Nutrient Separating Baffle Box

NJDEP/SWEMA Hydrodynamic Protocol Evaluation with 100 μm Sediment Particles

Quality Assurance Project Plan

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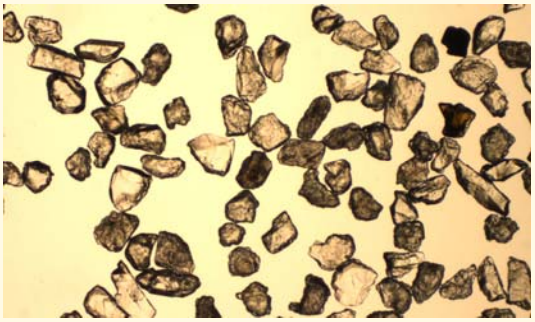

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BACKGROUND

The national goal of protecting and restoring the quality of U.S. surface waters requires that pollutant loadings from stormwater runoff be reduced. The Nutrient Separating Baffle Box (NSBB) is a structural Stormwater Control Measure (SCM), or Manufactured Treatment Device (MTD), that reduces pollutant loadings by capturing sediments, gross solids, and associated pollutants. The treatment effectiveness of the NSBB can be assessed through definitive experimental evaluations that quantify the suspended sediment removal efficiency under controlled conditions (1).

A procedure and protocol for MTD performance evaluation has been established by the New Jersey Department of Environmental Protection (NJDEP) in consultation with the Stormwater Equipment Manufacturers Association (SWEMA). SWEMA has recently submitted a document to NJDEP titled *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (MTD)* (2). The document provides a general template for the experimental evaluations of the NSBB to be conducted in this study.

The NJDEP/SWEMA Hydrodynamic Sedimentation protocol presents detailed procedures to be used in the laboratory evaluation of hydrodynamic separation devices for determining suspended sediment removal efficiency and sediment resuspension. The protocol requires that a full scale, commercially available MTD be used in performance testing, with a determined Effective Sedimentation Area. The protocol includes specifications of the particle size distribution (PSD) of test sediment, sediment pre-loading for resuspension testing, methods of sampling and analyses, maximum water temperature and maximum background sediment levels. Necessary qualifications of the independent, 3rd party testing laboratory are established.

OBJECTIVE

The objective of this Quality Assurance Project Plan (QAPP) is to evaluate the Nutrient Separating Baffle Box (NSBB) for suspended sediment removal using a modification of the NJDEP/SWEMA laboratory protocol for hydrodynamic separation devices (2). The Nutrient Separating Baffle Box is manufactured by Suntree Technologies Inc. of Cocoa, Florida. The NSBB is a subsurface rectangular vault MTD that is placed inline in the stormwater collection system. The NSBB vault is subdivided into a series of chambers by engineered vertical baffles which influence hydrodynamics and capture suspended particles by sedimentation. The NSBB additionally contains a basket screen that is located above the top of the chamber baffles. The screen captures floating and suspended solids and holds them out of the water column during non-flow periods. Details of the NSBB can be found on the Suntree Technologies Inc. website (3).

The basis of the experimental methods described in this QAPP is the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (MTD)* (2). This QAPP for NSBB testing follows the protocol with one significant exception. The NSBB evaluation experiments will be conducted using 100 μm size sediment with a relatively narrow particle size distribution (PSD). The 100 μm centered PSD contrasts with the broader PSD specified in the NJDEP protocol (2) and in the previous NJDEP protocols. The 100 μm particle size was selected as a single particle size test platform that reasonably represents the removal capabilities of NSBB. Use of sediment with a relatively narrow PSD centered on 100 μm is congruent with the treatment functionality of the NSBB. In addition, many municipalities and stormwater agencies seek MTD performance data based on sediment with a 100 μm particle size. Other than the use of a narrow PSD test sediment centered on 100 μm particles, NSBB testing will be conducted according to the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (MTD)* (2). Therefore, Suntree will not be submitting the NJCAT NSBB verification report to NJDEP for certification.

SUNTREE TECHNOLOGIES INC.®

Corporate History The stormwater treatment division of Suntree Technologies was founded by Mr. Henry Happel and Mr. Tom Happel in 1993 in response to local environmental concerns and the need to protect the Indian River Lagoon from stormwater pollutants. Initially incorporated as Suntree Isles and currently doing business as Suntree Technologies Inc., the company has been designing and manufacturing stormwater pollution control devices since 1993. The Nutrient Separating Baffle Box® was developed in 1998 by incorporating screen capture devices into in-line sedimentation chambers in order to capture large stormwater materials and hold them out of the water column between storm events. The first NSBB was installed in 1999, and NSBB designs have since continued to evolve and improve. Suntree has also developed an extensive line of other products for the stormwater management industry, including a variety of inlet filter systems, media filtration systems, polymer filtration systems, and advanced skimmer systems. Suntree provides both standardized BMP units and customized designs, and holds eleven patents for innovative technologies that are related to their NSBB product line.

Organization and Management Suntree Technologies Inc.® is a privately owned Florida corporation with corporate headquarters located at 798 Clearlake Road, Cocoa, FL (PH: 321-637-7552). Suntree Technologies is currently owned and managed by Tom Happel as president and John Happel as Vice President. Suntree's product market place has expanded beyond Florida to include all 50 states, with an extensive distributor network.

Operating Experience with Respect to the Proposed Technology To date there are approximately 1500 installations of the Suntree Nutrient Separating Baffle Box® across the United States, which vary in size and configuration to treat storm pipes ranging in size from 6" to 84" in diameter. In addition to 12 different standard sizes, custom NSBB configurations are manufactured to accommodate various unique treatment and site specific requirements.

The Nutrient Separating Baffle Box® (NSBB) is also referred to as the 2nd Generation Baffle Box and is a significant design improvement over previous old style baffle boxes. Key innovations have been the incorporation of a raised screen basket in line with the stormwater inlet pipe to keep organic material and debris separate from the static water between rain events, and the addition of turbulence deflectors to improve the settling of fine sediments while minimizing re-suspension. While Suntree initially developed the Nutrient Separating Baffle® as a gross pollutant removal device prior to stormwater outfalls, NSBB application has since been expanded to a pretreatment option prior to underground detention, exfiltration fields, filtration systems, and injection wells, as well as its general use as a component of a treatment train. A variety of media treatment systems are also available as options for the NSBB. The unique design of the Nutrient Separating Baffle Box® results in minimal head loss through the treatment structure. As a result, the NSBB can be installed in either an inline or offline configuration, making for an easy retrofit within existing water sheds.

Patents The proprietary technology behind the Nutrient Separating Baffle Box® is protected by 1 or more patents issued by the U.S. Patent office with patents pending. The trade name, Nutrient Separating Baffle Box®, is a federally registered trademark of Suntree Technologies, Inc. Below is a list of issued utility patents:

6,428,692	6,979,148	7,294,256	8,034,236
7,270,747	6,270,663	7,981,283	8,034,234
6,797,162	7,153,417	7,846,327	

Technical Resources, Staff and Capital Equipment Suntree Technologies employs 30 employees which includes 2 staff engineers. In addition to in-house design work, additional engineering is often outsourced to several different firms. Specialized product testing and evaluations are performed in house and by third party testing laboratories.

Suntree Technologies representatives oversee the assembly and installation of every Nutrient Separating Baffle Box® to ensure that installation is always perfect, and that the treatment system is quality controlled to ensure optimum treatment of the water flow. Suntree Technologies Inc. warranties all of its products to be free from manufacturer's defects for a period of at least five (5) years from the date of purchase. Suntree Technologies Inc. also warranties that the materials used to manufacture its products are able to withstand and remain durable to typical environmental conditions for a period of at least five (5) years from the date of purchase.

The vault that makes up the Nutrient Separating Baffle Box® is typically made of either concrete or fiberglass. Typically, the concrete is cast by an independent casting company that is located relatively local to the installation site. The interior components are manufactured in Cocoa Florida and shipped to the casting company where the components are then installed. If a project requires a fiberglass vault, the vault with all the interior components pre-installed is shipped from Cocoa, Florida. In almost all cases, all the unique interior components are installed prior to delivery of the vault. This makes for a quick and easy installation, in which the excavation, setting Nutrient Separating Baffle Box®, and restoration of the excavation often takes less than a day.

The products of Suntree Technologies Inc.® are available either directly from Suntree Technologies or through a national sales network of authorized distributors. There are no other manufacturers authorized to sell or market the Nutrient Separating Baffle Box®.

EXPERIMENTAL METHODS

NJDEP/SWEMA Evaluation Overview The protocol requires the manufacturer to:

- Establish a Maximum Treatment Flow Rate (MTFR), which is a flow rate for which a performance claim will be made for the treatment device. The performance claim is stated as a flow weighted removal efficiency of suspended solids (TSS/SSC). For NSBB, the target removal efficiency is 80%. In practice, the MTFR will be based on continuous curve of weighted removal efficiency versus flow rate with individual experiments that bracket the MTFR-scaled flow rates.
- Establish a Maintenance Sediment Storage Volume (MSSV), which is the maximum amount of sediment that can accumulate in the MTD prior to maintenance based on a minimum six month maintenance interval.
- Evaluate suspended sediment removal performance of the treatment device in five individual flow rates experiments at 25, 50, 75, 100 and 125% of the MTFR.
- Conduct each experiment with a false floor placed at the depth of the 50% of the Maintenance Sediment Storage Volume.
- Conduct each experiment at an influent suspended sediment concentration of 200 mg/l and collect eight background influent samples and analyze for TSS/SSC.
- Determine suspended sediment dosing rate by measuring the mass flow rate of sediment from the dosing device at least six times at evenly spaced intervals over the duration of each of the five experiments.
- Calculate overall TSS/SSC removal efficiency using the individual flow rate removal efficiencies and the NJDEP flow weighting procedure.
- Compare overall TSS/SSC removal efficiency of the NSBB to target 80% criteria.
- If warranted, perform an additional individual flow rate experiment to bracket the flow rates (25 to 125%) that will be used to derive the MTFR. Derive a continuous removal efficiency function and determine the MTFR as the flowrate for which the weighted removal efficiency equals the target removal efficiency.
- Evaluate sediment resuspension at a flow rate of 200% of the Maximum Treatment Flow Rate (MTFR), without sediment dosing into the NSBB influent, and with sediment pre-loading of 50% of the Maintenance Sediment Storage Volume (MSSV). The sediment pre-load will be the Best Sand sediment used in the TSS Removal Efficiency experiments.
- Collect a minimum of eight background water samples and fifteen NSBB effluent samples during the resuspension experiment and analyze for TSS/SSC.
- Compare effluent TSS/SSC from the resuspension experiment with NJDEP on-line MTD criteria.

Nutrient Separating Baffle Box The NJDEP performance evaluation of the Nutrient Separating Baffle Box will be conducted using the commercial NSBB Model 3-6-72. Details of NSBB 3-6-72 are summarized in Table 1. Drawings of the NSBB 3-6-72 are included in Appendix A. Operating characteristics of the NSBB 3-6-72 are illustrated in Table 2 for an example Maximum Treatment Flow Rate (MTFR) flow rate of 1.5 cfs.

The Maintenance Sediment Storage Volume (MSSV) of the NSBB 3-6-72 has been established as 18 ft^3, which represents an average sediment depth of 12 in. over the plan area of each of the three bottom chambers. The NJDEP protocol requires that TSS/SSC removal efficiency experiments be conducted with a false floor at the 50%

Table 1 NSBB 3-6-72 Specifications

Internal length, inch	72
Internal width, inch	36
Number of bottom chambers	3
Baffle height, inch	36
Effective sedimentation area, ft^2	18
Vertical area, ft^2	9.0
Chamber empty bed volume, gallon	404
Maintenance Sediment Storage Volume, ft^3	18.0
Screen box length, inch	51
Screen box width, inch	21

Table 2 Illustrative Operating Characteristics of NSBB 3-6-72 for 1.5 cfs MTFR

% of Treatment Flowrate	Flowrate, cfs	Sediment Mass Flow, gram/min	Hydraulic Retention Time, min[1]	Surface Overflow Rate, gal/ft^2-min
25	0.375	127	2.40	9.4
50	0.750	255	1.20	18.7
75	1.125	382	0.80	28.1
100	1.500	510	0.60	37.4
125	1.875	637	0.48	46.8

[1]based on chamber volume

MSSV depth, and that the resuspension experiment be conducted with a sediment pre-loading at the 50% MSSV depth. For the NSBB 3-6-72, 50% of the MSSV is a volume of 9 ft^3, which is equivalent to a uniform sediment depth of 6 inch over the bottom surface of all three chambers. The TSS/SSC Removal Efficiency experiments will be conducted with a false bottom at 6 in. depth in each of the three chambers. In practice, sediment accumulation depths in the NSBB are typically not uniform among chambers, with the greatest depth of sediment accumulating in the first chamber and least depth of sediment accumulating in the third chamber. The sediment accumulation depths in initial TSS/SSC Removal Efficiency experiments will be monitored and documented. Results will be evaluated as a possible basis for establishing a non-uniform depth profile for the 50% MSSV. An example 50% MSSV depth profile is 8.0, 6.0 and 4.0 inch in Chambers 1, 2 and 3, respectively. If TSS/SSC removal efficiency test results are able to justify non-uniform depth profiles, then removal efficiency and resuspension experiments will be conducted with false bottoms at the non-uniform sediment depths of 50% MSSV. The default condition for the resuspension experiment is false bottoms at 2.0 inch above chamber volumes with the top of the sediment pre-load at 6.0 inch above chamber bottoms. If a non-uniform depth distribution is established for the 50% MSSV sediment accumulation depth, false bottom levels will be adjusted such that they do not result in an overlying sediment preload depth that is less than 4.0 inch.

Experimental System Experiments will be conducted at the Applied Environmental Technology Test Facility (AET-TF) in Hillsborough County, Florida. AET-TF is a 4 acre site dedicated to the evaluation of water treatment technologies, with electric power, water supply, shop and pilot support facilities, and an analytical laboratory which will perform TSS/SSC analyses according to protocols detailed in Appendix B. A schematic of the experimental system for conducting the NJDEP evaluation of the NSBB is shown in Figure 1. The system consists of a Nutrient Separating Baffle Box (NSBB), Water Supply Recycle Reservoir (WSRR), influent pump (IP), influent flow controller valve, influent flow meter, a Sediment Hopper System (SHS)
for dosing of influent sediment, sampling access locations in influent and effluent pipes, and associated valves, ports and piping. Through a process of adaptive development, the apparatus depicted in Figure 1 will be iteratively assembled to devise a complete experimental system that is capable of meeting the testing requirements described in the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (MTD)* (2).

The Influent Pump (IP) will lift water from the upper level of the Water Supply Recycle Reservoir to an open channel conveyance (12 to 15 in. pipe). IP is the only power requiring component of the experimental system; all other flow is by gravity. A flow valve will be used to throttle and adjust flow rate to the NSBB. Flow rate will be measured using an inline electronic flowmeter (Portaflow SE ultrasonic flowmeter, Greyline Instruments, Massena, NY), which will provide instantaneous readout of flow

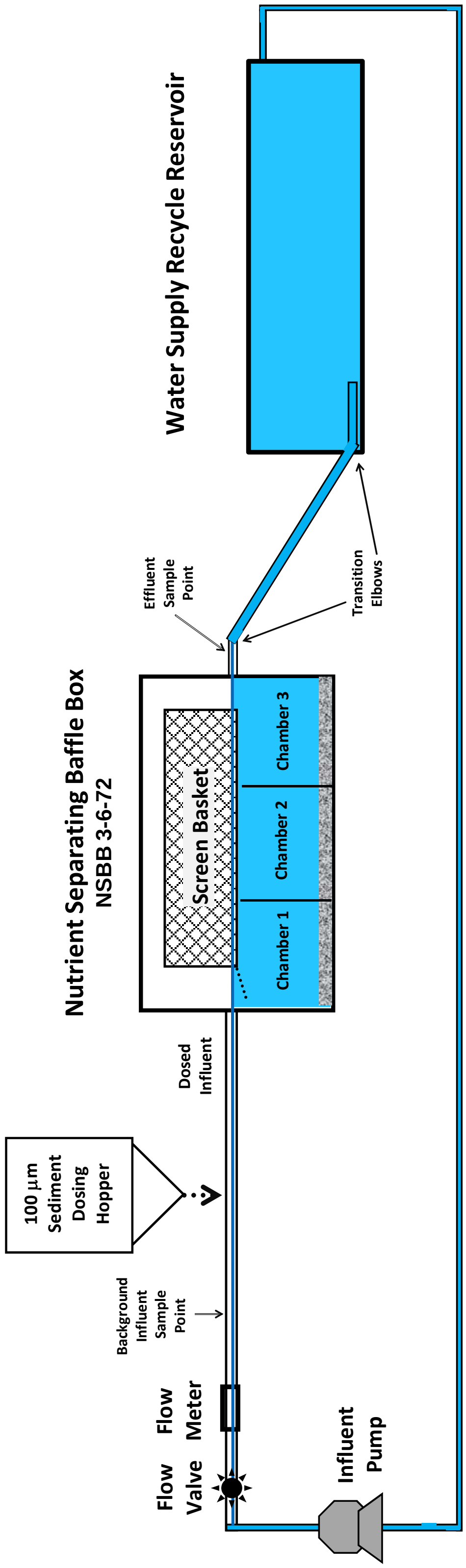

Figure 1 Schematic of experimental system.

rate and has an accuracy of 2%. The flowmeter will be positioned in close proximity to the flow valve to enable expeditious adjustment of the flow rate by a single operator.

Sediment will be dosed from an open hopper directly into the conveyance pipe through a slot in the crown of the pipe. The dosing point will be within five pipe diameters or ten feet of the NSBB entrance, whichever is less. The dosed sediment will mix in the water stream and the dosed influent will enter the NSBB 3-6-72. NSBB effluent will pass through the effluent pipe, through downward transition, through a straight section, and another transition such that effluent flow enters the WSRR in a horizontal direction near the bottom and parallel with the WSSR sidewall.

Test water will be the AET-TF groundwater supply which will be supplied by pump to the Water Supply Recycle Reservoir prior to initiation of experimentation. The groundwater supply is of circumneutral pH, has limited dissolved oxygen, and is virtually free of suspended sediment. Although the WSRR will be covered, the temperature of the test water will increase to levels appropriate for NJDEP protocol testing by contact with ambient air, but <80F. The groundwater supply will possibly contain some level of reduced iron which could oxidize and lead to ferric iron deposition within the Water Supply Recycle Reservoir. To insure a clean water supply, provision will be made to remove any possible precipitate prior to initiation of protocol testing.

Sediment Removal Efficiency Evaluation The sediment removal efficiency of the NSBB will be evaluated at five flow rates as per the NJDEP protocol (2). An individual flow rate experiment will be conducted in a sequence of operations listed in the evaluation template shown in Table 3. Listed are intial periods for pump startup and stabilization, , six hopper sediment dosing calibrations of 1 minute each, and collection of 8 influent background samples. Although not required by NJDEP protocol (2), effluent samples may be collected during the individual flow rate experiments.

The characteristics for the five individual flow rate experiments are listed in Table 4 for a projected Maximum Treatment Flow Rate (MTFR) of 1.50 cfs. The Hydraulic Residence Time (HRT) ranges from 2.4 min. at 25% MTFR to 0.48 min. at 125% MTFR. The individual experimental durations range from 119 min. at 25% MTFR to 33 min. at 125% MTFR. Total water volumes of single flow rate experiments range from 20 to 28 thousand gallons. The mass of sediment dosed to the NSBB range from 33 to 38 lbs., and satisfies the NJDEP requirement of a minimum of 25 lbs. of sediment dosed to the NSBB at 200 mg/L influent SSC.

The projections shown in Table 4 provide the basic experimental outline that will be implemented in the NJDEP evaluation of the NSBB SSC removal efficiency. The results of experimentally measured SSC removal efficiencies at the five experimental flow rates may result in a weighted SSC removal efficiency greater than or less than the 80% target. To determine a MTFR that meets the 80% weighted SSC removal efficiency target, another individual flow rate experiment will be conducted at either higher or

Table 3 Individual Flow Rate Experiment Template

Test Period	Duration, minute
Start water flow, adjust and stablilze	6.0
Start sediment dosing	0
Number of hopper calibration samples	6
Time for hopper calibration sample	1.0
Number of background influent samples	8
Time for background influent sample	1.0

lower flow rate in order to bracket at the high and low end the five equally spaced flow rates needed for the NJDEP efficiency calculation. In additional individual flow rate experiments, the test period, water volume, and sediment mass flow rate would be adjusted accordingly, but the basic experimental template and sequence would be similar to those shown in Table 4.

Table 4 Characteristics of Individual Flow Rate Experiments for 1.5 cfs MTFR

% of Treatment Flowrate	25		50		75		100		125	
Test Times and Volumes										
Flowrate, cfs	0.375		0.750		1.125		1.500		1.875	
Flowrate, gal/min	168		337		505		673		842	
SOR, gal/ft^2-min	0.64		1.27		1.91		2.54		3.18	
HRT, minute	2.40		1.20		0.80		0.60		0.48	
Sediment Mass Flowrate, gram/min	127		255		382		510		637	
Time Period to dose approxmately 30 lb. sediment to NSBB, min.	107		53		36		27		21	
Time for hopper calibration samples	6		6		6		6		6	
Time Period of sediment dosing, min.	113		59		42		33		27	
Time Period of Individual Flow Rate Experiments										
Period	**Time, min**	**Volume, gallon**	**Time, min**	**Volume, gallon**	**Time, min**	**Volume, gallon**	**Time, min**	**Volume, gallon**	**Time, min**	**Volume, gallon**
Start water flow, adjust and stablilize	6.0	1,010	6.0	2,020	6.0	3,029	6.0	4,039	6.0	5,049
Start sediment dosing	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0
End sediment dosing	113.0	19,018	59.0	19,859	42.0	21,206	33.0	22,216	27.0	22,721
Sediment Dosing Period	113.0	19,018	59.0	19,859	42.0	21,206	33.0	22,216	27.0	22,721
Total All Periods	119.0	20,028	65.0	21,879	48.0	24,235	39.0	26,255	33.0	27,770
Sediment Dosing										
Time for hopper calibration samples	6.0	1,010	6.0	2,020	6.0	3,029	6.0	4,039	6.0	5,049
Time for influent samples	8.0	1,346	8.0	2,693	8.0	4,039	8.0	5,386	8.0	6,732
Total Inter-sampling time	99.0	16,662	45.0	15,147	28.0	14,137	19.0	12,791	13.0	10,940
Total Dosing Time	113.0	19,018	59.0	19,859	42.0	21,206	33.0	22,216	27.0	22,721
Total mass sand dosed, g	14,397		15,034		16,053		16,817		17,199	
Total mass sand dosed, lb.	31.7		33.1		35.3		37.0		37.9	
Bulk volume sand dosed, gal.	2.3		2.4		2.6		2.7		2.8	
Hopper calibration sample time, min.	2,8,27,46,65,84,103		5,15,25,35,45,55		3,10,17,24,31,38		3,8,14,19,25,30		2,7,11,16,20,25	
Background influent sample time, min.	4,19,34,49,63, 79,94,109		3,11,20,28, 37,44,53,62		2,8,15,21, 27,34,40,46		2,7,12,17, 22,27,32,37		1,5,10,14, 19,23,28,32	
Sediment Dosing to NSBB										
Dosing Time to NSBB	107.0	18,008	53.0	17,840	36.0	18,176	27.0	18,176	21.0	17,672
Total mass sand dosed, g	13,632		13,505		13,760		13,760		13,377	
Total mass sand dosed, lb.	30.0		29.7		30.3		30.3		29.4	

Water Supply Recycle Reservoir The Water Supply Recycle Reservoir (WSRR) will recycle water for NSBB experiments and remove suspended sediment from the NSBB effluent. Suspended sediment removal will take place by sedimentation within the WSRR volume. WSRR will limit influent SSC to a maximum of 10% of target influent SSC (20 mg/L). Required SSC removal efficiency in the WSRR ranges from 20.8% for 25% MTFR to over 80% for 125% MTFR (Table 5). The surface overflow rate at 125% MTFR is 1.58 gal/ft^2-min (0.108 cm/sec). For comparison, the calculated settling velocities of 100 and 50 μm sand particles are on the order of 0.9 and 0.2 cm/sec, respectively.

The following list includes WSRR factors that are significant to limiting the rise in SSC during the experimental procedure and approaches to achieving this objective:

- Inlet pipe immobilized in place
- Inlet pipe entry level at bottom of reservoir
- Outlet appurtenance immobilized in place
- Outlet appurtenance withdrawal level at top of reservoir
- Outlet appurtenance baffles
- Inlet/outlet locations to achieve farthest flow paths
- Orient inlet pipe parallel to sidewall to enhance radial flow pattern
- Outlet pipe orientation options: facing vertically upwards, horizontal with fixed weir, horizontal with floating weir/skimmer
- Internal baffles to minimize short circuit flow paths
- Direct water flow through geotextile strainer curtains

Table 5 Water Supply Recycle Reservoir Solids Removal for 1.5 cfs MTFR

Circular Reservoir Diameter, ft.	26		Working depth, in.		46
Working Volume, gal	15,216		Surface Area, ft^2		531
% of Treatment Flowrate	25	50	75	100	125
Flowrate, cfs	0.375	0.750	1.125	1.500	1.875
Surface Overflow Rate, cm/sec	0.022	0.043	0.065	0.086	0.108
Sediment dosing duration, min	113	59	42	33	27
Total mass sand dosed to NSBB, g	13,632	13,505	13,760	13,760	13,377
Average SSC Removal efficiency	92	82	77	71	66
Mass SSC In NSBB Effluent, g	1,091	2,431	3,165	3,990	4,548
Reservoir SSC if all NSBB effluent solids distributed evenly though reservoir volume, mg/L	18.9	42.2	54.9	69.3	79.0
Required SSC Removal Efficiency with 5 mg/L reserve %	20.8	64.5	72.7	78.4	81.0

The sediment removal efficiency of the WSRR will be evaluated prior to conducting removal efficiency experiments. The 125% MTFR will be used with sediment dosing and SSC will be measured in water that is pumped from the WSRR. Sediment removal by WSRR will be increased if needed by the techniques listed above. The temperature of WSRR water entering the NSBB will be equal to or less than 80^oC (2). A reservoir cover will be employed, and a spray system for evaporative cooling employed if necessary.

Particle Size Distribution of Test Sediment A strategic decision was made to conduct the NSBB evaluation using sediment with a relatively narrow particle size distribution (PSD) centered on 100 μm. The PSD to be used in the NSBB experiments contrasts with the broader PSD specified in the NJDEP protocol (2) and in previous NJDEP protocols. Sediment removal in hydrodynamic devices is highly dependent on particle size and settling velocity (4,5,6). The 100 μm particle size was selected as a single particle size test platform that reasonably represents the removal capabilities of the NSBB. The rationale for the selection of a 100 μm test sediment with narrow PSD is that the short water residence times of the NSBB limits its effectiveness in removing smaller sediment particles, while removal efficiency for larger particle sizes can be extrapolated. The presence in the test sediment of smaller particle sizes with limited removal efficiency makes it more difficult to delineate the treatment performance for the larger particles which the NSBB is capable of removing. Use of sediment with a relatively narrow PSD centered on 100 μm is congruent with the treatment functionality of the NSBB. Other than the use of a narrow PSD test sediment centered on 100 μm particles, the NSBB testing described in this QAPP will generally meet the requirements of the NJDEP hydrodynamic protocol (2).

NSBB test sediment will be a processed Best Sand 110, supplied by Best Sand Corporation, 11830 Ravenna Road, Chardon, OH 44024. Best Sand 110 is a high quality sub-angular grain silica sand with a purity of greater than 99% SiO_2 and a d_{50} in the 100 μm range. A series of sieving and decanting procedures have been developed to narrow the spread of the Particle Size Distribution (PSD) and to focus the mass of particles near the 100 μm particle size. PSD analyses were conducted by ASTM D 422 (7) by a NELAC certified laboratory (BTL Engineering Services, 5802 North Occidental Street, Tampa, FL 33614). The PSD of the processed Best Sand 110 is shown in Figure 2, which also includes PSDs according to the NJDEP protocol for all particles and for particles greater than 50 µm (2). Inspection of Figure 2 shows that sediment processing of Best Sand 110 resulted in a narrow PSD centered on 100 μm which is markedly contracted versus the NJDEP PSDs. PSD parameters for the three sediment distributions are shown in Table 6. The processed Best Sand 110, like the NJDEP particles greater than 50 μm, does not contain particle sizes less than 50 μm. A PSD analysis will be conducted on the test sediment prior to each individual flow rates experiment.

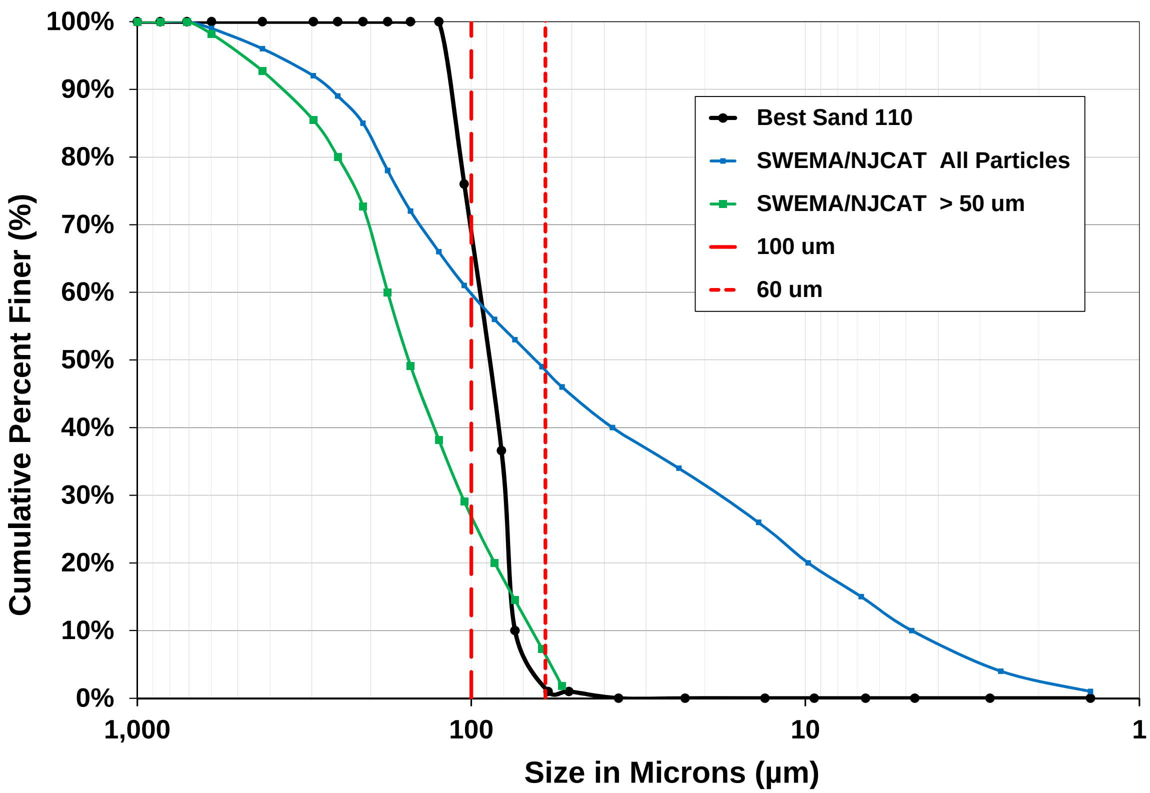

Figure 2 Particle Size Distribution of NSBB and NJDEP/SWEMA Test Sediment

Table 6 Best Sand 110 and NJDEP/SWEMA PSD Parameters

Sediment	$d_{90,\ um}$	$d_{50,\ um}$	$d_{10,\ um}$	% < 50 um
NSBB Best Sand 110	115	88	74	0
SWEMA/NJCAT All Particles	263	64	5	45
SWEMA/NJCAT Particles > 50 um	368	154	65	0

Flow Rate Flow rate to the NSBB will be measured using an in-line electronic flow meter with ultrasonic sensor (Portaflow SE ultrasonic flowmeter, Greyline Instruments, Massena, NY). The instrument will be calibrated by the manufacturer and the stated accuracy is within 2% (hwww.greyline.com/products.htm). The flowmeter will provide an instantaneous readout and will be located in proximity to the flow adjustment valve. In a single flow rate experimental procedure, water flow rate will be adjusted and stabilized in an initial time period before sediment dosing is initiated (Table 3,4). Flow rate will be monitored and recorded at least once per minute throughout the entire resuspension experiment. The flow rate will remain within 10% of the target flow rate throughout the experiment and the Coefficient of Variation (CV) shall not exceed 0.03.

Sediment Preparation and Dosing Sediment dosing at constant rate is critical to insuring that the suspended solids in the influent have a constant concentration. Sediment will be dosed though an opening in the crown of the conveyance pipe at a location downstream of the flow meter (Figure 1). The distance between the dosing point and the NSBB inlet will be not more than five diameters of the conveyance pipe, or ten feet, whichever is less. Sediment dosing will employ a dry hopper dosing system with flow controlling orifice plates, as was successfully demonstrated in previous NJCAT verification testing (8). The dosing hopper will have a square geometry of 23.5 i.d. in. side length, rounded corners, and an inverted square pyramid geometry with a 42^{o} angle from horizontal. Sediment will be added to the hopper to a specific depth with a level surface, and its depth maintained within 1 inch during testing. To achieve determined mass flow rates of sediment, removable aluminum orifice plates will be machined with one or more round orifice and placed in a retaining slot at the bottom of the sediment hopper (8).

Test sediment (processed Best Sand 110) will be stored in sealed containers without light before use. Shortly before each experimental flow rate experiment, test sediment will removed from sealed containers and dried at 180^{o}C, and cooled. For each experimental flow rate experiment, three portions of test sediment will be subsampled for transport to the laboratory for PSD analyses according to ASTM D 422-63 (7), and sediment moisture content will be determined according to ASTM D 4959 (9). The dosing hopper will be fully dried if necessary before adding sediment.

Sediment dosing will be initiated after the water flow to the NSBB has stabilized. For a single flow rate experiment, the Test Period is the period from the initiation of sediment dosing to the cessation of sediment dosing. Sediment dosing will be initiated by sliding the pre-calibrated aluminum orifice plate into the slot at the bottom of the hopper while simultaneously displacing the blank (no flow) aluminum plate. The time of initiation of sediment dosing is the start of the Test Period and will be recorded. Sediment dosing and water flow will continue uninterrupted and at constant rates throughout the entire Test Period. Sediment dosing will be discontinued by sliding a blank orifice plate into the slot at the hopper bottom. The time of cessation of sediment dosing at the end of the Test Period will be recorded. The total elapsed time of the Test

Period will be calculated as the time from initiation of hopper flow to end of hopper flow.

For each individual flow rate experiment, six sediment mass flow rate calibrations will be conducted during the Test Period. The calibration will be performed by inserting the aluminum orifice plate into the slot at the hopper bottom, directing sand flow from the hopper into a clean, dry, container for a 60 second period, and measuring the tare weight and collected sediment mass to the nearest milligram. The average, standard deviation and Coefficient of Variation (COV) of the six sediment mass flow rates will be determined, and the COV shall not exceed 0.10 (2). The influent SSC concentration should accordingly be maintained within 10% of the target values of 200 mg/L.

Measurement of Mass Accumulation NSBB will be completely cleaned and sealed between experiments when not in use. The NSBB will be recleaned just before initiating a single flow rate experiment, so the experiment will be started with the NSBB in a dry, clean condition. Following the initiation of water flow, sediment dosing will be initiated and will continue throughout the Test Period. Following the cessation of sediment dosing at the end of the Test Period, sediment accumulation in the NSBB chambers will be quantified. Estimated sediment mass dosed to the NSBB 3-6-72 is shown in Table 4 for individual flow rate experiments.

The removal and quantification of sediment will be conducted as follows. A rigid sediment withdrawal pipe with shaped withdrawal head will be connected to a suction source which will discharge into a sediment filter collection apparatus. The suction source will be tubing with a siphon or tubing connected to peristaltic pump. At the conclusion of the Test Period, when the NSBB is filled with water, siphon or pumped withdrawal will be initiated by manually working the shaped head across the chamber bottoms in repeated back and forth motions. Water/sediment slurry will be drawn from the bottom level of NSBB chambers. The goal is to collect as much sediment as can be visually discerned. A black coating may be used on the NSBB chamber bottoms to assist in visual inspection.

Sediment will be directed to an external sediment filtration system. A paper filter will be placed on a filter support matrix that provides structural support and separation/ retention of sediment particles while removing the majority of water mass. The filter paper will be a food grade preparation paper (Bunn 20124 or equivalent) with purported pore size range of 5 to 15 μm (http://en.wikipedia.org/wiki/Coffee_filter). A bank of filter/filter support units will be assembled as needed to filter all sediment accumulated in the NSBB 3-6-72, which could range from 2 to 4 gallons. Paper filters will be dried and tare weighed to a precision of 10 grams before filtration. Filters and sediment will be dried to constant weight at 180^{o}C and sediment mass determined by subtracting the tare weight.

Previous experiments were conducted using this filter paper with siphon evaluation of sediments that were added in known mass to a three chamber laboratory NSBB. Mass recovery of added sediment was greater than 99% in each of three separate experiments, lending confidence that the method can be applied in the NJDEP protocol experiments. The siphon removal of sediment slurry provided a relatively slow flow of slurry and enabled very careful and efficient collection of sediment at the bottom of the NSBB water column.

Another slurry removal method is to provide a port at the extreme bottom of each NSBB chamber through which water/sediment can be withdrawn by gravity. Slurry would flow by gravity directly to the filter/filter support units. Slurry removal could be aided by providing a means to tilt the NSBB 3-6-72 so the port was at the lowest elevation and all water readily flows through the port. This would allow rinsing of sidewalls. A valve could be used to control flow rate so that the sediment collection could be conducted carefully and accurately. It is possible to combine the suction approach for initial removal of concentrated sediment mass followed by the gravity approach for removal of large volumes of water with relatively low SSC.

PSD analyses will be performed on accumulated sediment collected from the NSBB. Prior to conducting the NJDEP single flow rate testing, methods of sediment recovery will be fully evaluated by adding know sediment mass to the NSBB 3-6-72 and verifying the method recoveries.

Removal Efficiency Calculation The percent SSC removal efficiency for a single flow rate experiment will be calculated by dividing the total sediment mass collected in the NSBB during the Test Period by the total sediment mass input to the NSBB during the Test Period and multiplying by 100 (2). The total sediment mass input to the NSBB is the total sediment mass dosed during the Test Period minus the total sediment mass collected in the six hopper calibration samples. The total sediment mass input during the Test Period is the sum of sediment added from hopper dosing and the background influent SSC. Sediment mass added from hopper dosing is the product of the elapsed time during the Time Period and the average mass flow rate of sediment from the dosing hopper. Background influent SSC mass added is the product of the total flow time, the average background influent SSC, and the average flow rate. The total flow time is the elapsed time during the Time Period plus the pump pre-stabilization period prior to initiation of sediment dosing.

Sampling of Background Influent and Effluent Sampling will be conducted to determine background influent SSC and optionally the SSC in the NSBB effluent. Background influent SSC samples will be collected with a peristaltic pump or siphon from an opening in the top of the conveyance pipe located downstream of the flow meter and upstream of the hopper sediment dosing point. Samples will be collected in 1,500 ml sample collection containers. SSC sediment particles in either the background influent or NSBB effluent will be small slowly settling particles with minimal potential to result in in-pipe stratification. Therefore, manual sampling will be likely to yield water samples that are representative of the entire water flow in the conveyance pipe.

Sediment Pre-Loading For the resuspension experiment, false bottoms will be installed in Chambers 1, 2 and 3 at 2.0 inch and test. sediment will be pre-loaded to uniform depths of 6.0 in Chambers 1, 2 and 3. Estimated pre-load sediment masses are listed in Table 7. If non-uniform depths are established for the 50% MSSV in TSS/SSC Removal Efficiency experiments, the false bottom and sediment pre-load depths will be accordingly adjusted. Three samples of pre-load sediment will be collected and analyzed for PSD according to ASTM D422-63 (7).

Table 7 Sediment Pre-Loading to NSBB 3-6-72

Intrinsic Density, g/cc 2.65 Porosity 0.38					
Chamber	Plan Area, ft^2	Sediment Surface Level, in.	False Bottom, in.	Sediment mass, g	Sediment mass, lb
1	6.0	6	2	93,049	204.8
2	6.0	6	2	93,049	204.8
3	6.0	6	2	93,049	204.8
Total				279,147	614.5

Prior to pre-loading, the NSBB 3-6-72 will be completely cleaned. Sediment pre-loading will be accomplished using a batch addition procedure consisting of the following steps:

- Test sediment will be dried and cooled
- Sediment will be added to clean, dry containers
- The mass of container plus added sediment will be measured and recorded (A)
- Sediment will be poured into NSBB Chambers 1, 2 and 3
- The mass of container plus residual sediment will be measured and recorded (B)
- The mass of added sediment will be calculated (A-B).

Batch additions will be continued until sediment level approximates the pre-load depths in Chambers 1, 2, and 3. The sediment surface will be levelled using a metal straight edge until the pre-load depth and level surface are achieved.

Resuspension Experiment The resuspension experiment will be conducted at a sediment pre-load of 50% of the Maintenance Sediment Storage Volume and at a steady flow rate of 200% of the MTFR (2). The NSBB will be pre-loaded with sediment to depths of 6.0 inch in Chambers 1, 2 and 3. The NSBB will be filled to chamber full level with clean water from the WSRR after at least 24 hours of zero flow to the WSRR to enable maximum sedimentation. The resuspension experiment will be initiated within 96 hours of sediment pre-loading. Water flow to the NSBB will be initiated and ramped up to 200% of MTFR within 5 minutes (Figure 3). During the 34 minute period at 200% MTFR, the volume of water flowing through the NSBB 3-6-72 will be 5,760 ft^3, 620 times the Maximum Sediment Storage volume (MSSV), and 103 times the empty bed volume of the three bottom chambers. Fifteen effluent samples will be collected at two minute intervals at the 200% MTFR, starting at 6 minute and continuing through 34 min (15 total samples). NSBB effluent sampling will employ manual sampling as stated in the above section sampling. A minimum of eight background influent samples will be collected through the resuspension experiment. The first background influent sample will be collected at 5 minute and samples will be collected at 4 minute intervals thereafter (9,13,17,21,25,29,33 minutes). The maximum background influent SSC will not exceed 20 mg/L. A curve will be drawn of background influent SSC versus time. NSBB effluent SSC will be corrected for background influent SSC using the point on the background influent SSC curve corresponding to one HRT prior to the time at which the effluent sample was collected. The average corrected effluent SSC from the resuspension experiment will be compared to the average SSC criteria of 20 mg/L for on-line MTD installation.

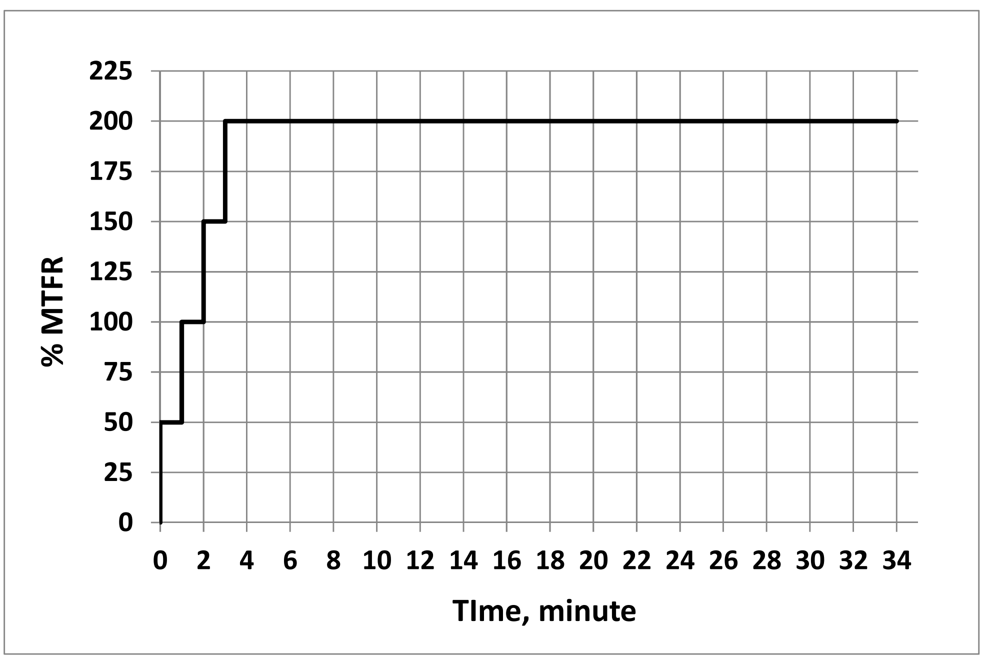

Figure 3 Resuspension Experiment Flow Sequence

Suspended Solids Analysis Suspended solids will be measured by Suspended Solids Concentration (SSC) using the filtration methodology (Test Method B) in ASTM D 3977-97, *Standard Test Methods for Determining Sediment Concentrations in Water Samples* (9). SSC analyses will be conducted according to the Standard Operating Procedure included in Appendix B, which is ASTM compliant.

CONDUCT OF EXPERIMENTS

Sediment Removal Efficiency Experiments

- Prior to single flow rate experiments, several experimental component evaluations will be conducted, including pump flow rate adjustment and controllability, development and verification of hopper dosing, NSBB mass accumulation methods, effluent mixer/sampler, and SSC methods, test sediment PSD analyses, and WSRR SSC removal efficiency evaluation and design modification.
- Conduct single flow rate experiment at 50% of projected MTFR to assess the effectiveness of all components and systems, and make needed modifications
- If necessary, repeat single flow rate experiment at 50% of projected MTFR to produce usable data
- Conduct single flow rate experiment at 100% of projected MTFR and assess need to reevaluate target MTFR
- Conduct remaining single flow rate experiments to produce data sets for the five flow rates required by the NJDEP hydrodynamic protocol (2). An option that could reduce the number of needed experiments is to produce a continuous curve of SSC removal efficiency versus flow rate based on discreet flow rate SSC removal efficiencies, and to mathematically derive the MTFR for other flow rates.

Each experiment will be conducted according to a standard sequence of steps:

- Measure WSRR temperature on prior day and apply evaporative cooling during dark hours
- Prepare water filters on prior day by rinsing, drying and cooling, and measure tare weights
- Prepare and label all sample containers
- Assemble proper hopper orifices
- Prepare sediment quantities 5 hours before initiation and start oven drying procedure
- Cool sediment
- Collect subsamples for PSD and moisture analyses
- Open hopper and dry if necessary
- Open NSBB and conveyance channel and clean if necessary
- Place all sample bottles into appropriate positions

- Measure WSRR water temperature to insure <80F
- Start influent pump and adjust and stabilize flow
- Initiate hopper dosing at start time and record time
- Record time of all subsequent events
- Operate at steady flow/dosing for time duration equal to or greater than that shown in Table 4.
- Collect hopper calibration samples, background influent SSC samples, and NSBB effluent samples as per schedule in Table 4 or adjusted Table 4
- Stop hopper dosing at end time and record time
- Turn off water pump
- Perform procedures for measurement of mass accumulation in NSBB
- Clean and close up all system components
- Perform SSC analyses on samples

Resuspension Experiment The resuspension experiment will be conducted by the sequence of:

- Measure WSRR temperature on prior day and apply evaporative cooling during dark hours
- Prepare water filters on prior day by rinsing, drying and cooling, and measure tare weights
- Prepare and label all sample containers
- Perform sediment pre-loading
- Open NSBB and conveyance channel and clean if necessary
- Adjust sediment pre-loading
- Place all sample bottles into appropriate positions
- Measure WSRR water temperature to insure <80F
- Start influent pump at 25% MTFR flow rate and record time
- Record time of all subsequent events
- Collect first background influent sample at 1 min.
- Collect first effluent sample at 2 min.
- Increase influent pump stepwise to 200% MTFR according to Figure 3
- Collect effluent samples at 2 min. intervals through 30 min.
- Collect background influent samples at 4 min. intervals through 29 min.
- Turn off pump after last sample collection at 30 min.
- Clean and close up all system components
- Perform SSC analyses on samples

Analytical and Quality Assurance Procedures

Objectives The objective of this study plan is to evaluate the effectiveness of the Suntree Technologies Inc. Nutrient Separating Baffle Box (NSBB) in removing suspended sediments according the procedures required by the NJDEP protocol.

Quality Criteria

Precision and Accuracy Precision describes the reproducibility of results and will be determined through evaluation of duplicate SSC standards. Accuracy is the degree of agreement between an observed value and an accepted reference value. Accuracy will be evaluated through the analysis of Laboratory Control Samples (LCS). Precision and accuracy information will be tracked. Precision and accuracy requirements for the target analyte (SSC) and matrices are presented Appendix B.

Representativeness Representativeness refers to the relationship of a sample taken from a site to be analyzed to the remainder of the sample matrix. The specialized effluent mixer/sampler will be verified to provide representative effluent samples.

Completeness Completeness is defined as a measure of the extent to which the data fulfill the data quality objectives of the project. The completeness of the data will be determined during the data validation and verification process.

Documentation and Records Documentation archives are listed in Table 8. All documentation archives will be kept for 5 years after the date of project completion**.**

Table 8 Documentation and Records Storage

Document/Record	Location	Format
QAPP and revisions	AET	Paper, electronic
Test site notebooks	AET	Paper
Laboratory SOPs	AET	Paper, electronic
Laboratory data reports	AET	Paper, electronic

Test Site Procedure Documentation The following information will be maintained:

- Date and time of sample collection
- Location of sample (i.e., influent or effluent)
- Result value and unit
- Narrative comments discussing corrective/preventive actions taken for any failed QC measure, unacceptable test site measurement or other problems related to the sampling event
- Test Site Logs. Test site notes will be documented by staff in a notebook

Sampling Process Design

Site Location The testing location will be at the Applied Environmental Technology Research Facility in Hillsborough County, Florida

Monitoring and Sampling Frequency and Duration have been presented previously

Number of Samples and Matrices Have been presented previously

Aqueous Sample Collection Have been presented previously

Equipment Specifications The sampling equipment construction materials will be plastic tubing for peristaltic pumps and siphons

Equipment Cleaning Sample collection containers and tubing will be cleaned after each sampling event. Sampling equipment will be dedicated to each location. Equipment cleaning will be carried out at the site

Sample Containers, Preservation and Holding Times Sample containers, preservation methods, and holding times are listed in Table 9.

Test Site Quality Control Samples Test site quality control samples evaluate the precision of sampling techniques, the effectiveness of decontamination, and address possible effects of sample handling and transport. All quality control samples will be prepared on-site at the test site, preserved and analyzed along with the routine samples.

Table 9 Containers, Preservation and Holding Times

Parameter	Container	Preservation	Holding Time
Suspended Solids Concentration	1,500 ml polyethylene	Storage at < 6C	7 days
Sieve analysis	1,500 ml polyethylene	N/A	N/A

Data Management

Record Retention All laboratory and test site records as outlined will be retained for a minimum of five years after the project completion

Test Site Logs Notebooks generated in the test site will be maintained by AET

Laboratory Data Hardcopy and electronic reports will be retained for five years

Data Archival Electronic deliverables and the final report will be maintained by AET

Assessment and and Response Actions

Planning Review Audit Within 15 days of the completion of the first sampling and analysis event the QAPP shall be reviewed relative to the completed activities to determine if the data quality objectives are being met, identify any improvements to be made to the process, and refine the sampling and/or analytical design or schedule. A summary of the review, including any corrective action plans or amendments, shall be documented and a copy shall be maintained with the permanent project records

Corrective Action Any deviations from the QAPP procedures will be cleared with NJCAT and documented in a revised QAPP.

Data Review, Verification and Validation

Data Verification Data verification is the process for evaluating the completeness, correctness, and conformance of the data set against the methodology. Sampling, analyses, and data verification will be performed according to the requirements set forth in the quality control requirements discussed in the *Quality Criteria* section.

Data Validation Data validation is an analyte and sample specific process that determines the quality of the data set relative to the end use. Any data deemed to be unusable for the stated objectives will be identified as such in the project report

Analytical Procedures Suspended sediment concentration (SSC) analyses by ASTM D3977-97D will be conducted by Applied Environmental Technology (Appendix B). Particle size distribution analyses will be conducted by BTL Engineering Services, Inc., 5802 Occident Street, P.O. Box 15718, Tampa, Florida, by ASTM D422-63 (Standard Test Method for Particle-Size Analysis of Soils). Dry sieving of sediment samples will be conducted using U.S. Standard Sieve sizes to 200 mesh or smaller. Hydrometer tests will be conducted on whole samples.

EVALUATION OF RESULTS

A comprehensive report including results and evaluations will be provided. Results will be evaluated according to the NJDEP requirements as follows:

- The individual SSC removal efficiency for each flow rate will be calculated based on results of the mass accumulation method testing conducted with a false bottom at depth corresponding to 50% of the Maintenance Sediment Storage Volume (MSSV).
- The overall SSC removal efficiency of the NSBB will be calculated by multiplying the SSC removal efficiency for each flow rate by the weighting factor for each flow rate and summing the products, as illustrated with the example data in Table 10.
- The overall experimental SSC removal efficiency will be compared to the target removal criteria of 80% established by the manufacturer.

- If the overall SSC removal efficiency for NSBB is significantly greater than or less than the 80% target, one or more additional individual flow rate experiments may be conducted. The purpose of the additional experiments is to bracket the five-fold flow rate range (i.e. 25,50,75,100,125%) that will be the basis for calculating the flow rate that results in 80% weighted SSC removal efficiency (i.e. the MTFR). The flow rate of the additional experiment(s) will be determined based on the flow rate range of the five flow rates initially tested and the removal efficiency results. If the calculated SSC removal efficiency from the first five experiments is greater than 80%, the additional experiment will be conducted to extend the flow rate range to a higher level. If the calculated SSC removal efficiency from the first five experiments is less than 80%, the additional experiment will be conducted to extend the flow rate range to a lower level.
- A plot of SSC removal efficiency versus flow rate will be prepared as shown in Figure 4 for the example data in Table 11, where an additional experiment was conducted at a flow rate of 2.25 cfs to extend the data to a higher flow rate range. A correlation will be prepared of individual flow rate removal efficiency versus flow rate (Figure 4).
- A plot will be prepared of flow weighted removal efficiency versus flowrate (Figure 5). This plot will be based on the correlation of individual flow rate removal efficiency versus flow rate (Figure 4).
- The Maximum Treatment Flow Rate will be determined at that flow rate that results in 80% SSC/TSS removal efficiency (Figure 5).
- Resuspension will be evaluated at a flow rate of 200% of the Maximum Treatment Flow Rate (MTFR), sediment pre-loading of 50% of the Maintenance Sediment Storage Volume (MSSV), and without sediment dosing. A curve will be prepared of background influent SSC versus time. Effluent SSC will be corrected for background influent SSC using the point on the background influent SSC curve corresponding to one HRT prior to time of effluent sample collection. The average effluent SSC for the resuspension experiment will be calculated using the corrected effluent SSC values. The average corrected effluent SSC from the resuspension experiment will be compared to the average SSC criteria of 20 mg/L for on-line MTD (2).

Table 10 Example SSC Removal Efficiency Calculation

% of Treatment Flowrate	Flowrate, cfs	Average Removal Efficiency, %	Weighing Factor	Overall Removal Efficiency, %
25	0.375	93	0.25	
50	0.750	87	0.30	
75	1.125	79	0.20	
100	1.500	71	0.15	
125	1.875	64	0.10	82.2

Table 11 Example SSC Removal Efficiency Calculation with Additional Test

% of Treatment Flowrate	Flowrate, cfs	Average Removal Efficiency, %
25	0.375	93.0
50	0.750	87.0
75	1.125	79.0
100	1.500	71.0
125	1.875	64.0
150	2.25	56.0

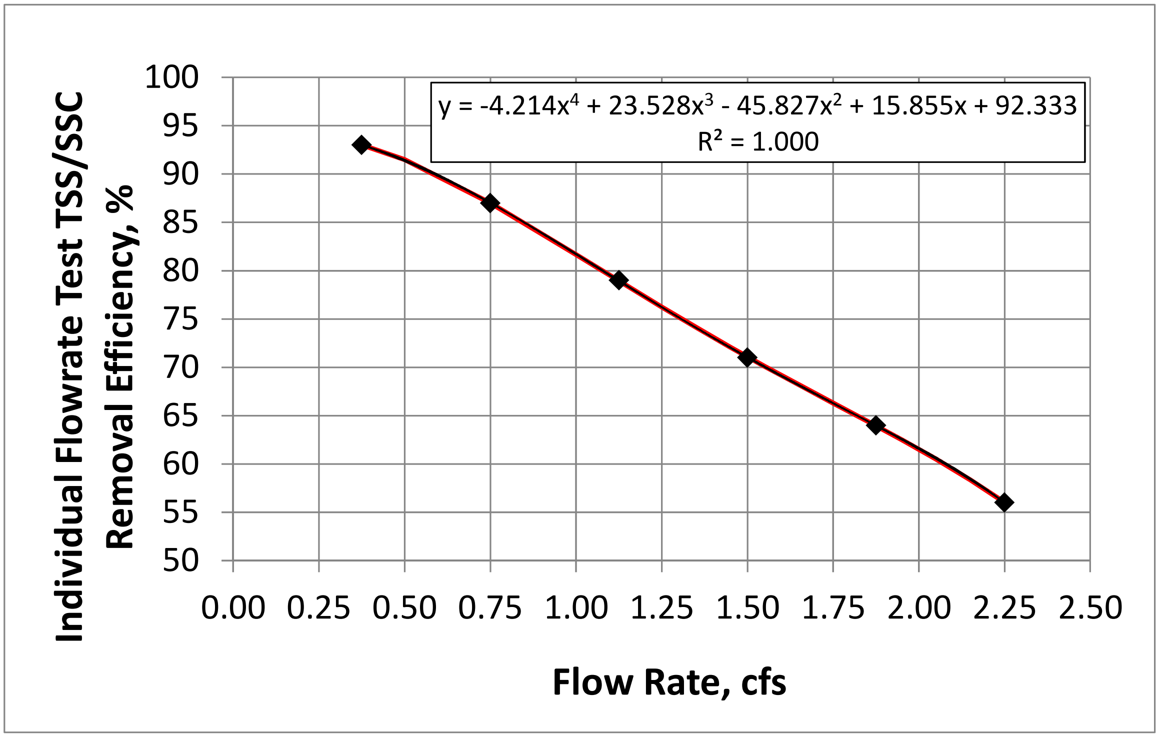

Figure 4 Continuous SSC Removal Efficiency Correlation

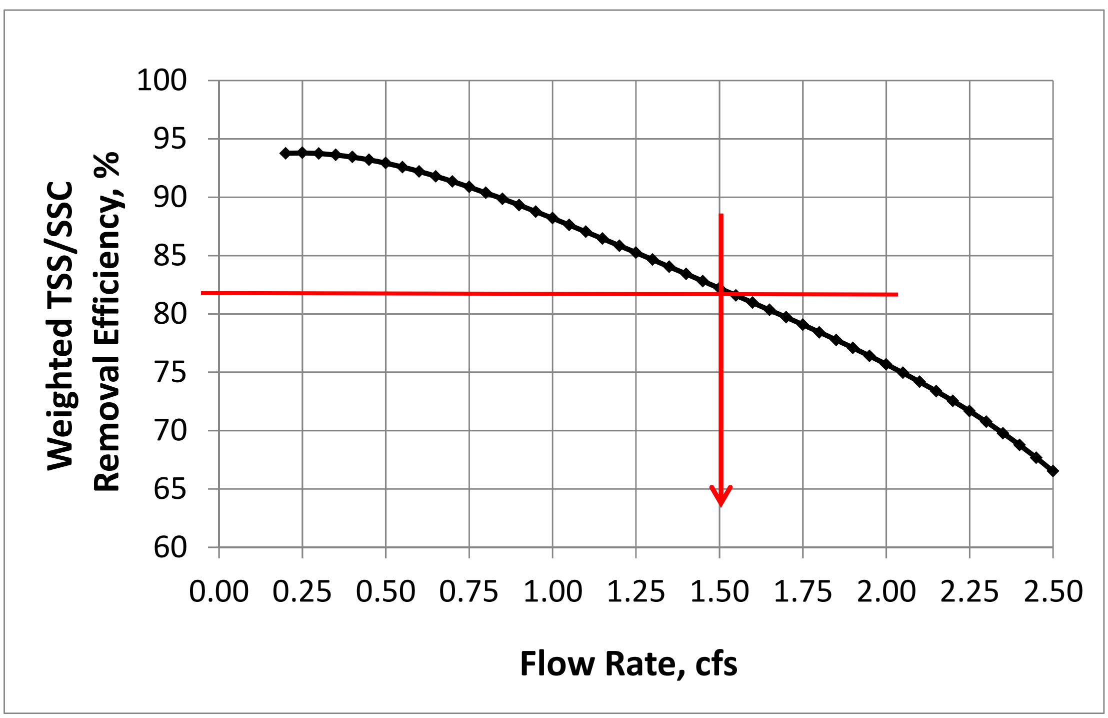

Figure 5 Maximum Treatment Flow Rate Determination

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[2] Stormwater Equipment Manufacturer's Association (2012). New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (MTD). Submitted to New Jersey Department of Environmental Protection and New Jersey Corporation for Advanced Technology, August 10, 2012.

[3] Suntree Technologies Inc. (2012) *http://www.suntreetech.com/Products/Nutrient+Separating+Baffle+Box/default.aspx*

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[5] Prandit and Gopalakrishnan (1996) Physical Modeling of a Stormwater Sediment Removal Box Final Report submitted to Brevard County, Florida and the National Estuary Program, Civil Engineering Program, Florida Institute of Technology, Melbourne, FL, June 1996.

[6] Fluid Mechanics With Engineering Applications 9th Edition, Franzini and Finnemore, WCB/McGraw Hill, New York.

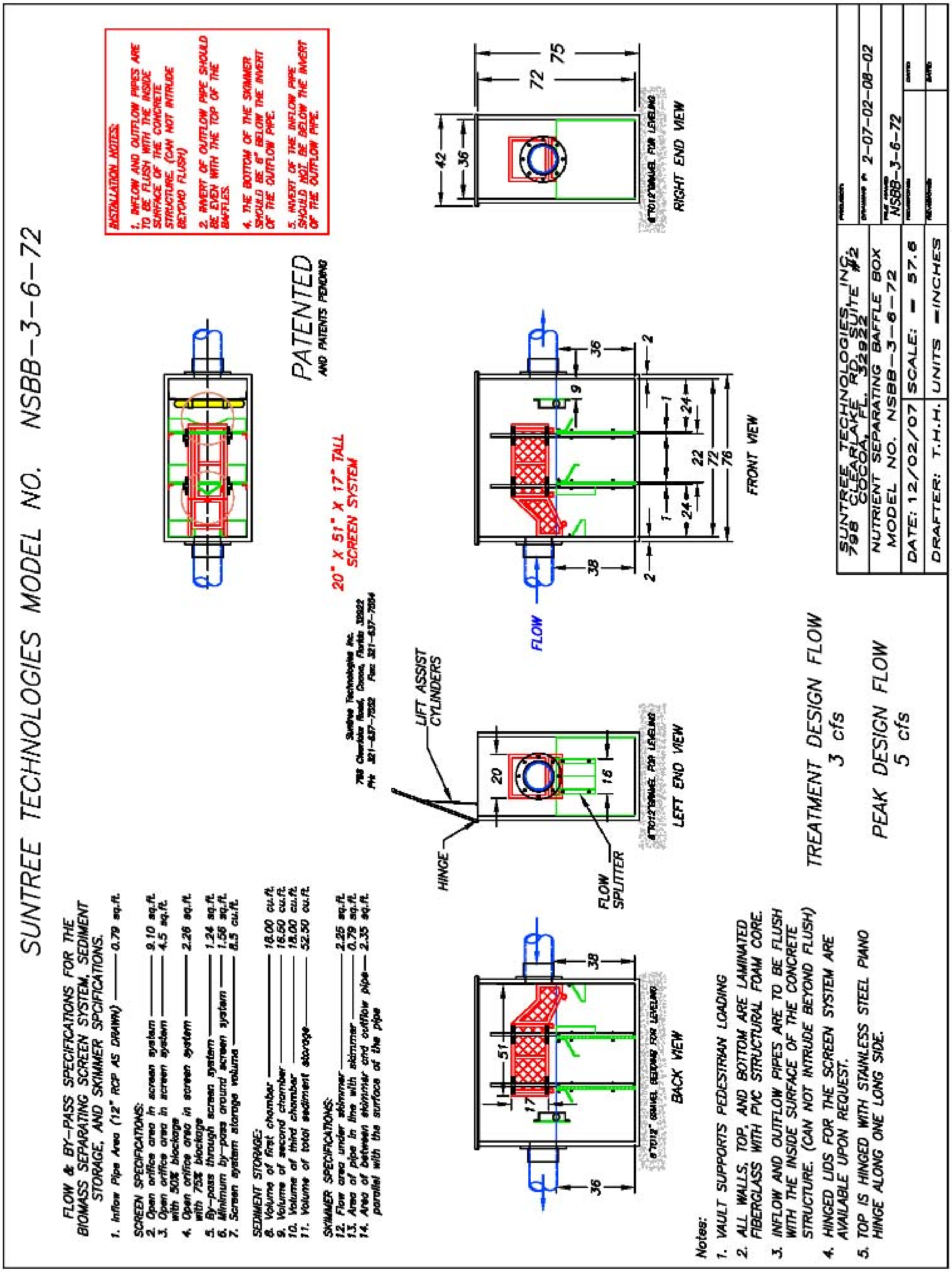
[7] American Society for Testing and Materials (2007) Standard Test Method for Particle Size Analysis of Soils. ASTM D 422-63 (Reapproved 2007). ASTM, Philadelphia, PA.

[8] Smith, D. (2008) Nutrient Separating Baffle Box NJCAT Evaluation Full Scale Laboratory Testing for Interim Certification, submitted to New Jersey Corporation for Advanced Technology, Newark, New Jersey, June 25, 2008.

[9] American Society for Testing and Materials (2007) Standard Test Method for Determination of Water (Moisture) Content of Soil By Direct Heating. ASTM D 4959 (Reapproved 2007), ASTM, Philadelphia, PA.

APPENDIX A

Nutrient Separating Baffle Box No. 3-6-72


SUNTREE TECHNOLOGIES MODEL NO. NSBB-3-6-72
FLOW & BY-PASS SPECIFICATIONS FOR THE BIOMASS SEPARATING SCREEN SYSTEM, SEDIMENT STORAGE, AND SKIMMER SPCIFICATIONS.
1. Inflow Pipe Area (12" RCP AS DRAWN) — 0.79 sq.ft.
SCREEN SPECIFICATIONS:
2. Open orifice area in screen system — 9.10 sq.ft.
3. Open orifice area in screen system with 50% blockage — 4.5 sq.ft.
4. Open orifice area in screen system with 75% blockage — 2.26 sq.ft.
5. By-pass through screen system — 1.24 sq.ft.
6. Minimum by-pass around screen system — 1.56 sq.ft.
7. Screen system storage volume — 8.5 cu.ft.
SEDIMENT STORAGE:
8. Volume of first chamber — 18.00 cu.ft.
9. Volume of second chamber — 16.50 cu.ft.
10. Volume of third chamber — 18.00 cu.ft.
11. Volume of total sediment storage — 52.50 cu.ft.
SKIMMER SPECIFICATIONS:
12. Flow area under skimmer — 2.25 sq.ft.
13. Area of pipe in line with skimmer — 0.79 sq.ft.
14. Area of between skimmer and outflow pipe parallel with the surface of the pipe — 2.35 sq.ft.
INSTALLATION NOTES:
1. INFLOW AND OUTFLOW PIPES ARE TO BE FLUSH WITH THE INSIDE SURFACE OF THE CONCRETE STRUCTURE. (CAN NOT INTRUDE BEYOND FLUSH)
2. INVERT OF OUTFLOW PIPE SHOULD BE EVEN WITH THE TOP OF THE BAFFLES.
4. THE BOTTOM OF THE SKIMMER SHOULD BE 6" BELOW THE INVERT OF THE OUTFLOW PIPE.
5. INVERT OF THE INFLOW PIPE SHOULD NOT BE BELOW THE INVERT OF THE OUTFLOW PIPE.
PATENTED
AND PATENTS PENDING
20" X 51" X 17" TALL SCREEN SYSTEM
Suntree Technologies Inc.
798 Clearlake Road, Cocoa, Florida 32922
PH: 321-637-7552 Fax: 321-637-7554
HINGE
LIFT ASSIST CYLINDERS
FLOW SPLITTER
FLOW
BACK VIEW
LEFT END VIEW
FRONT VIEW
RIGHT END VIEW
6"TO12" GRAVEL BEDDING FOR LEVELING
51
17
36
38
20
16
9
2
1
24
22
72
76
42
75
Notes:
1. VAULT SUPPORTS PEDESTRIAN LOADING
2. ALL WALLS, TOP, AND BOTTOM ARE LAMINATED FIBERGLASS WITH PVC STRUCTURAL FOAM CORE.
3. INFLOW AND OUTFLOW PIPES ARE TO BE FLUSH WITH THE INSIDE SURFACE OF THE CONCRETE STRUCTURE. (CAN NOT INTRUDE BEYOND FLUSH)
4. HINGED LIDS FOR THE SCREEN SYSTEM ARE AVAILABLE UPON REQUEST.
5. TOP IS HINGED WITH STAINLESS STEEL PIANO HINGE ALONG ONE LONG SIDE.
TREATMENT DESIGN FLOW
3 cfs
PEAK DESIGN FLOW
5 cfs
SUNTREE TECHNOLOGIES, INC.
798 CLEARLAKE RD. SUITE #2
COCOA, FL. 32922
NUTRIENT SEPARATING BAFFLE BOX
MODEL NO. NSBB-3-6-72
DATE: 12/02/07
SCALE: = 57.6
DRAFTER: T.H.H.
UNITS =INCHES
2-07-02-08-02
NSBB-3-6-72

APPENDIX B

Suspended Sediment Concentration Analyses Protocol

Standard Operating Procedure

Analysis for Determining Suspended Sediment Concentration (SSC) in Water Samples

Purpose This Standard Operating Procedure (SOP) describes the procedures used to determine Suspended Sediment Concentration (SSC) as described in ASTM method D3977-97 B

Scope and Application

- This method is applicable to water samples collected from a Nutrient Separating Baffle Box (NSBB) for NJDEP/SWEMA evaluation
- Range of determination is 1 mg/L to 10,000 mg/L
- The minimum reporting limit (RL) is 1 mg/L
- Water samples to be tested will have SSC generally in the range of 10 to 200 mg/L
- This SOP was prepared for method-compliant use by AET

Summary of Method:
A glass fiber filter is placed into an aluminum pan and dried to constant weight at 104^o C. A well-mixed sample of known volume is passed through the filter. The filter/pan and residue retained on the filter are dried to constant weight at 104^o C. The difference in weight (mass) is divided by the volume of the filtered sample to determine SSC.

Interferences

- Critical to this analyses are well mixing of the sample, preparation of the filter and filtration apparatus, rinsing of the sample container and filtration apparatus to capture all residual sediment, and drying time and temperature
- Only well characterized sand in a well characterized matrix will be present in test samples leading to relatively limited interferences

Safety

- It is mandatory to wear personal safety equipment while working with samples, glassware, and apparatus
- Sound judgment and good laboratory procedures are always recommended

Equipment and Supplies

- Glass fiber filter discs, 15.0 cm, without organic binder, Whatman type 934-AH
- Buchner funnel
- Filtration flask, 2000 mL
- Vacuum pump

- Drying oven, 103-105°C
- Desiccator
- Analytical balance capable of weighing to 0.1 mg
- Graduated cylinders
- Aluminum pans
- Indelible marker, Sharpie or equivalent

Sample Collection, Preservation, and Handling

- Samples are collected in plastic containers and preserved and stored at >0 to 6° C (32 to 43 ° F). There is no specific holding time defined for this analysis.

Reagents and Standards

- Suspended Solid Standards, 10 to 200 mg/L, prepared by adding known mass of test sediment to a known volume of distilled water

Calibration and Standardization

- The analytical balance is calibrated annually to NIST Traceable standards
- Calibration verification: calibration verifications are performed with NIST traceable standards and documented

Procedure

Preparation of glass fiber filters/aluminum pans

- Assemble filter and aluminum pans for projected number of samples for SSC analyses
- Including two additional filter/pans for Lab Control Sample and Method Blank
- In each filter/pan, include a small piece of additional filter material (wipe filter) for post filtration cleaning of the interior surfaces of the Buchner funnel to remove any remaining sediment
- Number all filter pans sequentially with an indelible marker
- Place first filter in the Buchner funnel apparatus with the wrinkled side up
- Apply vacuum to the funnel
- While vacuum is applied, wash the disc with approximately 50 mL distilled water
- Continue vacuum to remove as much water as possible
- Discontinue vacuum
- Remove filter from apparatus and place in aluminum pan along with wipe filter
- Place pan in drying oven at 103-105°C and dry for two hours
- Remove filter/pan/wipe filter assemblage from oven and place in a desiccator for two hours

- Place filter/pan/wipe filter assemblage onto analytical balance and weigh (tare weight)
- Record tare weight = A (gram)

Filtration

- Prepare the Lab Control Sample (LCS) by adding a known mass of test sediment to a known volume of distilled water in a standard sample container, where the volume of distilled water volume is within the range of volume of samples being analyzed and the added sediment mass provides SSC of 10 to 200 mg/L
- A Method Blank (MB) is prepared by adding a known volume of distilled water to a standard sample container, where added distilled water volume is within the range of volume of samples being analyzed
- Mark the level of water sample on the side of the sample container
- Place filter into Buchner funnel
- Shake the unknown sample vigorously, pour initial sample volume into Buchner funnel, quickly start the vacuum pump
- Continue to pour remainder of sample into Buchner funnel as sample water is filtered
- Rinse the filter with copious amounts of distilled water and continue vacuum to remove as much water as possible, trying to bring the sand to the middle of the filter
- Remove the filter from apparatus and place it in the aluminum pan
- Wipe the inside of the Buchner funnel with the wipe filter to remove any remaining sediment
- Maintain the filter order for all filters to provide more orderly analyses process
- Fill the sample container to the marked level
- Measure it water volume in the container using a graduated cylinder
- Record sample volume = C (ml)

Drying

- Place the filter/pan/wipe filter assemblage into the drying oven at 103-105°C for at least 2 hours
- Remove the filter/pan/wipe filter assemblage from the oven and place immediately in desiccator

Final Weighing

- Place filter/pan/wipe filter assemblage onto analytical balance and weigh (filtered weight)
- Record filtered weight = B (gram)

Data Analysis and Reporting

- Calculate SSC in mg/L as SSC = (B – A) / C x 1,000,000, where:
  - A = Weight of filter assemblage before filtration, gram
  - B = Weight of filter assemblage after filtration, gram
  - C = Volume of sample filtered, mL

Method Performance

- Demonstration of Capability (DOC) DOC for this method is based on the analyst experience with Total Suspended Solids, SM 2540 D and with Standard Test Methods for Determining Sediment Concentration in Water Samples, Method D3977-97 Part B., 1997.
- Standard Test Methods for Determining Sediment Concentration in Water Samples, Method D3977-97 Part B., 1997 lists precision and bias for Method B.

Concentration Added, mg/L	Concentration Recovered, mg/L	Standard Deviation of Test Method	Bias, %
100	91	5.3	- 9
10	8	2.6	- 20

- An Initial Demonstration of Capabilities (IDOC) Study will be performed prior to evaluation of NJDEP/SWEMA verification test samples
- The IDOC will entail analysis of 3 consecutive prepped LCSs at 100 mg/L SSC and 3 consecutive prepped LCSs at 10 mg/L SSC. The recovery of each of the 100 mg/L LCSs must be 85%-115% to pass and the recovery of each of the 10 mg/L LCSs must be 60%-140% to pass.

Quality Control

- A Lab Control Sample (LCS) is prepared by adding a known mass of test sediment to a known volume of distilled water in a standard sample container, where the volume of distilled water is within the range of volume of samples being analyzed and the added sediment mass provides SSC of 10 to 200 mg/L

- A Method Blank (MB) is prepared by adding a known volume of distilled water to a standard sample container, where added distilled water volume is within the range of volume of samples being analyzed
- SSC procedure uses entire sample volume and duplicate analyses cannot be performed
- Any deviations from the norm encountered while conducting this analysis will be noted in the bench sheet and corrected
- An analysis event is performance of SSC analyses on multiple samples in one analytical campaign, such as analyses of samples resulting from one or more flowrate tests
- Quality Control (QC) specifications are:

QC Check	Minimum	Frequency	Acceptance Criteria	Corrective Action
Constant weight	None	Once at initiation of NJDEP/SWEMA testing	Weight change of less than 0.5 mg for a sample with SSC > 250 mg/L	Longer duration drying time
Method Blank (MB)	1	Per analyses event	< Reporting Limit	Repeat analyses; identify problems
Lab Control Sample (LCS)	1	Per analyses event	90 - 110% recovery	Repeat analyses; flag data
Demonstration of Capability	4	Once for each analyst	90 - 110% recovery	Identify problem(s), repeat analyses

References

- American Society for Testing and Materials, Standard Test Methods for Determining Sediment Concentration in Water Samples, Method D3977-97 Part B., 1997

- Standard Methods for the Examination of Water and Wastewater, Method 2540D