavy loading within the mulch layer.
- Record and photograph any observations in the provided Inspection and Maintenance Log.
- Finalize the inspection report with the designated manager to determine required maintenance.

Recommendations for Achieving Optimal Performance

New Installations – A minimum of two inspections should be done for the unit each year, but regular inspections during the first two to three years of operation will help to establish a site-specific frequency for future inspections. During these regular inspections, light maintenance procedures such as clearing out trash and debris caught in the plant stabilization media and inlet grates or tending to vegetation can be completed. Clearing out trash and debris will prevent obstructions to the inlets and ensure the unit is operating at its maximum capacity. As mentioned before, it is recommended to inspect the unit after each major storm event during the first month.

Ongoing Operations – The system should be routinely inspected to ensure that all grates and drains are free of blockage. After several storm events, inspections should look for signs of erosion of, or accumulation of, sediment in the plant stabilization media layer. If the plant stabilization media has been displaced due to flows and the media layer is visible, or heavy accumulation of sediment is apparent in the plant stabilization media layer, the steps outlined in the maintenance section below should be followed to ensure that the ***SVBF*** unit is able to continue to operate at maximum capacity.

Maintenance

From observations noted during previous inspections, the following items may be indications of necessary maintenance to the ***SVBF*** unit:

- Damage to the concrete structure
- Damaged or missing grates
- Obstruction of the curb inlet or inlet rack
- Water stagnation in the biofiltration chamber more than a full day after a rainfall event
- Trash and debris in the inlet rack that cannot be easily removed at the time of inspection
- Invasive vegetation growth
- Excessive trash and debris

- Heavy sediment load present in the biofiltration chamber
- Excessive erosion of the plant stabilization media or bio-soil media

Maintenance Equipment

For proper cleanout, it is recommended the use of a vacuum truck in addition to the basic tools also required for routine inspections.

- Appropriate clothing (pants and shoes, gloves, safety vest, hard hat, etc.)
- Traffic control equipment (Traffic cones, signage, etc.)
- Manhole hook or crowbar
- Inspection & Maintenance Log or other recording method
- Flashlight
- Tape measure
- Trash grabber
- Shovel, rake, and broom
- Pruners
- Trash can/bag
- Vactor Truck

Maintenance Procedures

Cleanout of the ***SVBF*** unit at the end of a rainfall season is recommended to ensure captured trash, debris, sediment, and invasive vegetation do not compromise the unit's functionality or harm plants housed in it.

Jensen recommends a visual inspection of the unit every 6-months or for every 10-inches of rainfall, whichever occurs first to determine the need for mulch and media raking or replacement.

The following maintenance activities should be performed during service:

- Inspection of the treatment system and housing structure
- Removal of any material or debris blocking flow into and through the unit
- Removal of trash and debris from mulch and visible flow paths
- Raking or replacement of mulch layer

- *Sierra Blend* media replacement should only be necessary after an oil or chemical spill clean-up or when the filter has become totally occluded with fines or possibly biofouling.

- Raking the top quarter inch (0.25-inches), of media to discourage occlusion and plugging of the media surface.

- If vegetation is planted:

  - Pruning of vegetation
  - Replacement with new vegetation if current vegetation is in poor health for aesthetic purposes

- Disposal of any trash or debris collected

The visual presence of a scum line on the wall above the mulch layer that is higher than the crest of the overflow pipe is a general indicator that the filter bed has operated in bypass mode and the filter media may be plugged.

If the media appears plugged due to the presence of a prominent scum line on the vault wall above the crest of the bypass:

- Remove the mulch layer, which should be replaced

- Rake the top several inches of the media to break any cementitious crust that may have formed.

- Clean off a section of the scum line on the side wall

- If operations continue to appear to be in bypass condition, suggest replacing just the top 3 to 6-inches of media and replace mulch.

- Again, clean off a section of the scum line on the side wall

- If bypass events appear to continue, remove all the media, expose the undrain pipe, wash or replace the rock layer clean and place new media and mulch.

Replacement of the media is done either with hand tools or a mini-excavator.

Cleanout and Disposal

Cleanout of the unit primarily involves the removal of trash and sediment from the unit. Trash and debris can be removed from the curb inlet, inlet rack, and the biofiltration chamber manually with tools such as rakes, shovels, brooms or by Vactor trucks if required.

- Disposal of material from the ***SVBF*** unit should be in accordance with the local municipality's requirements. Typically, the removed solids can be disposed of in a similar fashion as those materials collected from sump catch basins or manholes.
- After replacement of the plant stabilization media, the ***SVBF*** unit should be inspected 24-hours after the next major storm event for water stagnation. Standing water in the unit is an indication that the media is clogged and will need to be replaced.
- If any of the unit's parts previously mentioned under the inspection section are damaged or missing, or media is needed for replacement, please contact Jensen Water Resources (Jensen Precast)

The generic O&M manual can be found at: https://www.jensenprecast.com/water-resources/product/biofiltration-systems/

7. Statements

The following attachments are signed statements from the manufacturer (Jensen Water Resources), the independent third-party observers, the testing laboratories (Lumos and Associates Inc., WETLAB), and NJCAT. These statements are a requirement for the NJCAT verification process.

February 6, 2020

Dr. Richard Magee, Sc.D., PE., BCEE
Executive Director
New Jersey Corporation for Advanced Technology (NJCAT)
Center for Environmental System
Stevens Institute of Technology
One Castle Point on Hudson
Hoboken, NJ 07030

Subject: Certification of Compliant Testing

Reference: ***StormVault BioFiltration*** with ***Sierra Blend*** Verification Report

Dear Mr. Magee:

We certify that the ***StormVault BioFiltration (SVBF)*** stormwater treatment unit with ***Sierra Blend*** Bio Soil Media was tested 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.*

Please do not hesitate to call me at either my office: (775) 352-6336, or cell: (408) 427-7571 or email me at wstein@jensenprecast.com if you have any questions regarding our unit testing or any item of the testing verification report.

Sincerely,

Walter L. Stein

Walter Stein, P.E.
Division Manager
Jensen Stormwater BMP/LID Systems
Jensen Precast

WWW.JENSENENGINEEREDSYSTEMS.COM
(855) 468 – 5600 | A JENSEN PRECAST DIVISION

University of Nevada, Reno

Keith E. Dennett, Ph.D., P.E.
Associate Professor
University of Nevada, Reno
Department of Civil and Environmental Engineering
Reno, Nevada 89557
Phone 775-784-4056
kdennett@unr.edu

February 6, 2020

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

Dear Dr. Magee,

Protocol Compliance Statement

I, Dr. Keith Dennett, Ph.D., P.E., served as a third-party independent observer for testing that was performed by the Jensen Precast Concrete Company on the Storm Vault Bio-Filtration (SVBF) unit. All tests were performed at the Jensen Stormwater Testing Facility located at 470 Dunn Circle in Sparks, NV. All testing met or exceeded the standard procedures described in ***Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology, January 25, 2013.***

I was present during the following tests:

- Tests 1-3, 12/3/2019
- Tests 4-6, 12/5/2019
- Tests 7-8, 12/10/2019
- Tests 9-10, 12/11/2019
- Tests 11-13, 12/12/2019
- Tests 17-19, 12/17/2019
- Tests 23-25, 12/19/2019
- Scour test loading, 1/23/2020
- Scour test loading, 1/28/2020

During those periods, I observed and monitored the testing based on the approved Quality Assurance Project Plan (QAPP) which was prepared in compliance with the standard procedures outlined in the approved QAPP by the New Jersey Corporation for Advanced Technology (NJCAT).

Conflict of Interest Statement

I, Dr. Keith Dennett, Ph.D., P.E., served as a non-biased, independent, third-party observer. I am a full-time faculty member of the Department of Civil and Environmental Engineering at the University of Nevada, Reno (UNR). I declare that I do not have any vested interest in the products that were tested or in any of the affiliated Jensen companies. There is no financial, personal, or professional conflict of interest between me and the Jensen Precast Concrete Company.

If I can provide any additional information, please do not hesitate to contact me by telephone at (775) 784-4056 or by e-mail at kdennett@unr.edu.

Sincerely,

Keith E. Dennett

Keith E. Dennett, Ph.D., P.E.
Associate Professor

February 15, 2020

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

Dear Dr. Magee:

Protocol Compliance Statement

I, Mark B. Hausner, Ph.D., served as a third-party independent observer for testing that was performed by Jensen Precast Concrete Company on stormwater treatment technologies. All tests were performed at the Jensen Stormwater Testing Facility located at 470 Dunn Circle in Sparks, Nevada. All testing met or exceeded the standard procedures described in *Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology, January 25, 2013.*

I was present during the following tests:

- Tests 14-16, 12/16/2019
- Tests 20-22, 12/18/2019
- Tests 26-28, 12/20/2019
- Scour test loading, 1/21/2020
- Scour test loading, 1/22/2020
- Scour test, 1/29/2020

During those periods, I observed and monitored the testing based on the approved Quality Assurance Project Plan (QAPP), which was prepared in compliance with the standard procedures outlined in the approved QAPP by the New Jersey Corporation for Advanced Technology (NJCAT).

Conflict of Interest Statement

I, Mark B. Hausner, Ph.D., served as a non-biased, independent, third-party observer. I am a full-time faculty member of the Division of Hydrologic Sciences at the Desert Research Institute (DRI). I declare that I do not have any vested interest in the product or Jensen affiliated companies. There is no financial, personal, or professional conflict of interest between the Jensen Precast Concrete Company and me.

If I can provide any additional information, please do not hesitate to contact me by telephone at 775-673-7352 or by email at mark.hausner@dri.edu.

Sincerely,

Mark B. Hausner, Ph.D.
Assistant Research Professor

WETLAB
WESTERN ENVIRONMENTAL TESTING LABORATORY

www.WETLaboratory.com

Specializing in Soil, Hazardous Waste and Water Analysis.

February 18, 2020

Dr. Richard Magee, Sc.D., PE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental System
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030

REF: Protocol Compliance Statement & Conflict of Interest Statement

Protocol Compliance Statement:

Western Environmental Testing Laboratory (WETLAB) is an independent company with an analytical chemistry laboratory that will perform testing on aqueous samples submitted by Jensen Precast Concrete from their tests on storm water treatment technologies. WETLAB maintains certifications with the states of Nevada, California, Idaho and Wyoming under several different programs and analyzes aqueous samples according to the ASTM D3977 B. Our work will be professionally oriented and will be carried out using the mentioned ASTM standard.

Conflict of Interest Statement:

Western Environmental Testing Laboratory (WETLAB) is a non – biased independent entity with a lab for analytical testing of sediment and aqueous samples. WETLAB does not have any vested interest in the products it analyzes for their affiliated companies. There is no financial, personal or professional conflict of interest between WETLAB and the manufacturer of any storm water treatment technologies that send sediment or aqueous samples for analysis.

If you have any questions, please do not hesitate to reach out to me via phone: (775) 355 – 0202 or email: katl@wetlaboratory.com

Sincerely,

Kat Langford
Project Manger
February 18, 2020

SPARKS
475 E. Greg Street, Suite 119
Sparks, Nevada 89431
tel (775) 355-0202
fax (775) 355-0817

ELKO
1084 Lamoille Hwy.
Elko, Nevada 89801
tel (775) 777-9933
fax (775) 777-9933

LAS VEGAS
3230 Polaris Ave., Suite 4
Las Vegas, Nevada 89102
tel (702) 475-8899
fax (702) 776-6152

LUMOS
& ASSOCIATES

Carson City • Fallon • Lake Tahoe • Reno

Reno
9222 Prototype Drive
Reno, Nevada
775.827.6111

www.LumosInc.com

Dr. Richard Magee, Sc.D., PE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental System
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030

February 18, 2020

Protocol Compliance Statement
Lumos & Associates, Inc. is an independent company with a geotechnical lab that will perform analytical tests on sediment samples sent by Jensen Precast Concrete from their tests on stormwater treatment technology tests. Lumos & Associates Lab is certified for analyzing samples according to the ASTM D 422-63 (reapproved 2007) for Particle Size Distributions (PSD) analysis. Our work will be professionally oriented and will be carried based on the mentioned ASTM Standard.

Conflict of Interest Statement
Lumos & Associates, Inc. is a non-biased independent entity with a geotechnical lab for analytical tests on sediment samples. Lumos & Associates does not have any vested interest in the products it analyzes the samples for, or their affiliated companies. There is no financial, personal or professional conflict of interest between Lumos & Associates, Inc. and the manufacturer of any stormwater treatment technologies that send sediment samples for analysis.

Mitch Burns, P.E.
Materials Engineering Manager

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

February 26, 2020

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

Dear Mr. Mahon,

Based on my review, evaluation and assessment of the testing conducted on the Jensen Stormwater Systems StormVault Biofiltration (***SVBF***) Model ***4x4*** under the direct supervision of Professor Keith Dennett, Ph.D. and Professor Mark Hausner, Ph.D., 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, January 2013) were met or exceeded. Specifically:

Test Sediment Feed

Appropriate sediment was purchased in bulk from a variety of suppliers and vendors. Jensen blended these sediments to meet the mass gradations and particle size distribution (PSD), requirements explicitly set forth by the New Jersey Department of Environmental Protection (NJDEP). A batch of test sediment was prepared for TSS Removal Efficiency and Sediment Mass Loading Capacity testing. Samples were sent to Lumos & Associates, Sparks, NV, an independent material testing laboratory, for analysis using ASTM D422-63 (Reapproved 2007), *Standard Test Method for Particle Size Analysis of Soils.* All three of the required samples of the test sediment batch had a median particle size (d_{50}) of less than 75-microns (µm), as required. The d_{50} of the test sediment was approximately 48 µm.

Removal Efficiency Testing

Twenty-eight (28) removal efficiency testing runs were completed in accordance with the NJDEP test protocol. Thirteen (13) of the 28 test runs were conducted during mass loading and 15 during removal efficiency testing. The target flow rate and influent sediment concentration were 32 gpm and 200 mg/L (increased to 400 mg/L after Run 15) respectively. The system did not reach maximum driving head during the test process. The cumulative mass removal efficiency exceeded 90% after the first run.

Sediment Mass Loading Capacity

Mass loading capacity testing was conducted as a continuation of removal efficiency (RE) testing. Mass loading test runs were conducted using identical testing procedures and targets as those used in the RE runs, the only change was to increase the target influent concentration to 400 mg/L after test run 15. Testing concluded after 28 test runs as it was deemed an appropriate stopping point with the amount of sediment loaded into the system.

.

The total influent mass loaded through Run 28 was 193.4 lbs and the total mass captured by the ***SVBF4x4*** was 176.7 lbs. The cumulative mass removal efficiency for the 28 runs was 91.3%. This is equivalent to a sediment mass loading capacity of 11.0 lbs/ft^2 of filter surface area.

No maintenance was performed on the ***SVBF4x4*** during the entire testing program.

Scour Testing

Scour testing was conducted at 62.6 gpm (195% of the MTFR), the maximum flow rate that Jensen intends to convey through the ***SVBF***, in order to demonstrate the ability of the filter to be used as an on-line treatment device. Background concentrations were ≤ 5 mg/L (reported as 3 times the MDL) throughout the scour testing (with one exception – 6 mg/L), much less than the 20 mg/L maximum background concentration specified by the test protocol. The average adjusted effluent concentrations were 14.7 mg/L. qualifying the ***SVBF*** for on-line installation up to 195% of the MTFR.

Sincerely,

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

References

ASTM D422-63. *Standard Test Method for Particle Size Analysis of Soils*.

ASTM D3977-97. *Standard Test Methods for Determining Concentrations in Water Samples*.

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

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

NJDEP Laboratory Test protocol and Verification Procedure: NJCAT Interpretations, June 2017.

VERIFICATION APPENDIX

Introduction

- Manufacturer – Jensen Water Resources, 521 Dunn Cir, Sparks, NV 89431. Phone: (855) 468-5600. Website: https://www.jensenprecast.com/water-resources/

- ***StormVault Biofiltration*** (***SVBF***) MTD – Various sizes found in **Table A-1.**

- TSS Removal Rate: 80%

- Online Installations up to 195% MTFR and Offline Installation

Detailed Specification

- NJDEP sizing tables for the ***SVBF*** verified models are found in **Table A-1**.

- Maximum inflow drainage area is also shown in **Table A-1.**

- The depth of the ***Sierra Blend*** media in the ***SVBF*** is 18-in.

- The maximum head level prior to bypass is 33-in.

- Jensen Water Resources supplies detailed installation and assembly procedures for contractors as well as design support. Jensen Water Resources also offers onsite installation consulting.

- An Operations and Maintenance Guide is provided for each project installation. A generic O&M Manual ready for project specific revisions can be downloaded at:

  https://www.jensenprecast.com/water-resources/product/biofiltration-systems/

Table A-1 SVBF Model Sizes and New Jersey Treatment Capacities

Configuration[3]	Dimensions	Media Surface Area	Effective Sedimentation Treatment Area (ESTA)	Effective Filtration Treatment Area (EFTA)	ESTA/EFTA	Wet Volume (WV)	WV/EFTA	MFTR[1]	Maximum Allowable Inflow Drainage Area[2]
	(ft)	(ft^2)	(ft^2)	(ft^2)	-	(ft^3)	-	(cfs)	(acres)
SVBF	3 x 5	15.00	15.00	15.00	1.0	16.5	1.1	0.07	0.28
	4 x 4	16.00	16.00	16.00	1.0	17.6	1.1	0.07	0.30
	4 x 6.5	26.00	26.00	26.00	1.0	28.6	1.1	0.12	0.48
	4.5 x 8.5	38.25	38.25	38.25	1.0	42.1	1.1	0.17	0.71
	5 x 5	25.00	25.00	25.00	1.0	27.5	1.1	0.11	0.48
	5 x 10.5	52.50	52.50	52.50	1.0	57.8	1.1	0.23	0.97
	6 x 6	36.00	36.00	36.00	1.0	39.6	1.1	0.16	0.67
	6 x 8	48.00	48.00	48.00	1.0	52.8	1.1	0.21	0.89
	6 x 12	72.00	72.00	72.00	1.0	79.2	1.1	0.32	1.33
	6 x 15	90.00	90.00	90.00	1.0	99.0	1.1	0.40	1.67
	8 x 8	64.00	64.00	64.00	1.0	70.4	1.1	0.29	1.19
	8 x 10	80.00	80.00	80.00	1.0	88.0	1.1	0.36	1.48
	8 x 16	128.00	128.00	128.00	1.0	140.8	1.1	0.57	2.37
	10 x 20	200.00	200.00	200.00	1.0	220.0	1.1	0.89	3.70
SVBF with Internal Bypass	3 x 5	14.91	14.91	14.91	1.0	16.4	1.1	0.07	0.28
	4 x 4	15.91	15.91	15.91	1.0	17.5	1.1	0.07	0.29
	4 x 6.5	25.91	25.91	25.91	1.0	28.5	1.1	0.12	0.48
	4.5 x 8.5	38.16	38.16	38.16	1.0	42.0	1.1	0.17	0.71
	5 x 5	24.91	24.91	24.91	1.0	27.4	1.1	0.11	0.46
	5 x 10.5	52.41	52.41	52.41	1.0	57.7	1.1	0.23	0.97
	6 x 6	35.80	35.80	35.80	1.0	39.4	1.1	0.16	0.66
	6 x 8	47.80	47.80	47.80	1.0	52.6	1.1	0.21	0.89
	6 x 12	71.80	71.80	71.80	1.0	79.0	1.1	0.32	1.33
	6 x 15	89.80	89.80	89.80	1.0	98.8	1.1	0.40	1.66
	8 x 8	63.80	63.80	63.80	1.0	70.2	1.1	0.28	1.18
	8 x 10	79.80	79.80	79.80	1.0	87.8	1.1	0.36	1.48
	8 x 16	127.80	127.80	127.80	1.0	140.6	1.1	0.57	2.37
	10 x 20	199.80	199.80	199.80	1.0	219.8	1.1	0.89	3.70

1. MTFR is based on 2.0-gpm/ft^2 (0.004-cfs/ft^2) of effective filtration treatment area.
2. Maximum Allowable Inflow Drainage Area is based on 11.0-lb/ft^2 (176.7-lb/16-ft^2) of effective filtration treatment area and the equation in the NJDEP Filtration Protocol Appendix, where drainage area is calculated on 600-lbs of mass contributed per acre of drainage area annually.
3. Filtration media layers must remain the same depth for all SVBF unit sizes.