NJCAT TECHNOLOGY VERIFICATION

Nutrient Separating Baffle Box
Evaluation with 100µm Particles

Suntree Technologies Inc.

June, 2013

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1. Introduction

1.1 New Jersey Corporation for Advanced Technology (NJCAT) Program

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program) the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency, other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and

- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

1.2 Technology Verification Report

The Nutrient Separating Baffle Box® (NSBB) is a manufactured treatment device (MTD) supplied by Suntree Technologies Inc.® (798 Clearlake Road, Cocoa, FL 32922) for removing solids from stormwater. The NSBB is a structural Stormwater Control Measure (SCM) that reduces pollutant loadings by capturing sediments, gross solids, and associated pollutants.

Suntree Technologies received New Jersey Corporation for Advanced Technology (NJCAT) verification of claims for the NSBB in November 2008 (1) based on the then existing New Jersey Department of Environmental Protection (NJDEP) laboratory test protocol. The NJDEP recently issued a new revised protocol for the laboratory evaluation of hydrodynamic separation devices to determine suspended sediment removal efficiency and sediment resuspension. The new protocol titled *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device* (2) is dated January 25, 2013.

NSBB testing follows the recently issued NJDEP protocol with one significant exception. The NSBB suspended sediment removal efficiency evaluation experiments were conducted using 100 µm size sediment with a relatively narrow particle size distribution (PSD) of 60 to 126 µm. The 100 µm centered PSD contrasts with the broader PSD (2 to 1,000 µm) specified in the new NJDEP protocol and in the previous NJDEP protocols. Suntree selected the 100 µm particle size for those stakeholders seeking MTD performance data based on sediment with a 100 µm particle size. The same 100 µm sediment PSD was also used for evaluation of sediment resuspension. Other than (a) the use of a narrow PSD test sediment centered on 100 µm particles for both removal efficiency and resuspension evaluations, and (b) the scaling method for the maximum water treatment flow rate (MTFR) sizing chart, NSBB testing was conducted in general accordance with the methods cited in the *New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device* (2) ***Suntree will not be submitting this NJCAT NSBB verification report for removal efficiency, resuspension evaluation or model sizing certification to NJDEP since the sediment particle sizes and model scaling methodology do not comply with those in the new NJDEP laboratory test protocol.***

1.3 Applicant Profile

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 NSBB units and customized designs, and holds fourteen 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. The product market place of Suntree Technologies 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 1,500 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 2^{nd} 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 Box® 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 on-line or off-line configuration, making for an easy retrofit within existing water sheds.

Patents The proprietary technology behind the Nutrient Separating Baffle Box® and its many unique and specialized features are protected by patents issued by the U.S. Patent office, and 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 for the NSBB and its features:

6,428,692	6,979,148	7,294,256	8,034,236
7,270,747	8,231,780	7,981,283	8,034,234
7,153,417	7,846,327	8,083,937	8,142,666
8,366,923	8,393,827		

Technical Resources, Staff and Capital Equipment Suntree Technologies Inc.® 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 Inc.® 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 install, 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®.

1.4 Key Contacts

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2. Nutrient Separating Baffle Box®

The NSBB is a subsurface rectangular vault that is placed on-line 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 (Figure 1). 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 SWEMA performance evaluation was conducted using the commercially available NSBB Model 3-6-72. Details of NSBB 3-6-72 are summarized in Table 1.

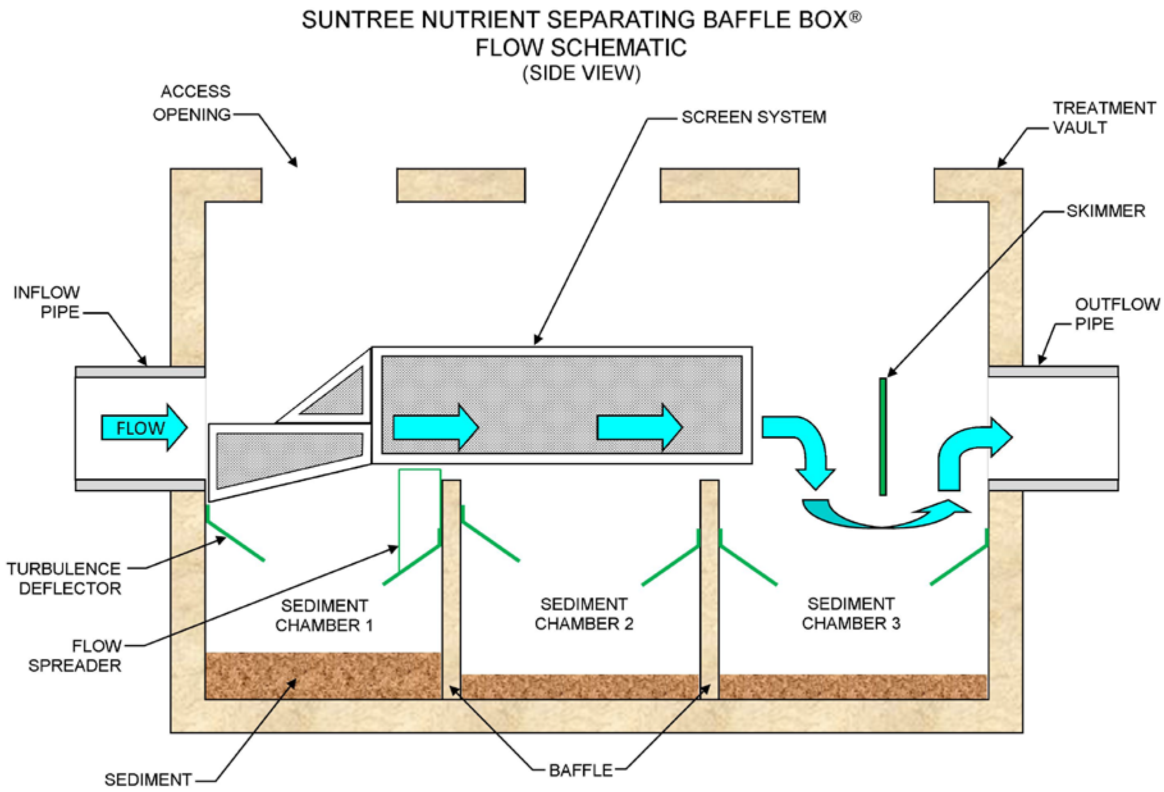

Figure 1 Nutrient Separating Baffle Box®

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
Chamber empty bed volume, gallon	404
Maintenance Sediment Storage Volume, ft^3	18.0
Screen box length, inch	51
Screen box width, inch	21

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 a sediment pre-loading of 50% of the MSSV, which for the NSBB 3-6-72 is a uniform sediment depth of 6 inches over the bottom surface of all three chambers (9 ft^3). In practice, sediment accumulation in the NSBB is typically not uniform, with the greatest accumulation of sediment in the first chamber and the least accumulation in the last. As per the protocol requirements, for removal efficiency testing, false bottoms were placed across the entire bottom of each chamber at 6 in. depth, i.e. at the 50% MSSV sediment depth. For the resuspension experiment, test sediment was placed to a uniform depth of 6 in. in each chamber; false bottoms were not used.

Standard Models

The NSBB is supplied in a range of sizes as shown in Table 2.

Table 2 NSBB Models

NSBB Model #	Inside Width, ft.	Inside Length, ft.	Baffle Height, in.	Sedimentation Area, ft^2
2-4-60	2	4	24	8
3-6-72	3	6	36	18
3-8-84	3	8	36	24
4-8-84	4	8	36	32
5-10-84	5	10	36	50
6-12-84	6	12	36	72
8-12-84	8	12	36	96
8-14-100	8	14	40	112
8-16-100	8	16	44	128
10-14-100	10	14	40	140
10-16-125	10	16	46	160
10-20-125	10	20	48	200
12-20-132	12	20	48	240
12-24-132	12	24	60	288

3. NSBB Performance Evaluation

Experiments were conducted at the Applied Environmental Technology (AET), 10809 Cedar Cove Drive, Thonotosassa, FL 33592-2250 testing facility in Thonotosassa. AET submitted a performance test report to NJCAT on the completion of their NSBB Performance Evaluation (4).

3.1 Experimental System

A schematic of the experimental system for conducting the NJDEP evaluation of the NSBB is shown in Figure 2. The system consists of a Screening Chamber, a Dosing Hopper System, the Nutrient Separating Baffle Box (NSBB), a Water Recycle Reservoir, influent pump, influent flow control valve, influent flow meter, and associated piping and appurtenances. Sampling access locations were provided for background influent and effluent concentrations. Through a process of adaptive development, the apparatus depicted in Figure 1 was iteratively assembled into a complete experimental system, fully capable of meeting the testing requirements of the NJDEP protocol. The Influent Pump was the only power requiring component of the experimental system; all other flow was by gravity. Sediment was dosed from an open hopper directly into the conveyance pipe through a slot in the crown of the pipe. Test water was AET-TF groundwater supplied by pump to the Water Recycle Reservoir. The groundwater supply was of circumneutral pH, was virtually free of suspended sediment, and had limited dissolved oxygen levels. Water pumped to the Water Supply Reservoir was aerated and filtered several days prior to performance testing. All experiments were conducted at water temperatures of less than 80F.

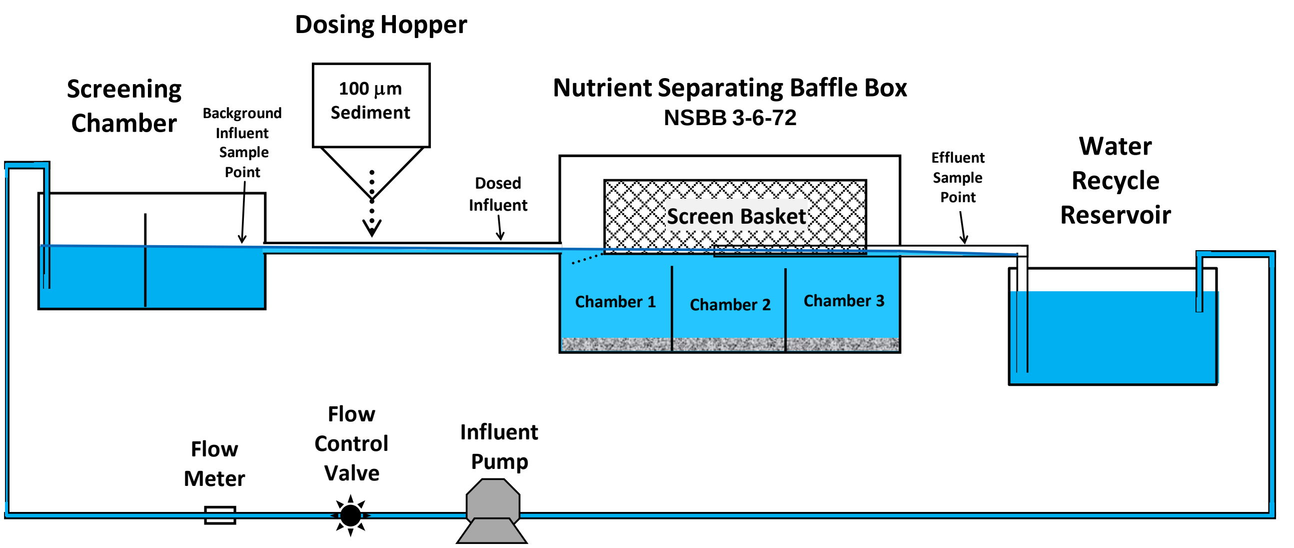

Figure 2 Schematic of Experimental System

Pump Flow to the experimental system was provided by a John Deere diesel powered vacuum well point pump (Model 6VW-DJDST-45D-M, Thompson Pump Co., Sarasota, FL). The pump was connected by 6 inch tubing to a PVC withdrawal pipe in the Water Recycle Reservoir that extended eight inches below the water surface. The pump had variable speed control to adjust the flow rate and was capable of maximum flow rates exceeding 3 cubic feet per second.

Flow Rate Control Valve A 6 inch knife gate valve (Thompson Pump Co., Sarasota, FL) was used for fine flow rate adjustment at test initiation and throughout the experiments as needed.

Flow Meter Flow rate was measured with a PT-500 Ultrasonic Flow Meter, Serial Number 7629 (Greyline Instruments Inc., Massena, New York). The PT-500 is a Transit Time ultrasonic flow meter that employs two sensors mounted on the outside of the pipe wall and has a manufacturer stated accuracy of ±2% (http://www.greyline.com/pt500.htm). The instrument was calibrated by Micronics Ltd. The flowmeter was positioned in close proximity to the flow valve to enable expeditious adjustment of the flow rate by a single operator.

Screening Chamber The screening chamber (3 ft. by 6 ft.) contained a coarse screen to remove any larger suspended material which inadvertently entered the experimental system. Water was pumped from the Water Supply Reservoir to the upstream end of the Screening Chamber, and all flow passed through the screen on its way to the 14 in. pipe that connected the Screening Chamber to the baffle box. An access cover was placed in the top of the Screening Chamber at the location of the outlet to enable samples to be taken for background influent Suspended Solids Concentrations.

Sediment Dosing System Sediment was dosed using a dry feed placed directly over the crown of the 18 inch pipe that connected the Screening Chamber to the NSBB. The location of sediment dosing was 6 ft. (72 in.) from the entrance to the NSBB. Sediment dosed from the hopper passed through a slot in the crown in the pipe. The hopper had a square geometry of 23.5 i.d. in. diameter, with rounded corners and an inverted square pyramid geometry with a 42^o angle from horizontal. Sediment mass flow was controlled by aluminum plates placed at the bottom of the hopper. The aluminum plates contained one or two circular orifices which were calibrated to deliver target mass flow rates. Seven plates were fabricated, one for each of the seven removal efficiency experiments. Plate calibration was conducted in situ by measuring the mass of sediment collected for 60 seconds using dried and prepared test sand.

NSBB 3-6-72 The NSBB 3-6-72 was placed on-line for all testing and treated 100% of the applied flow. For removal efficiency testing, false bottoms were placed across the entire bottom of each chamber at 6 in. depth, i.e. at the 50% MSSV sediment depth. For the resuspension experiment, test sediment was placed to a uniform depth of 6 in. in each chamber; false bottoms were not used. The NSBB was connected to the Water Recycle Reservoir by 18 inch piping. Piping proceeded horizontally from the NSBB to a location just inside the wall of the Water Recycle Reservoir, where a right angle in the piping directed flow in a vertically downward direction to the bottom of the Water Recycle Reservoir.

Water Recycle Reservoir Test water consisted of groundwater that was pumped to a recycle reservoir prior to testing. The Water Recycle Reservoir had a circular plan area of 22 ft. and mean working depth of ca. 46 in., with water capacity of ca. 10,800 gallons. Flow from the NSBB entered the reservoir at the bottom; it was directed parallel to the reservoir wall to create a circumferential flow field. Water withdrawal occurred from a location ca. 8 in. below the water surface, ca. 40 in. from the inflow pipe, but in the opposite direction from which influent flow was directed. The inflow and withdrawal locations and their orientations created a circumferential water flow path in the Water Recycle Reservoir.

3.1.1 Particle Size Distribution

The NSBB evaluation was conducted using sediment with a relatively narrow particle size distribution (PSD) ranging from 60 to 126 µm with a d_{50} of 97.5 µm centered on 100 µm. The 100 µm PSD contrasts significantly with the finer d_{50} of 75 µm and the broader PSD of 2 to 1,000 µm specified in the NJDEP protocol (2).

The test sediment was a processed Best Sand 110 (Best Sand Corporation, Chardon, OH). Best Sand 110 is a high quality sub-angular grain silica sand with a purity of greater than 99% SiO_2 and a median particle size (d_{50}) in the 100 µm range. A series of sieving and decanting procedures were developed to produce sediment with a d_{50} in the 100 µm particle size. Production steps were: remove coarser particles by dry sieving through US No. 125 sieve; remove finer particles by wet elutriation with continuous washing in a 12 in. x 18 in. slurry channel basin with water flow rate of ca. 4.4 gallon per minute; decant water; collect sand and dry at 170F, and store in sealed 5 gallon buckets until ready for use.

PSD analyses were conducted by a certified laboratory (BTL Engineering Services, Tampa, FL 33614) according to ASTM D 422 (5). A PSD of test sediment is shown in Figure 3. Results of PSD conducted on eight test sediment samples are listed in Table 3. Mean d_{50} was 97.5 µm, with a standard deviation of 3.7 µm and a coefficient of variation of 0.037.

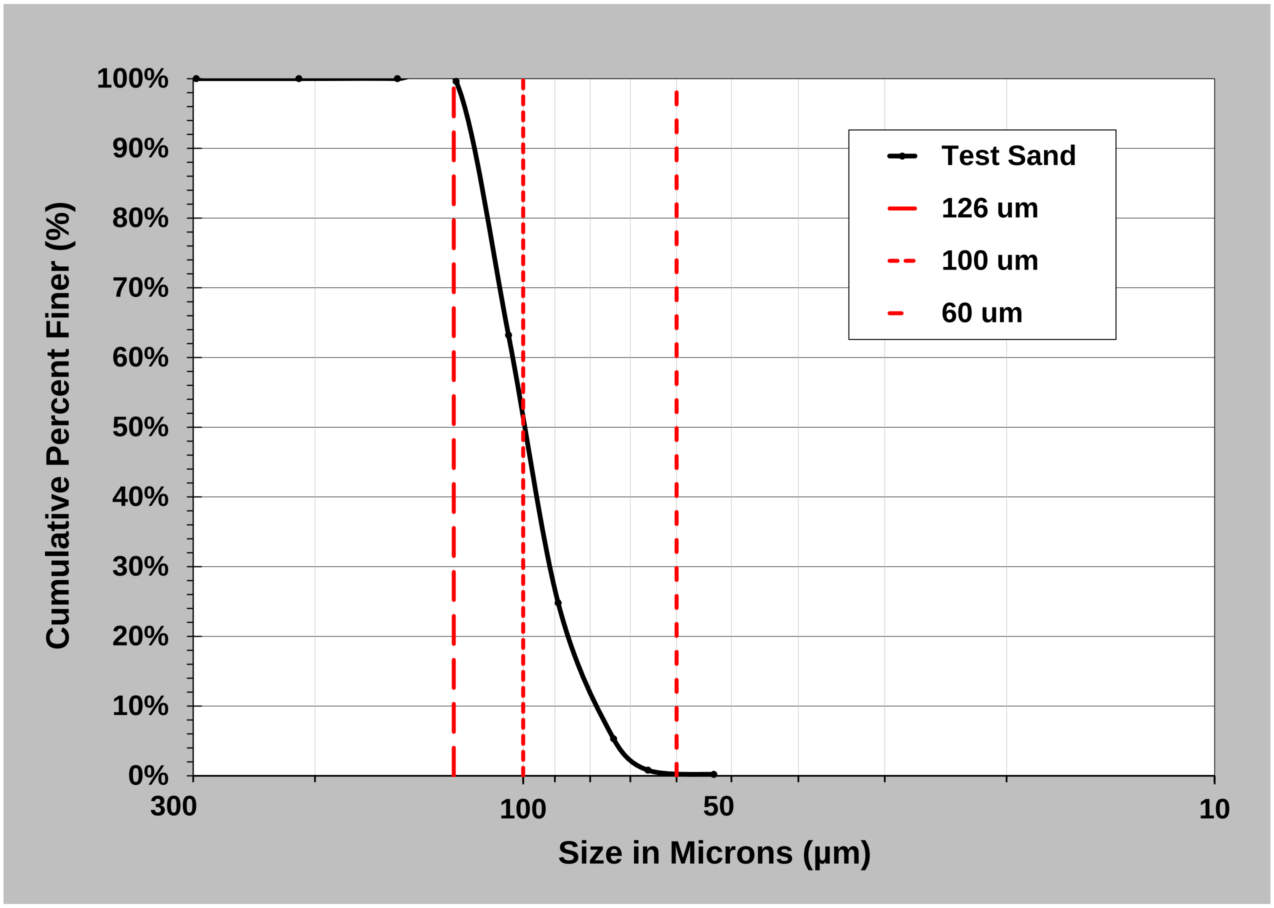

Figure 3 Particle Size Distribution of Test Sediment

The eight PSD sediment analyses (Table 3) demonstrated a remarkable consistency as shown by the d_{50} small standard deviation and coefficient of variation. Five (5) samples of the test sediment were analyzed prior to removal testing and three (3) samples of test sediment were analyzed prior to commencing resuspension testing.

3.2 Test Procedures

3.2.1 TSS Removal Efficiency

The removal efficiency experiments followed the testing protocol outlined below and were initiated prior to and anticipation of the issuance of the NJDEP test protocol in January 2013.

System Cleaning The NSBB, Screening Chamber, and piping were covered between experiments and were completely cleaned prior to testing to remove sediment.

Table 3 Test Sediment Particle Size Analysis

Sand Source	Date	d_{90}, um	d_{50}, um	d_{10}, um
Hopper	11/12/12	117.9	100.8	80.3
Hopper	11/16/12	118.5	101.2	78.6
Hopper	11/20/12	118.1	100.9	80.0
Hopper	11/26/12	106.5	92.5	76.3
Hopper	11/28/12	106.2	92.0	76.6
Chamber 1 Pre-Load	01/08/13	116.4	98.0	78.6
Chamber 2 Pre-Load	01/08/13	114.4	96.4	79.2
Chamber 3 Pre-Load	01/08/13	114.0	98.2	82.1
	Mean	114.0	97.5	79.0
	Standard Deviation	5.0	3.7	1.9
	Median	115.4	98.1	78.9
	Coefficient of Variation	0.044	0.037	0.024

Sediment Preparation Several hours before each experiment, ca. 33 lbs. of sediment was removed from sealed containers, dried for 2 hours at 180°F, cooled, and sieved though a U.S. No. 80 (180 μm) screen. The sediment was loaded into the dosing hopper shortly before the experiment was initiated.

Water Temperature Water temperature was verified to be less than 80F just before the initiation of each experiment using a NIST traceable thermometer (Traceable Calibration Control Company 281-482-1714).

Field Data Sheets Field data sheets were prepared for preparation of test sediment, temperature monitoring, flow rate target and monitoring, sediment dosing rate monitoring, total sediment dosing time, background suspended sediment concentration sample collection times, Suspended Sediment Concentration (SSC) laboratory analysis, and laboratory blank and laboratory control samples for SSC analysis. Data sheets specified and recorded time of sediment dosing initiation, time of sediment dosing termination, time of all sample events, and time of other observations.

Sample Containers Sample containers were prepared for at least eight background influent SSC samples and six sediment dosing samples. All containers had sealable tops. SSC containers were one half gallon PETE canisters with round 4 in. diameter open mouths. SSC containers and tops were rinsed at least three times with tap water and drained. SSC containers were numbered and deployed in order of increasing number with experimental time. Sediment containers were 4.5 x 6 in. open containers of 2.75 in. depth, cleaned by repeated wipings with clean paper towels. Sediment containers were lettered A though F and deployed progressively with experimental time.

Flow Initiation and Control When all experimental preparations were completed, the pump was started at an initial speed estimated to produce the target flow rate. The flow meter was then powered on and allowed to electronically stablilize. Once flow readings could be discerned, the pump speed was adjusted if necessary. Further adjustment was made with the flow control valve until stable flow was achieved that was centered around the target flow rate. The pump was run for several minutes of stable flow at the target flow rate before sediment dosing was initiated. Flow rate adjustments were made as needed throughout the experiments using the flow rate control valve. Flow rate was recorded on data sheets at 1 minute intervals throughout the experiments.

Sediment Dosing Initiation Sediment dosing was initiated after several minutes of stable flow centered at the target flow rate. Dosing was initiated by sliding the calibrated dosing plate into the dosing plate slot at the bottom of the dosing hopper, displacing the blank plate (i.e. zero dosing). The time of initiation of sediment dosing was the start of the sediment dosing time and was carefully recorded. The sediment dosing time ended when sediment dosing was terminated. The start of the sediment dosing time was the zero time point of the experiment and the basis of the time stamp for all sampling and all measurements.

Background Influent Sampling Eight background influent samples were collected at intervals spaced throughout the sediment dosing time. The sample location was in the sediment screening chamber, just in front of the entrance to the discharge pipe. Sampling was conducted by opening the cover in the top of the Screening Chamber; loosening but not removing the threaded cap on the cannister; immersing the container with the opening facing directly into the direction of water flow with the centerline of the opening ca. 6 in. below the surface of the water; removing the cap for a short time to allow water ingress; placing the cap over the opening; quickly removing the cannister from the water while simultaneously turning the cannister so that the opening was facing upward; and screwing the top closed.

Sediment Dose Sampling Six sediment dose samples were collected at intervals spaced through the sediment dosing time. Sediment dose sampling was conducted by placing a sediment collection container under the hopper dosing point for 60 seconds to collect all sediment leaving the hopper.

Sediment Dosing Termination Sediment dosing was terminated by sliding the the blank plate (i.e. zero dosing) into the dosing plate slot at the bottom of the dosing hopper, displacing the dosing plate. The duration of termination of sediment dosing was the end of the sediment dosing time and was carefully recorded. The sediment dosing time was used to calculated the total sediment dosed from the hopper. The sediment dosing time corrected for the time of six hopper dose samples was used to calculate the total sediment dosed to the NSBB.

Retained Sediment Collection and Analysis Following the termination of sediment dosing, the pump was turned off and water in the NSBB chambers was allowed to settle for 30 minutes. The clear water in each chamber was decanted to approximately eight inches above the surface of the accumulated sediment. The sediment was then decanted with a suction pipe and directed to an external sediment filtration system. Paper filters were dried and tare weighed to a precision of 0.01 grams before filtration. Filters and sediment were dried to constant weight and sediment mass determined by subtracting the tare weight.

Analytical and Quality Assurance Procedures Analysis of Suspended Sediment Concentration (SSC) analysis was conducted according to the AET SSC protocol. A 2 hour drying time for filtered samples was verified to be sufficient by weight changes of 0.05 mg and less for 250 mg/L equivalent SSC concentrations. For all removal efficiency experiment analyses events, Method Blanks were less than the established Reporting Limit of 2.07 mg/L. For all removal efficiency experiment analyses events, Lab Control Sample recoveries were within the established tolerance of 15%. Initial Demonstration of Capability samples in the low SSC range of ca. 10 mg/L were all within the 30% Recovery Criteria. Demonstrations of Capability samples in the high SSC range of ca. 100 mg/L were all within 15% Recovery Criteria.

Data Management Data sheets were assembled and a complete file maintained at AET for each experiment. All data were placed in electronic format by entering into Excel spreadsheets which are maintained at several locations.

A target SSC removal efficiency of 80% was established as the basis for a performance claim. The conducted removal experiments are listed in Table 4.

Table 4 Summary of Removal Efficiency Experiments

Flow Rate, cfs	% of MTFR[1]	Sediment Mass Flow, gram/min	Hydraulic Retention Time, min[2]	Surface Overflow Rate, gal/ft^2-min
0.25	19.2	85	3.60	6.2
0.50	38.5	170	1.80	12.5
0.75	57.7	255	1.20	18.7
1.00	76.9	340	0.90	24.9
1.25	96.2	425	0.72	31.2
1.50	115	510	0.60	37.4
1.75	135	595	0.51	43.6

[1] Maximum Treatment Flow Rate, determined in subsequent section of report

[2] Based on chamber volumes

3.2.2 Resuspension

The resuspension experiment followed the testing protocol outlined below.

Sediment Pre-Loading Test sediment was preloaded into each NSBB chamber to a uniform six inch depth on January 4, 2013. Sediment was added from sealed containers and water added to a level just above the sediment surface. Stirring and releveling of sand was conducted to insure absence of air from the system. The resuspenison test was conducted on January 8, 2013. Water was pumped slowly to fill the NSBB to the top of the baffles.

Water Temperature Water temperature was verified to be less than 80F just before the initiation of the experiment using a NIST traceable thermometer (Traceable Calibration Control Company 281-482-1714)

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Field Data Sheets Field data sheets were prepared for temperature monitoring, flow rate target and monitoring, total experimental time at target flowrate, background suspended sediment concentration sample collection times, effluent suspended sediment concentration sample collection times, SSC laboratory analysis, and laboratory blank and laboratory control samples for SSC analysis. Data sheets specified and recorded the times of all sample events of other observations.

Sample Containers Sample containers were prepared for at least eight background influent SSC samples and fifteen effluent SSC samples. All containers had sealable tops. SSC containers were one half gallon PETE canisters with round 4 in. diameter open mouths. SSC containers and tops were rinsed at least three times with tap water and drained. SSC containers were numbered and deployed in increasing number with experimental time.

Flow Initiation and Control The pump and flow control valve were pre-set to achieve the target resuspension flowrate of 2.70 cfs. When all experimental preparations were completed, the pump was started at the pre-settings. The flow meter was then powered on and allowed to electronically stablilize. Once flow readings could be discerned, the zero time was stamped, and checking of flow rate and adjustment of flow rate with the flow control valve were initiated. Flow rate adjustments were made as needed throughout the testing using the flow rate control valve. Flow rate was recorded on data sheets at 1 minute intervals throughout the experiment. The target 2.70 cfs flowrate was reached within 4 minutes of pump startup and maintained at that flow rate for the remaining 30 minutes of the test. Background influent and NSBB effluent samples were collected though the 30 minute constant flow rate period.

Background Influent Sampling Background influent samples were collected at intervals spaced throughout the 30 min. resuspension test time. The sample location was in the sediment screening chamber, just in front of the entrance to the discharge pipe. Background influent sampling was conducted by opening the cover in the top of the Screening Chamber; loosening but not removing the threaded cap on the cannister; immersing the container with the opening facing directly into the direction of water flow with the centerline of the opening ca. 6 in. below the surface of the water; removing the cap for a short time to allow water ingress; placing the cap over the opening, quickly removing the cannister from the water while simultaneously turning the cannister so that the opening was facing upward; and screwing the top closed.

Effluent Sampling Effluent samples were collected at intervals spaced throughout the 30 min. resuspension test time. Samples were collected though a slot in the top of the pipe connecting the NSBB to the Water Supply Reservoir at ca. 4 ft. downstream of the NSBB exit. Sampling was conducted by loosening but not removing the threaded cap on the cannister; immersing the container with the opening facing directly into the direction of water flow with the centerline of the opening ca. 4 in. below the surface of the water; removing the cap for a short time to allow water ingress; placing the cap over the opening, quickly removing the cannister from the water while simultaneously turning the cannister so that the opening was facing upward; and screwing the top closed.

Analytical and Quality Assurance Procedures The Method Blank for the resuspension test analysis event was within the established Reporting Limit of 2.07 mg/L. Recovery of the Lab Control Sample for the resuspension test analysis event was 103.3%, and was within the established tolerance of 15%.

Data Management Data sheets were assembled and a complete file maintained at AET for each experiment. All data were placed in electronic format by entering into Excel spreadsheets which are maintained at several locations.

4. NSBB Performance Evaluation Results

4.1 TSS Removal Efficiency Results

This section summarizes measured temperature, flow rate, sediment dosing rate and background sediment concentrations, presents the removal efficiency results of seven flow rate experiments, and derives weighted removal efficiencies using the NJDEP weighting factors (5). Full results of the removal efficiency experiments are presented in Appendix A.

Water Temperature The water temperature was verified to be less 80F just prior to the start of each of the seven removal efficiency experiments and remained less than 80F during testing.

Flow Rate Measured and target flow rates are shown in Figure 4 and summarized in Table 5. Mean flow rates were all within 1% of target flow rates, which was well within the ±10% criteria in the NJDEP protocol. Monitored flow rates for the 1.00 cfs experiment are shown in Figure 5, which illustrates that flow rates were well within the the NJDEP-permitted tolerance.

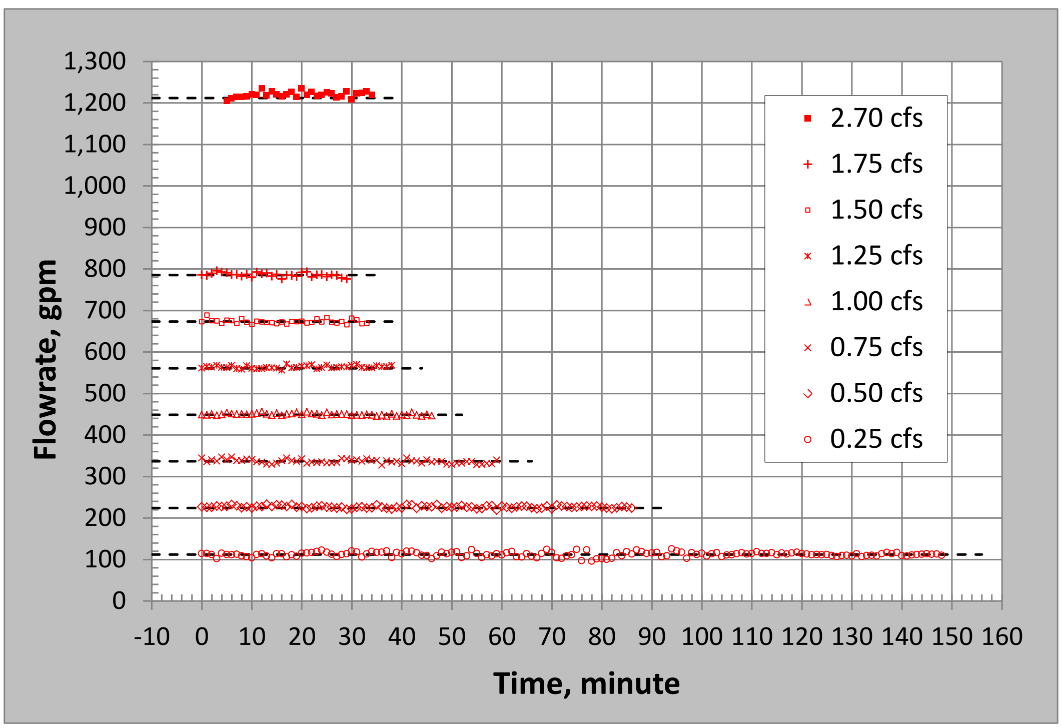


Figure 4 Monitored Flow Rates in Removal Efficiency Experiments

Table 5 Measured Flow Rates in Removal Efficiency Experiments

Target Flow Rate		Measured Flow Rate				
cfs	gpm	Mean, gpm	SD, gpm[1]	CV[2]	% RE[3]	Median, gpm
0.25	112.2	112.3	5.54	0.049	0.06	112.9
0.50	224.4	226.6	3.03	0.013	0.98	226.7
0.75	336.6	336.4	4.82	0.014	-0.05	336.4
1.00	448.8	449.9	2.65	0.006	0.25	449.7
1.25	561.0	563.6	3.40	0.006	0.47	563.1
1.50	673.2	673.3	5.11	0.008	0.02	672.5
1.75	785.4	785.7	4.89	0.006	0.04	785.8

[1] Standard Deviation
[2] Coefficient of Variation = Standard Deviation / Mean x 100
[3] % Relative Error = (Measured Mean - Target) / Target x 100

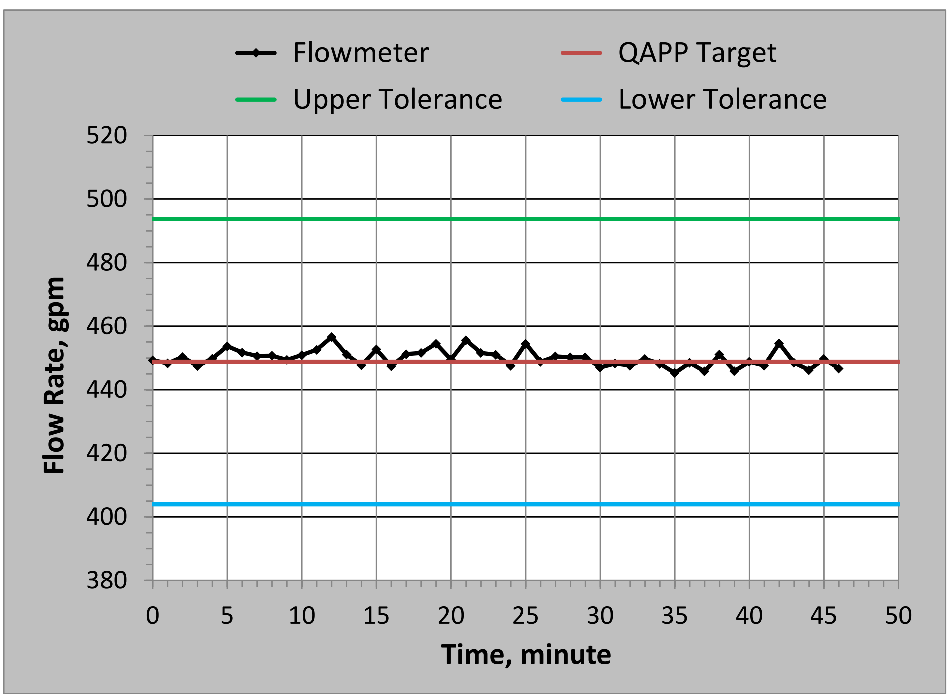


Figure 5 Monitored Flow Rate in 1.00 cfs Experiment

Sediment Dosing Measured and target sediment dosing rates are shown in Figure 6 and summarized in Table 6. Mean dosing rates were all within 5% of target flow rates, which was well within the ±10% criteria in the NJDEP protocol. Monitored sediment dosing rates for the 1.00 cfs experiment are shown in Figure 7, which illustrates that dosing rates were well within the NJDEP protocol-permitted tolerance. Mean influent SSC to the NSBB was estimated by dividing the mean sediment dosing rate by the mean flowrate. Mean influent SSC is compared to the target influent SSC of 200 mg/L in Figure 8. Estimated mean influent SSC were well within the ±10% NJDEP protocol-permitted tolerance (i.e. 180 to 220 mg/L).

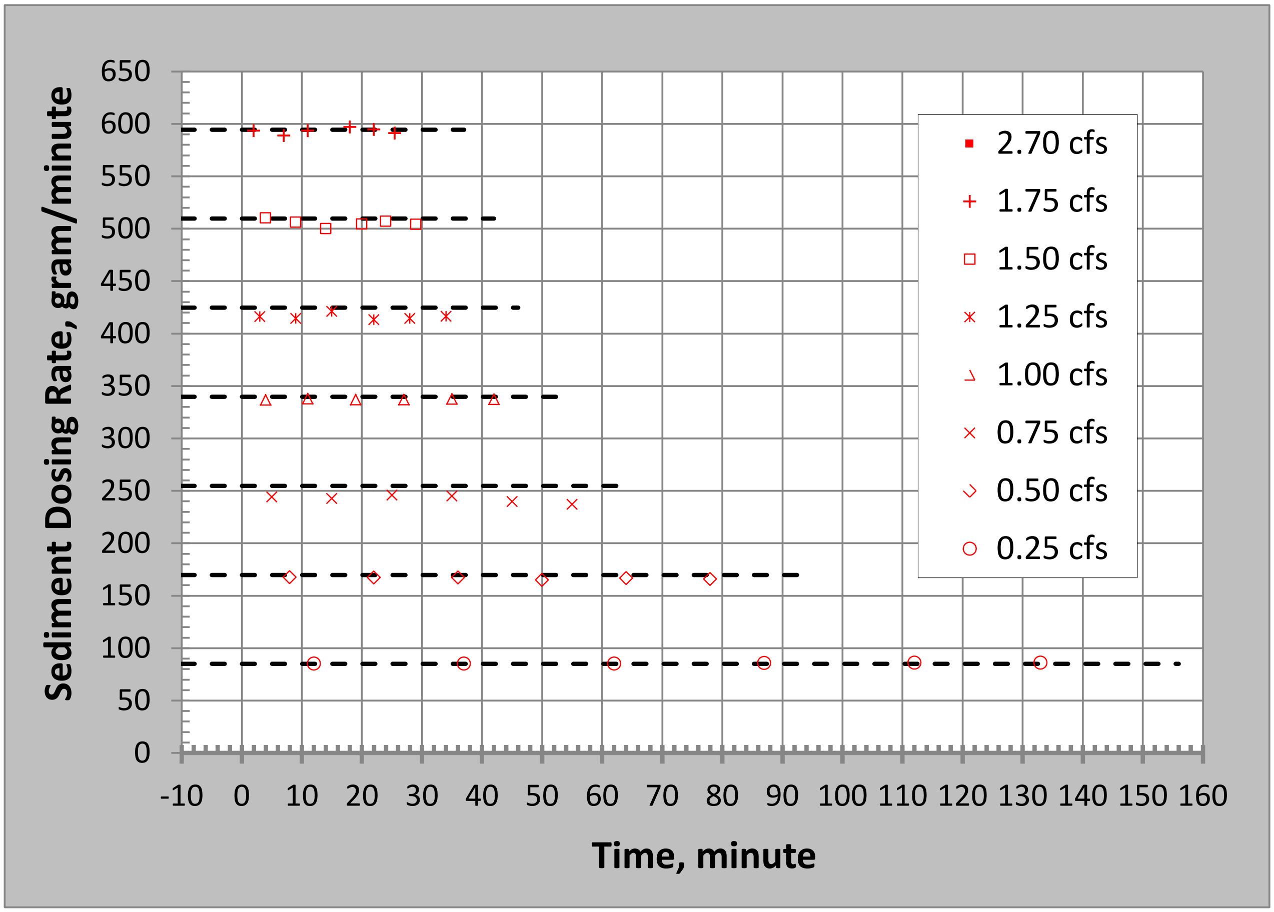


Figure 6 Sediment Dosing Rates in Removal Efficiency Experiments

Table 6 Measured Sediment Dosing Rates

Target Flow Rate	Target Dosing Rate	Measured Dosing Rate				
cfs	gram/min	Mean, gram/min.	SD, gram/min.[1]	CV[2]	% RE[3]	Median, gram/min.
0.25	84.9	85.6	0.4	0.004	0.76	85.6
0.50	169.9	166.9	1.0	0.006	-1.8	167.2
0.75	254.8	242.4	3.4	0.014	-4.9	243.4
1.00	339.7	337.2	0.5	0.001	-0.74	337.1
1.25	424.7	415.9	2.8	0.007	-2.1	415.2
1.50	509.6	505.2	3.4	0.007	-0.86	505.2
1.75	594.5	593.3	2.8	0.005	-0.20	593.8

[1] Standard Deviation

[2] Coefficient of Variation = Standard Deviation / Mean x 100

[3] % Relative Error = (Measured Mean - Target) / Target x 100

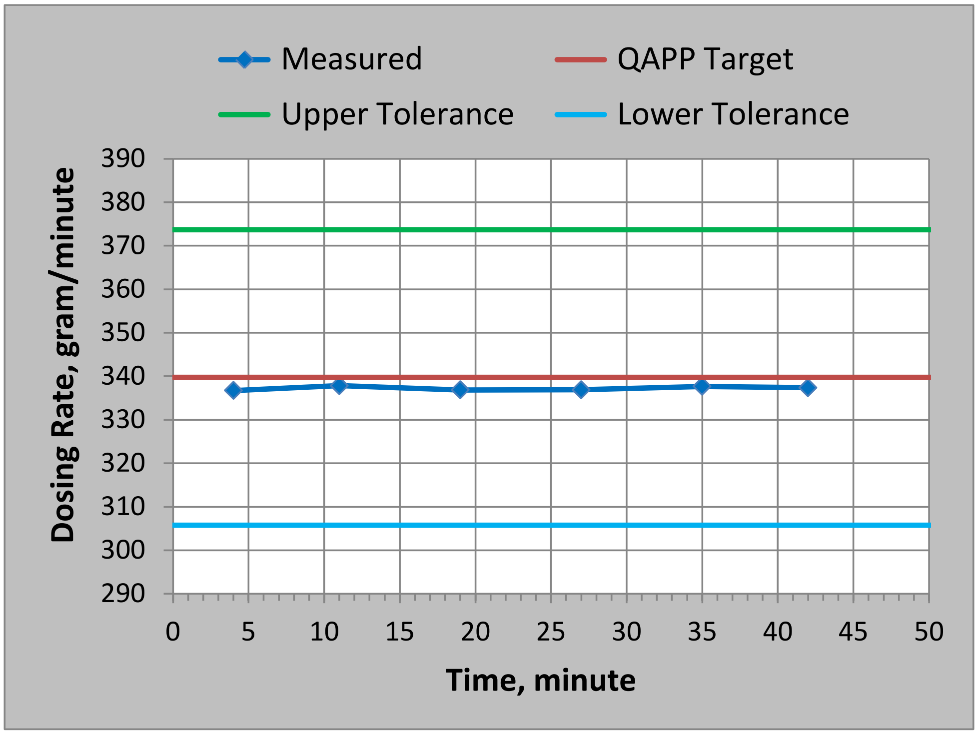


Figure 7 Sediment Dosing Rate in 1.00 cfs Experiment

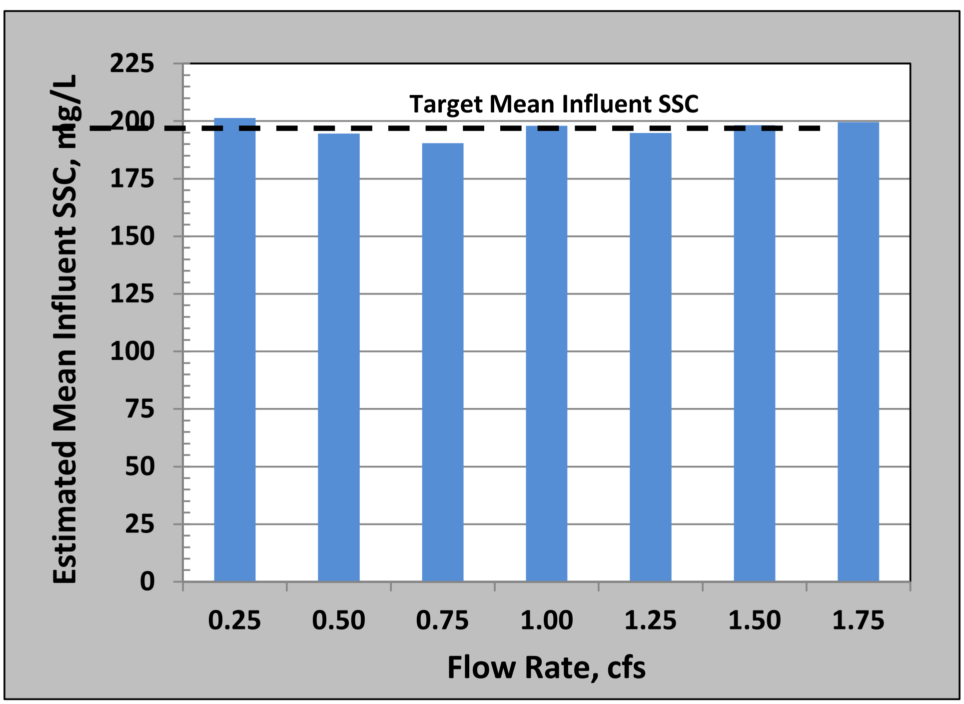


Figure 8 Estimated Mean Influent SSC in Removal Efficiency Experiments

Background Sediment Concentration Background SSC in the removal efficiency tests are summarized in a box plot in Figure 9 and in Table 7. Mean background SSC ranged from 2.2 to 13.4 mg/L. Figure 9 shows that all background SSC distributions were well within the 20 mg/L criteria in the NJDEP protocol (Figure 9). Background SSC generally increased with increasing flowrate, with the exception of the 1.25 cfs experiment. All measured background SSC were less than 20 mg/L except for one measurement of 24.4 mg/L in the 1.25 cfs experiment.

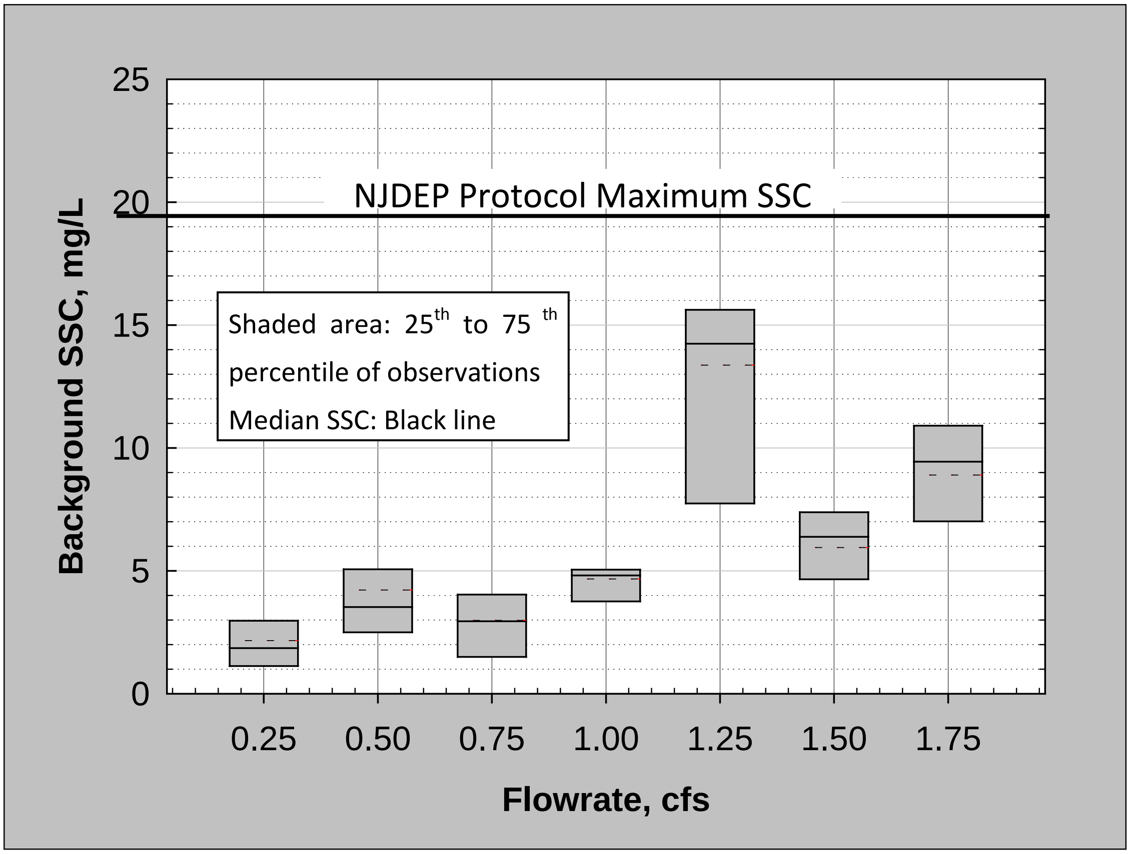


Figure 9 Background Sediment Concentrations in Removal Efficiency Experiments

Table 7 Measured Background Suspended Sediment Concentrations

Target Flow Rate	Measured Background Suspended Sediment Concentration			
cfs	Mean, mg/L	SD, mg/L[1]	CV[2]	Median, mg/L
0.25	2.16	1.4	0.659	1.86
0.50	4.22	2.4	0.574	3.53
0.75	2.98	1.5	0.500	2.94
1.00	4.67	1.2	0.260	4.81
1.25	13.4	6.3	0.471	14.2
1.50	5.95	2.0	0.332	6.38
1.75	8.89	2.7	0.302	9.44

[1] Standard Deviation

[2] Coefficient of Variation = Standard Deviation / Mean x 100

[3] % Relative Error = (Measured Mean - Target) / Target x 100

Sediment Mass Removal Efficiency The masses of sediment dosed to NSBB 3-6-72 and captured in the bottom chambers are listed in Table 8 for the seven removal efficient experiments. The dosed mass ranged from 26.8 to 30 lbs., and satisfied the 25 lb. minimum dosing mass requirement in the NJDEP protocol. Sediment removal efficiencies ranged from 98.2% at 0.25 cfs to 68.1% at 1.75 cfs, and progressively increased as flow rate decreased (Figure 10). A third order polynomial equation ($y = - 8.87x^3 + 46.76x^2 – 82.56x + 117.3$) was fit to the removal efficiency data (n=7) and provided an acceptable fit to the experimental data ($R^2 > 0.96$) as shown in Figure 10.

Table 8 Sediment Mass Removal Efficiency

Target Flow Rate, cfs	Sediment Mass Dosed, lbs.	Sediment Mass Captured, lbs.	Removal Efficiency, %
0.25	26.81	26.32	98.2
0.50	29.38	26.61	90.6
0.75	28.28	21.04	74.4
1.00	29.69	21.49	72.4
1.25	29.29	20.80	71.0
1.50	30.03	20.70	68.9
1.75	30.04	20.47	68.1

[1] Standard Deviation
[2] Coefficient of Variation = Standard Deviation / Mean x 100
[3] % Relative Error = (Measured Mean - Target) / Target x 100

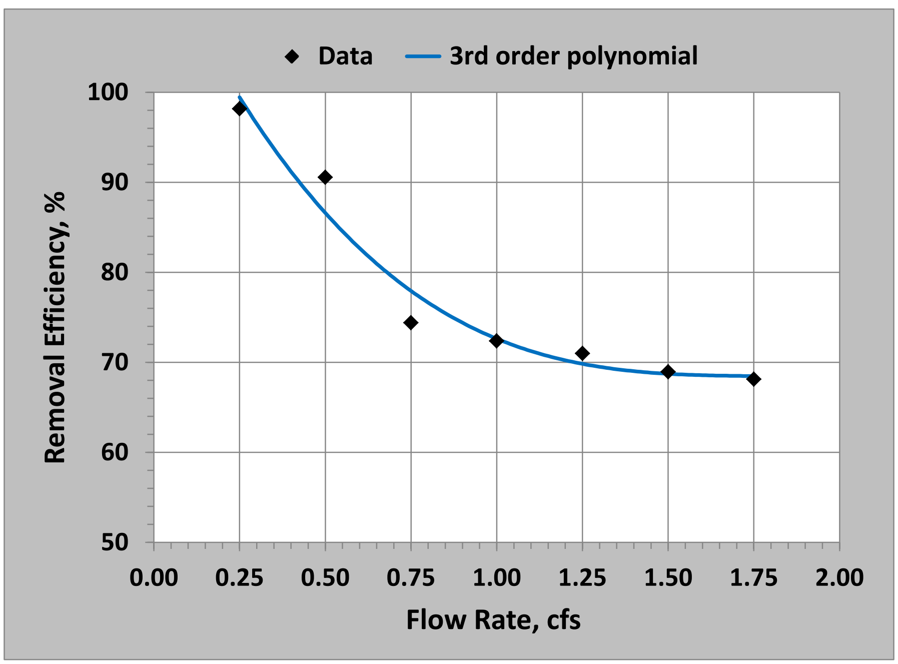


Figure 10 Removal Efficiency versus Flow Rate Correlation

Flow-Weighted Removal Efficiency The NJDEP protocol establishes the Maximum Treatment Flow Rate (MTFR) as a flow weighted removal efficiency, with weighting factors 0.25, 0.30, 0.20, 0.15 and 0.10 for flow rates of 25, 50, 75, 100 and 125% of the MTFR, respectively (2). To derive a MTFR for the NSBB 3-6-72, a continuous function was developed of the weighted removal efficiency versus flow rate. The weighted removal efficiency function was based on the removal efficiency versus flow rate correlation presented in Figure 10. For any MTFR, the removal efficiencies at the 25, 50, 75, 100 and 125% flow rates were calculated and the NJDEP weighting factors were applied. The results are shown in Figure 11. With increasing flow rate, the flow weighted removal efficiencies decrease. The verifiable flow range of the weighted removal efficiency calculation is constrained by the range of flow rates used in the removal efficiency experiments (0.25 cfs to 1.75 cfs). For the NSBB 3-6-72 experiments, the verifiable flow range is 1.00 to 1.40 cfs (Figure 11). Calculations of the flow weighted removal efficiency for MTFRs of 1.00 and 1.30 cfs are shown in Table 9.

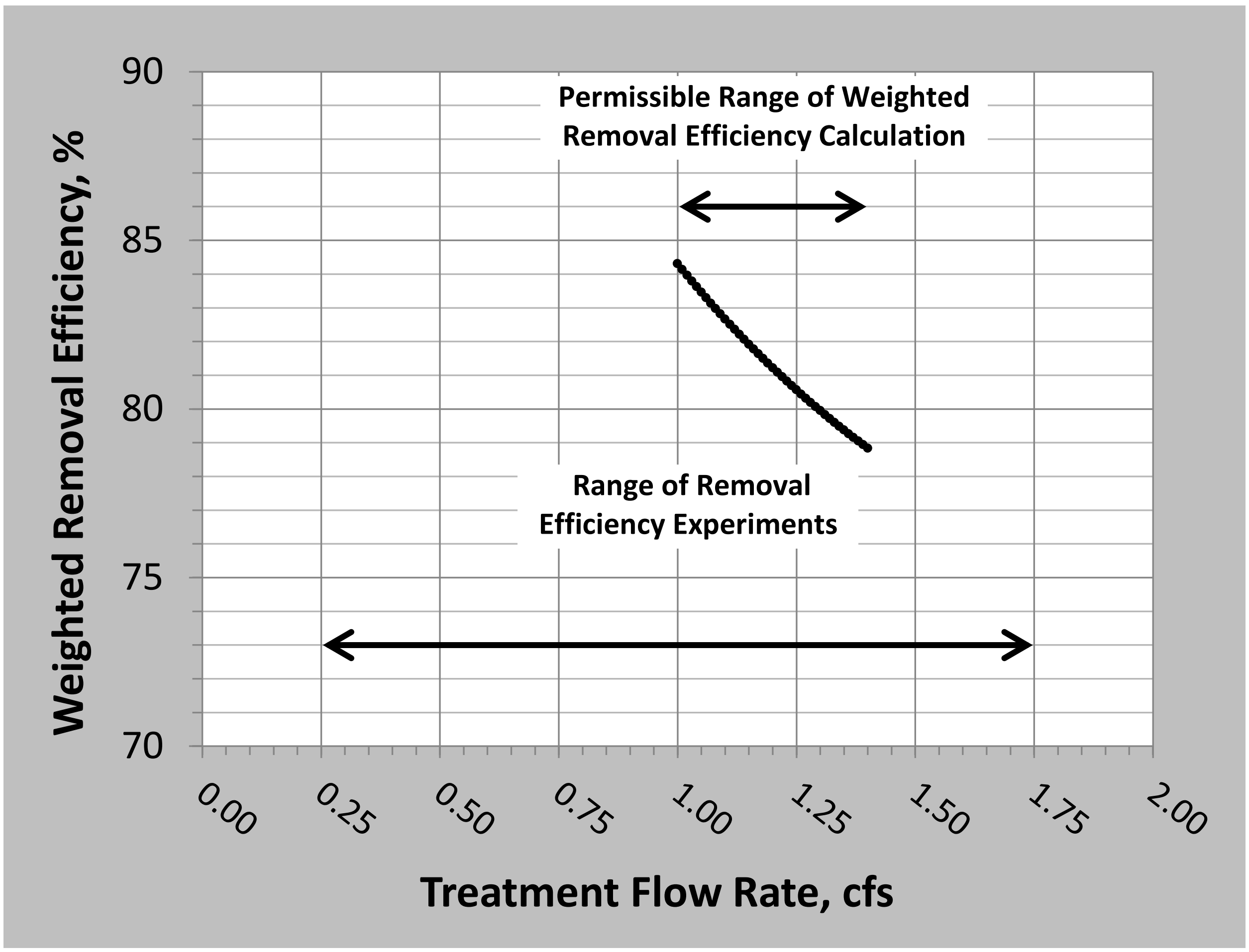


Figure 11 Flow Weighted Removal Efficiencies

Table 9 Flow Weighted Removal Efficiency Calculations

Treatment Flow Rate, cfs		% of Treatment Flow Rate					Flow Weighted Removal Efficiency, %
		25%	50%	75%	100%	125%	
1.00	Flow Rate, cfs	0.250	0.500	0.750	1.000	1.250	84.3
	Removal Efficiency, %	99.4	86.6	77.9	72.6	69.8	
1.30	Flow Rate, cfs	0.325	0.650	0.975	1.300	1.625	80.0
	Removal Efficiency, %	95.1	81.0	73.0	69.5	68.6	

Maximum Treatment Flow Rate (MTFR) A target weighted removal efficiency of 80% was established as the basis of the performance claim for NSBB 3-6-72. For 80% SSC removal of 100 μm sediment by NSBB 3-6-72, a Maximum Treatment Flow Rate of 1.30 cfs was determined as illustrated in Figure 12.

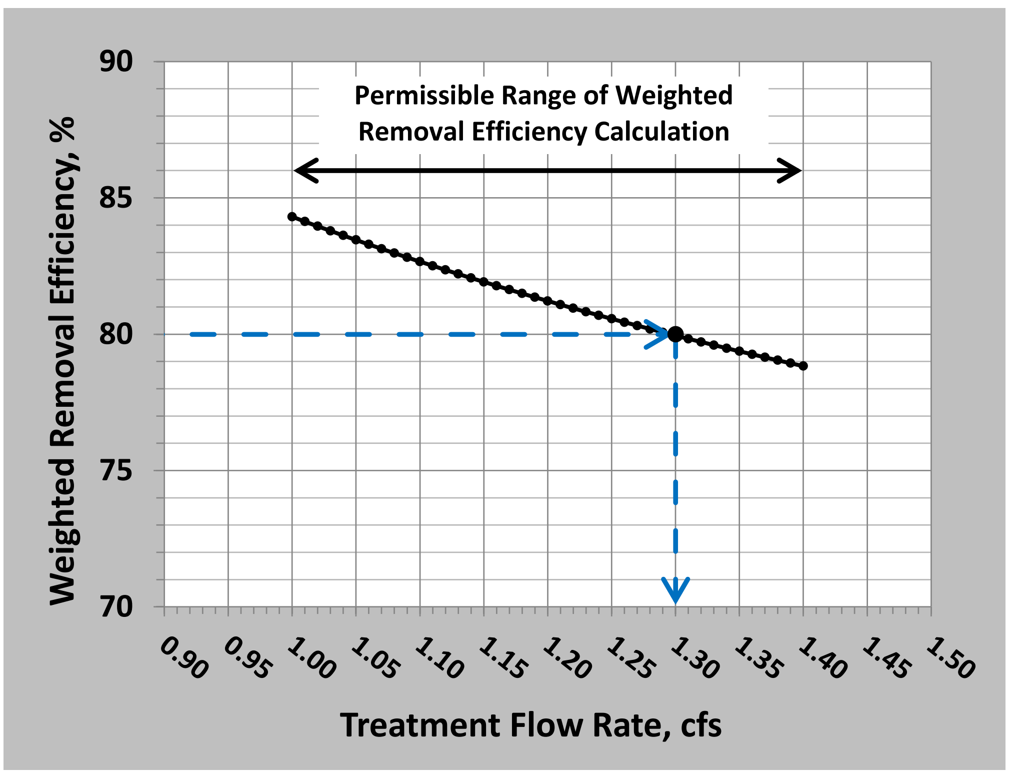


Figure 12 Maximum Treatment Flow Rate Determination

4.2 Resuspension Results

This section summarizes measured temperature, flow rate, background and effluent sediment concentrations in the resuspension experiment, and compares the data sets for background and effluent SSC to each other and to the NJDEP criteria for on-line installation of 20 mg/L SSC. Full results of the removal efficiency experiments are presented in Appendix A.

Comparison of NSBB and NJDEP Resuspension PSDs The NSBB resuspension experiment was conducted using the same sediment that was employed in the removal efficiency tests. The NSBB resuspension sediment had a relatively narrow PSD centered on 100 µm and was finer than the NJDEP protocol resuspension sediment (i.e. d_{50} of 98 versus 216 µm). The PSDs of the NSBB resuspension test and NJDEP resuspension protocol are compared in Figure 13. The NSBB resuspension test provided a more rigourous resuspension evaluation than if the NJDEP protocol sediment had been used.

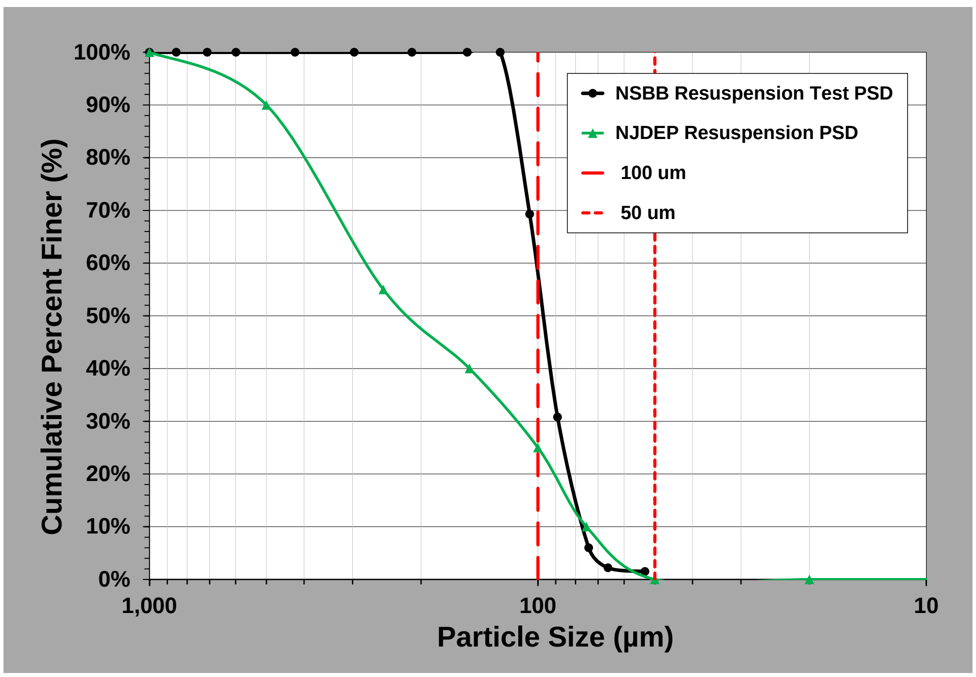


Figure 13 Comparison of PSD used in Resuspension Experiment with NJDEP PSD

Water Temperature The water temperature just prior to the start of the resuspension experiment was less than 80F and remained less than 80F during testing.

Flow Rate Measured and target flow rates are summarized in Table 10 and plotted in Figure 14. Mean flow rate was within 1% of target flow rate, which was well within the ±10% the NJDEP-permitted tolerance (Figure 14), with a coefficient of variation of less than 0.01.

Table 10 Measured Flow Rates in Resuspension Experiment

Target Flow Rate		Measured Flow Rate				
cfs	gpm	Mean, gpm	SD, gpm[1]	CV[2]	% RE[3]	Median, gpm
2.70	1,211.8	1,219.8	6.90	0.006	0.67	1,219.0

[1] Standard Deviation

[2] Coefficient of Variation = Standard Deviation / Mean x 100

[3] % Relative Error = (Measured Mean - Target) / Target x 100

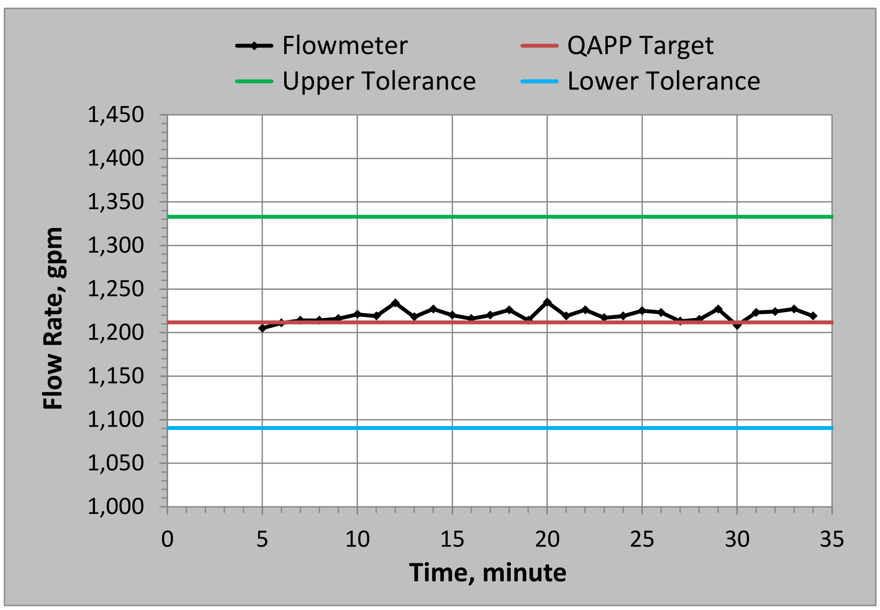


Figure 14 Flow Rate in Resuspension Experiment

Background and Effluent Suspended Sediment Concentrations The SSC concentrations in the resuspension experiment are plotted in Figure 15 and listed in Table 11.

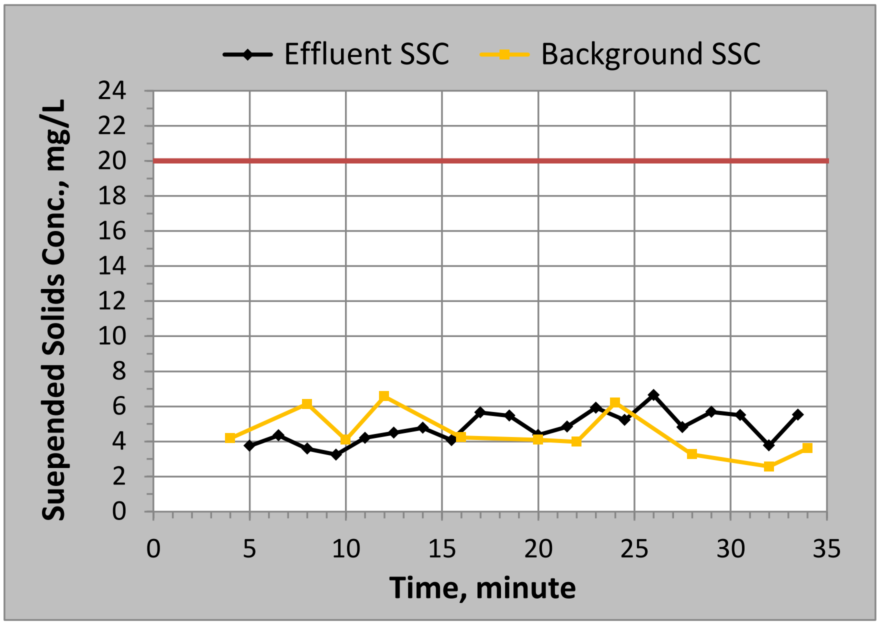


Figure 15 Suspended Sediment Concentrations in Resuspension Test

Table 11 Suspended Sediment Concentrations in Resuspension Experiment

Sample	Measured Suspended Sediment Concentration/ mg/L				
	Mean	SD[1]	CV[2]	Median	Maximum
Background (Influent)	4.44	1.3	0.290	4.10	6.56
Effluent	4.79	0.9	0.187	4.79	6.64

[1] Standard Deviation
[2] Coefficient of Variation = Standard Deviation / Mean x 100

Mean SSC in the NSBB effluent was 4.79 mg/L and ranged from 3.2 to 6.6 mg/L. Mean background SSC in NSBB influent was 4.44 mg/L and ranged from 2.6 to 6.6 mg/L. There was not a statistically significant difference between the influent and effluent SSC data sets. All SSC values in the NSBB effluent were well below 20 mg/L. The NJDEP protocol includes a procedure to correct effluent SSC for background levels by creating a curve of the background SSC and subtracting each effluent SSC for background at the time of sampling. Application of this technique resulted in a high percentage of negative values for background-corrected effluent SSC and was not considered appropriate.

5. Scaling

The Maximum Treatment Flow Rate (MTFR) of thirteen other NSBB models was determined from the NSBB 3-6-72 demonstrated MTFR of 1.30 cfs by applying the same flow rate per surface area, 0.072 cfs/ft^2 (32.4 gpm/ft^2), to all NSBB models. The surface area scaled MTFR of NSBB models are listed in Table 12***. It should be recognized that the current NJDEP protocol includes a more elaborate scaling methodology and these MTFRs would not be recognized by the NJDEP.***

Table 12 Maximum Treatment Flow Rate of NSBB® Models*

NSBB Model #	Inside Width, ft.	Inside Length, ft.	Baffle Height, in.	Sedimentation Area, ft^2	Maximum Treatment Flow Rate, cfs
2-4-60	2	4	24	8.0	0.58
3-6-72	3	6	36	18.0	1.30
4-8-84	4	8	36	32.0	2.31
5-10-84	5	10	36	50.0	3.61
6-12-84	6	12	36	72.0	5.20
8-12-84	8	12	36	96.0	6.93
8-14-100	8	14	40	112	8.09
10-14-100	10	14	40	140	10.1
10-16-125	10	16	46	160	11.6
10-20-125	10	20	48	200	14.4
12-20-132	12	20	48	240	17.3
12-24-132	12	24	60	288	20.8

*80% SSC Removal Efficiency

6. Summary

A full-scale Nutrient Separation Baffle Box® Model 3-6-72 was experimentally evaluated using TSS removal efficiency and resuspension protocols promulgated by the New Jersey Department of Environmental Protection (2). The experiments employed a relatively narrow particle size distribution (PSD) centered on 100 µm, in lieu of the broader NJDEP PSD. ***Consequently, Suntree will not be submitting this NJCAT NSBB verification report to NJDEP for removal efficiency certification since the sediment particle size did not comply with that of the current NJDEP laboratory test protocol.***

Seven removal efficiency experiments were conducted at flow rates ranging from 0.25 to 1.75 cubic feet per second (cfs), each at an influent Suspended Sediment Concentration (SSC) of 200 mg/L. SSC removal efficiencies ranged from 68.1 to 98.2 percent and progressively increased as flow rate decreased. A Maximum Treatment Flow Rate (MTFR) of 1.30 cfs was derived for 80% SSC removal by the NSBB 3-6-72, based on the NJDEP weighted removal efficiency procedure.

In a resuspension experiment conducted at 208% of MTFR (2.70 cfs), sediment resuspension was not significant; the mean SSC in the NSBB discharge was only 0.35 mg/L greater than the mean influent SSC. The maximum SSC in the NSBB discharge (6.6 mg/L) was well below the limit of 20 mg/L that is allowed by NJDEP for on-line installation.

The Maximum Treatment Flow Rate (MTFR) of the NSBB 3-6-72 was used to determine the MTFR of thirteen (13) additional NSBB models by applying the flow rate per surface area method for scaling. ***NJDEP has recently adopted a more elaborate scaling methodology (2) and these MTFRs would not be recognized by the current NJDEP protocol.***

7. References

1. NJCAT Verification Report; Nutrient Separation Baffle Box, Suntree Technologies Inc., Hoboken, NJ, October, 2008.
2. New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device, NJDEP, Trenton, NJ, January 25, 2013.
3. Suntree Technologies Inc.® (2012) *http://www.suntreetech.com/Products/Nutrient+Separating+Baffle+Box/default.aspx*
4. Nutrient Separating Baffle Box® NJDEP Hydrodynamic Protocol: Evaluation with 100 µm Particles. Daniel P. Smith, Applied Environmental Technology, Tampa, FL. April 18, 2013.
5. 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.

APPENDIX A

Experimental Data and Results

Experimental Data and Results

Table A-1 List of Experiments

Experiment	Test Date	Flowrate, cfs
Removal Efficiency	12/12/12	0.25
	12/11/12	0.50
	12/06/12	0.75
	12/18/12	1.00
	12/10/12	1.25
	12/19/12	1.50
	12/20/12	1.75
Resuspension	01/08/13	2.70

Table A-2 Summary of Results for 0.25 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	112.2	112.3	0.0494	96.1	125.4	0.06
NSBB Sediment Dosing Time, min	142.33					
Sediment Dosing Rate, gram/min	84.9	85.6	0.004	85.2	86.0	0.76
Mean Influent SSC, mg/L	201.4					
Background SSC, mg/L	20 mg/L max.	2.2	0.66	0.5	5.0	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed to NSBB	12,182	26.81		
Sediment Captured				
Chamber 1	10,723	23.60	89.7	88.0
Chamber 2	819	1.80	6.9	56.2
Chamber 3	415	0.91	3.5	64.9
Total	11,957	26.32	100.0	98.2

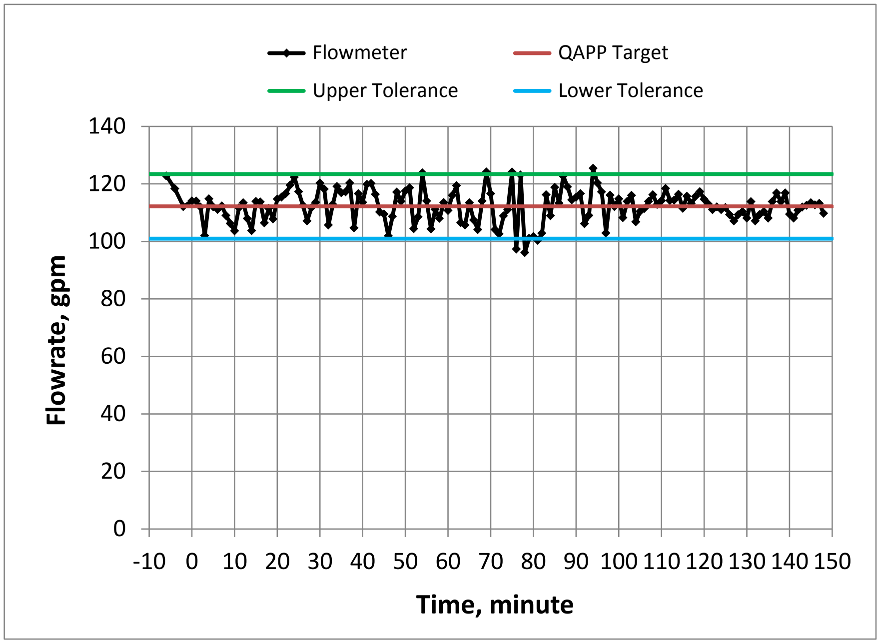


Figure A-1 Monitored Flow Rate for 0.25 cfs Experiment

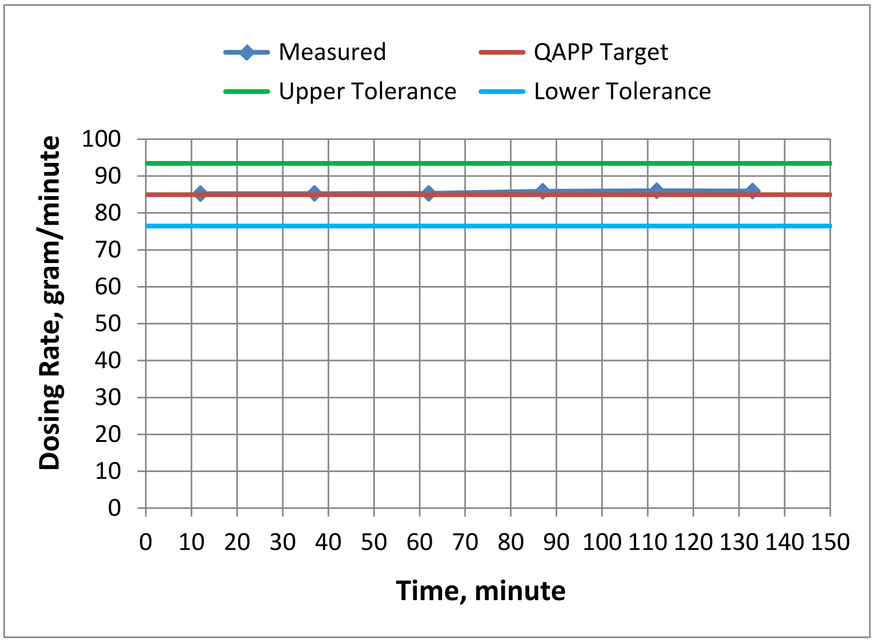


Figure A-2 Monitored Sediment Dosing Rate for 0.25 cfs Experiment

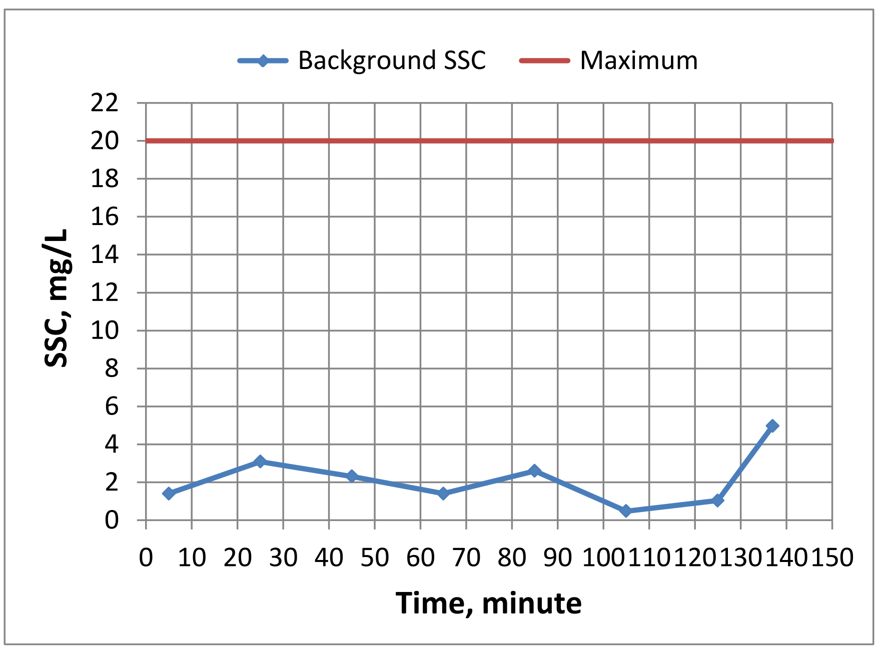


Figure A-3 Monitored Background SSC for 0.25 cfs Experiment

Table A-3 Summary of Results for 0.50 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	224.4	226.6	0.0134	218.8	232.9	0.98
NSBB Sediment Dosing Time, min	80.0					
Sediment Dosing Rate, gram/min	169.9	166.9	0.006	165.2	167.8	-1.77
Mean Influent SSC, mg/L	194.6					
Background SSC, mg/L	20 mg/L max.	4.2	0.57	2.0	9.6	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed	13,349	29.38		
Sediment Captured				
Chamber 1	10,650	23.44	88.1	79.8
Chamber 2	842	1.85	7.0	31.2
Chamber 3	596	1.31	4.9	32.1
Total	12,088	26.61	100.0	90.6

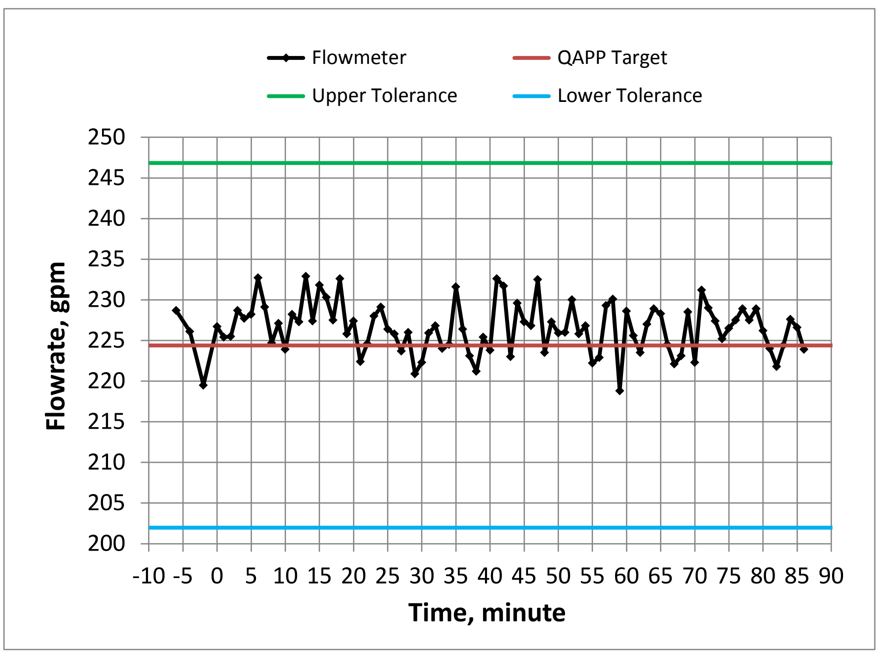


Figure A-4 Monitored Flow Rate for 0.50 cfs Experiment

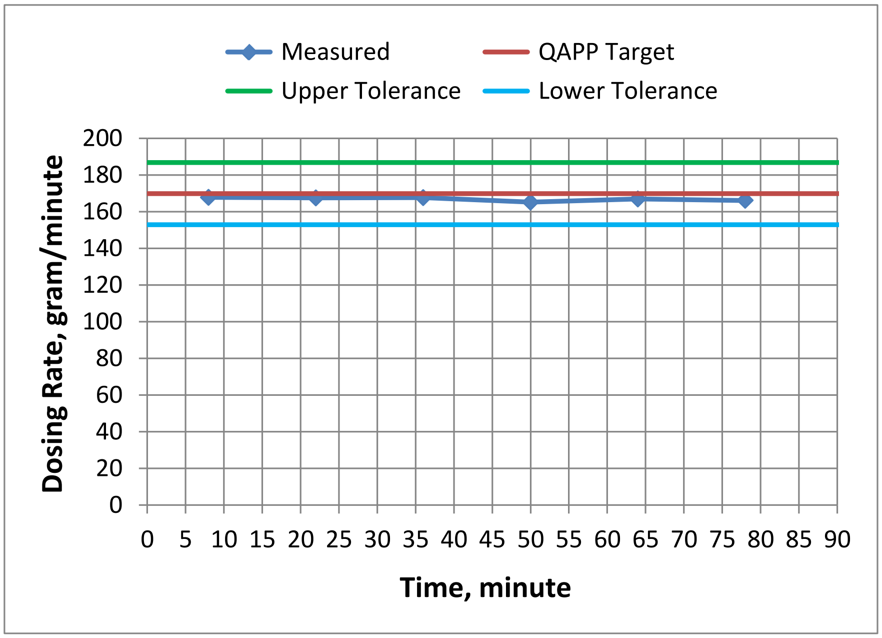


Figure A-5 Monitored Sediment Dosing Rate for 0.50 cfs Experiment

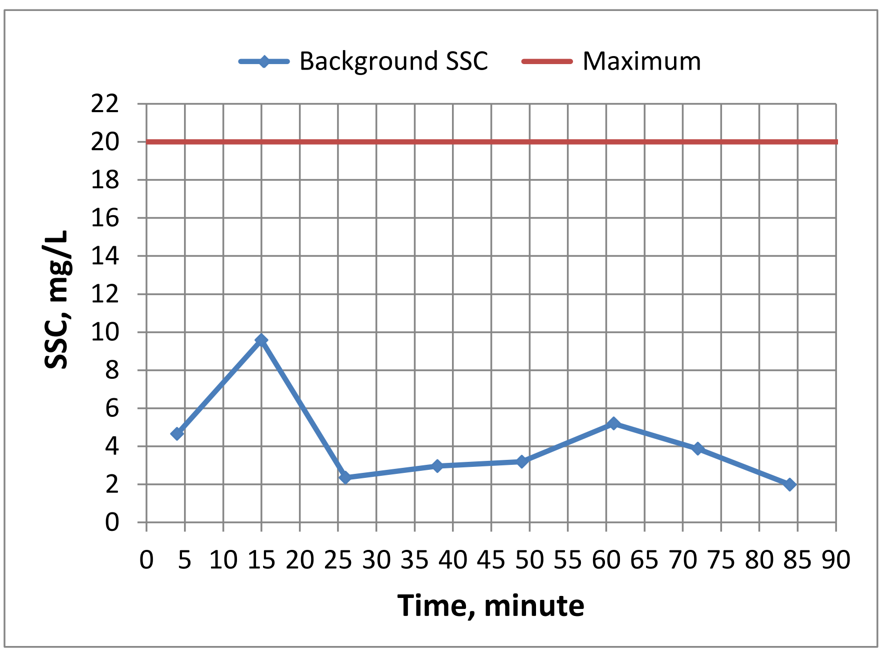


Figure A-6 Monitored Background SSC for 0.50 cfs Experiment

Table A-4 Summary of Results for 0.75 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	336.6	336.4	0.0143	327.5	346.8	-0.05
NSBB Sediment Dosing Time, min	53.0					
Sediment Dosing Rate, gram/min	254.8	242.4	0.014	237.1	245.9	-4.87
Mean Influent SSC, mg/L	190.4					
Background SSC, mg/L	20 mg/L max.	3.0	0.50	0.9	5.3	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed	12,847	28.28		
Sediment Captured				
Chamber 1	8,192	18.03	85.7	63.8
Chamber 2	849	1.87	8.9	18.2
Chamber 3	517	1.14	5.4	13.6
Total	9,559	21.04	100.0	74.4

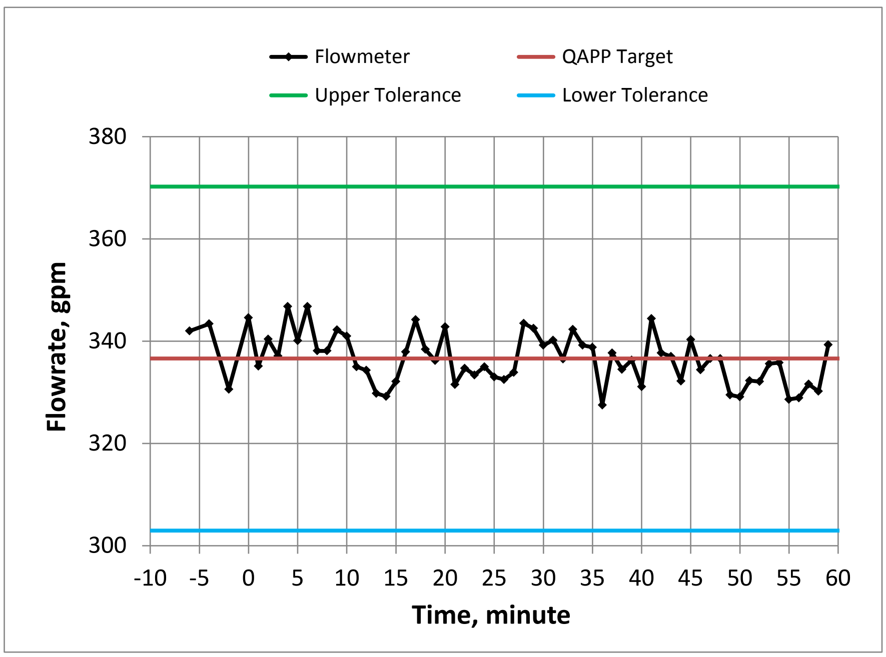


Figure A-7 Monitored Flow Rate for 0.75 cfs Experiment

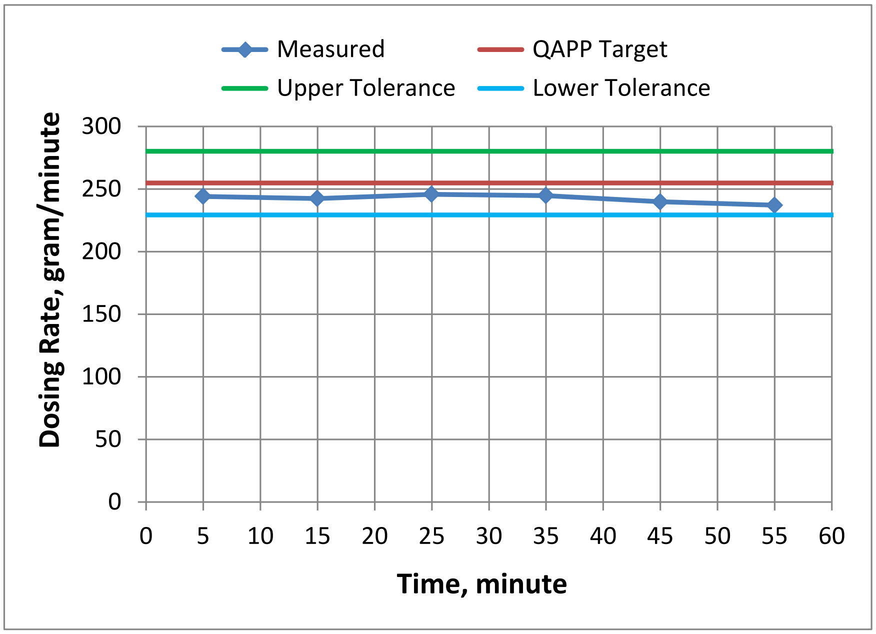


Figure A-8 Monitored Sediment Dosing Rate for 0.75 cfs Experiment

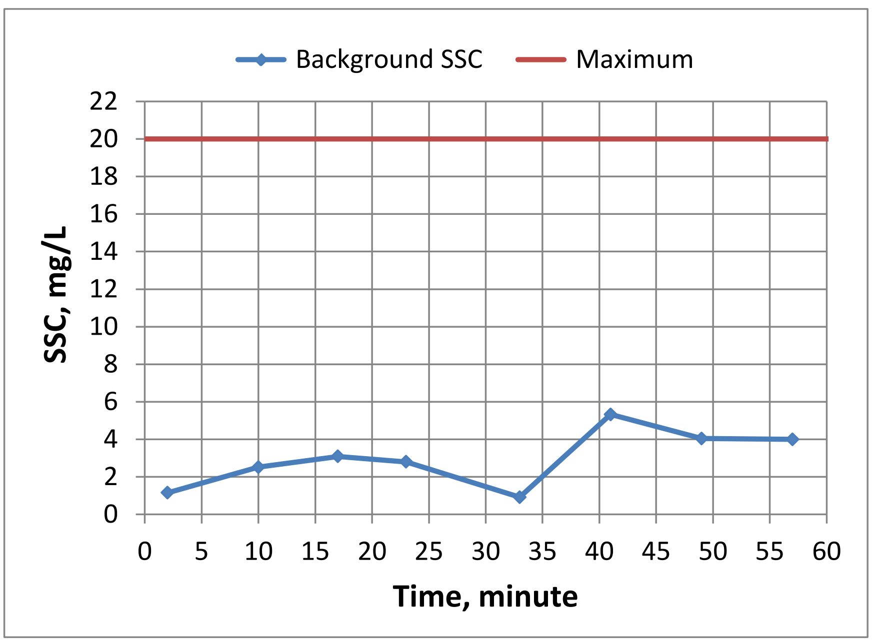


Figure A-9 Monitored Background SSC for 0.75 cfs Experiment

Table A-5 Summary of Results for 1.00 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	448.8	449.9	0.0059	445.3	456.6	0.25
NSBB Sediment Dosing Time, min	40.0					
Sediment Dosing Rate, gram/min	339.7	337.2	0.001	336.7	337.9	-0.74
Mean Influent SSC, mg/L	198.0					
Background SSC, mg/L	20 mg/L max.	4.7	0.26	3.0	7.0	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed	13,489	29.69		
Sediment Captured				
Chamber 1	7,943	17.49	81.4	58.9
Chamber 2	1,404	3.09	14.4	25.3
Chamber 3	416	0.91	4.3	10.0
Total	9,763	21.49	100.0	72.4

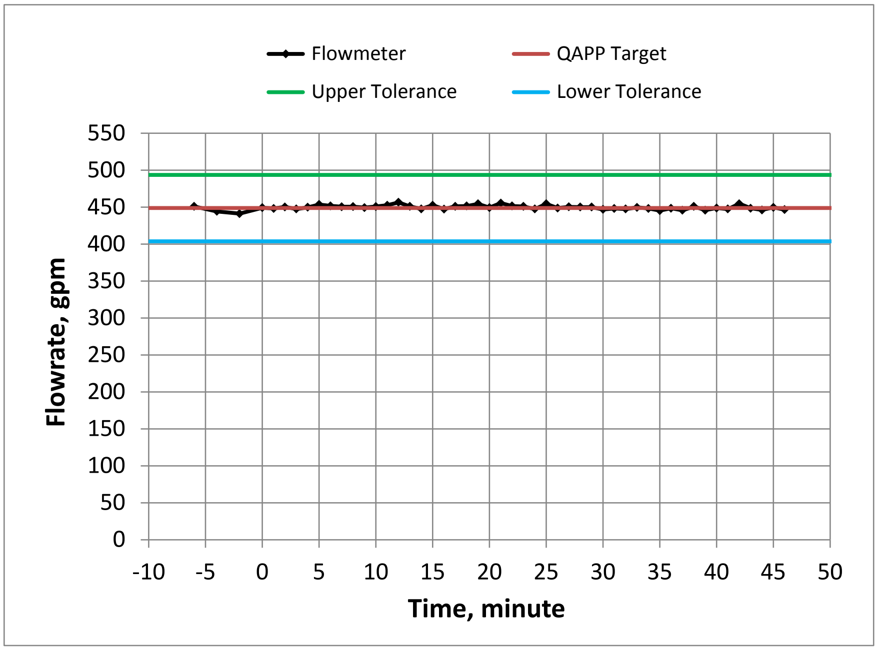
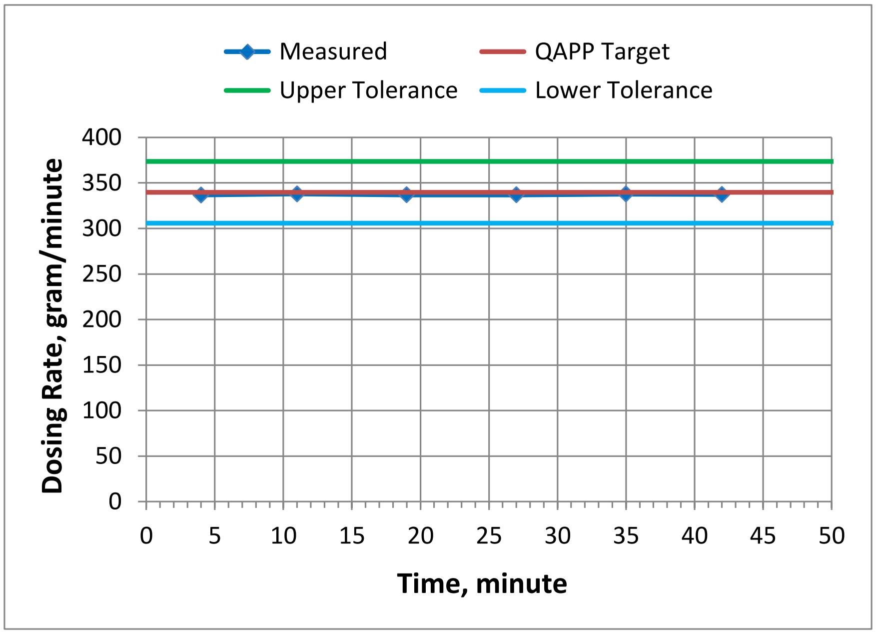


Figure A-10 Monitored Flow Rate for 1.00 cfs Experiment



A-11 Monitored Sediment Dosing Rate for 1.00 cfs Experiment

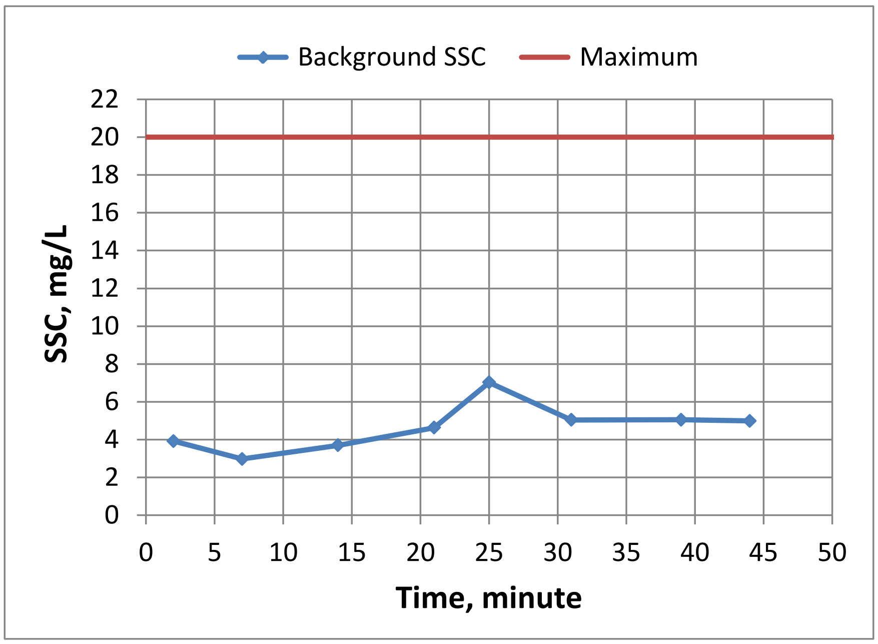


Figure A-12 Monitored Background SSC for 1.00 cfs Experiment

Table A-6 Summary of Results for 1.25 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	561	563.6	0.0060	556.4	570.8	0.47
NSBB Sediment Dosing Time, min	32.0					
Sediment Dosing Rate, gram/min	424.7	415.9	0.007	413.2	421.0	-2.07
Mean Influent SSC, mg/L	194.9					
Background SSC, mg/L	20 mg/L max.	13.4	0.47	4.0	24.4	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed	13,308	29.29		
Sediment Captured				
Chamber 1	7,277	16.02	77.0	54.7
Chamber 2	1,716	3.78	18.2	28.5
Chamber 3	456	1.00	4.8	10.6
Total	9,449	20.80	100.0	71.0

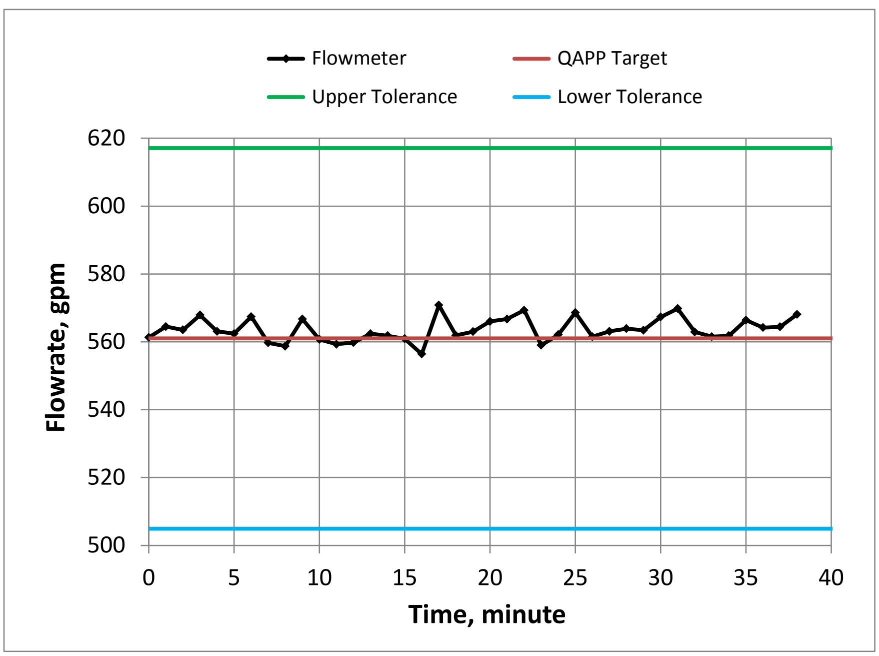


Figure A-13 Monitored Flow Rate for 1.25 cfs Experiment

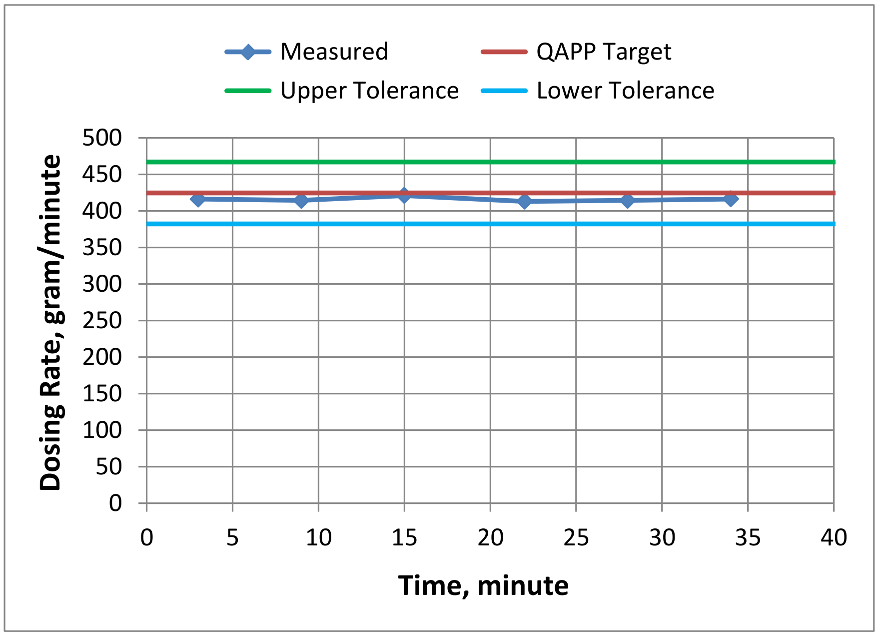


Figure A-14 Monitored Sediment Dosing Rate for 1.25 cfs Experiment

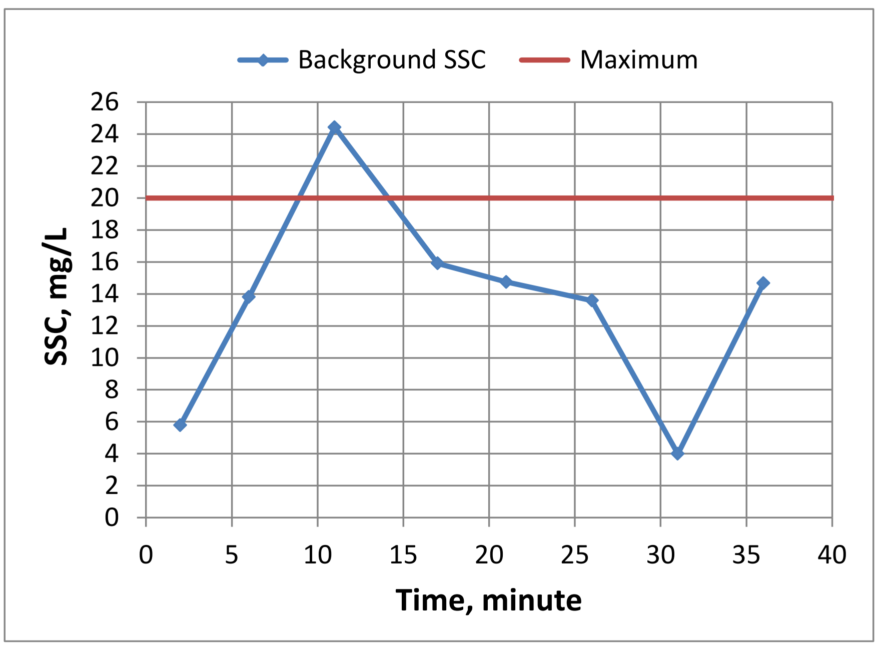


Figure A-15 Monitored Background SSC for 1.25 cfs Experiment

Table A-7 Summary of Results for 1.50 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	673.2	673.3	0.0076	665.7	689.3	0.02
NSBB Sediment Dosing Time, min	27.0					
Sediment Dosing Rate, gram/min	509.6	505.2	0.007	500.1	510.1	-0.86
Mean Influent SSC, mg/L	198.2					
Background SSC, mg/L	20 mg/L max.	5.9	0.33	2.1	8.2	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed	13,641	30.03		
Sediment Captured				
Chamber 1	7,206	15.86	76.6	52.8217613
Chamber 2	1,823	4.01	19.4	28.3261936
Chamber 3	376	0.83	4.0	8.15320012
Total	9,405	20.70	100.0	68.9

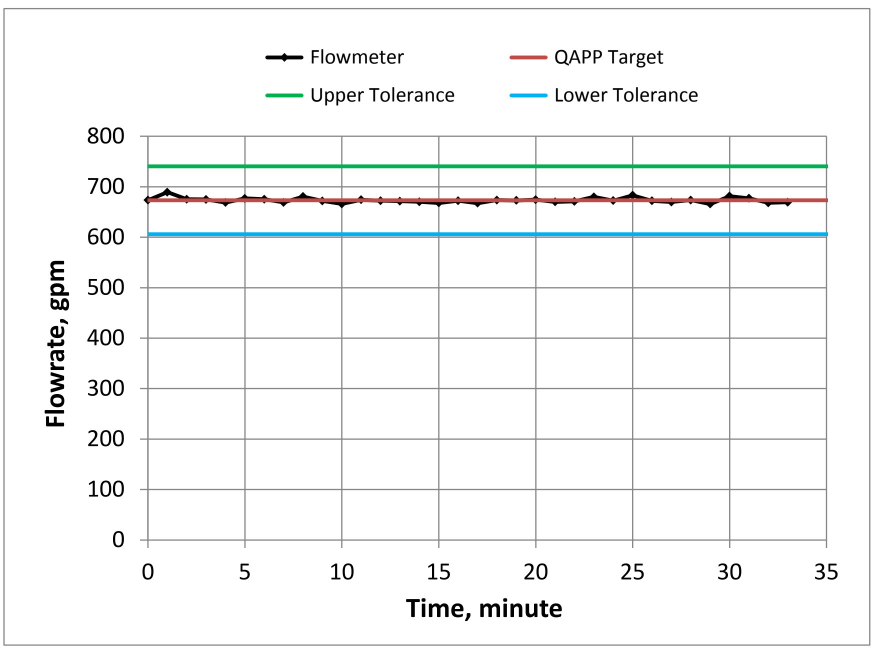


Figure A-16 Monitored Flow Rate for 1.50 cfs Experiment

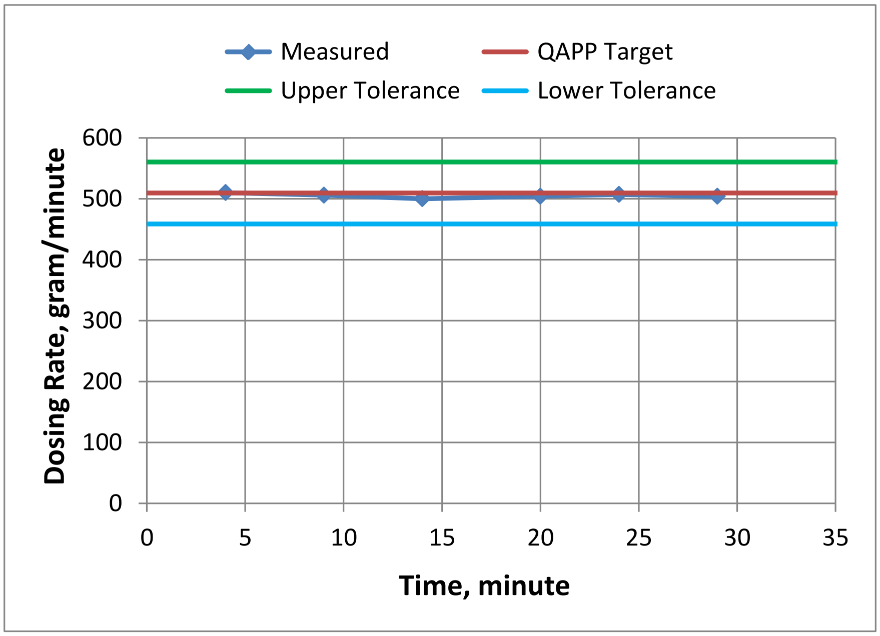


Figure A-17 Monitored Sediment Dosing Rate for 1.50 cfs Experiment

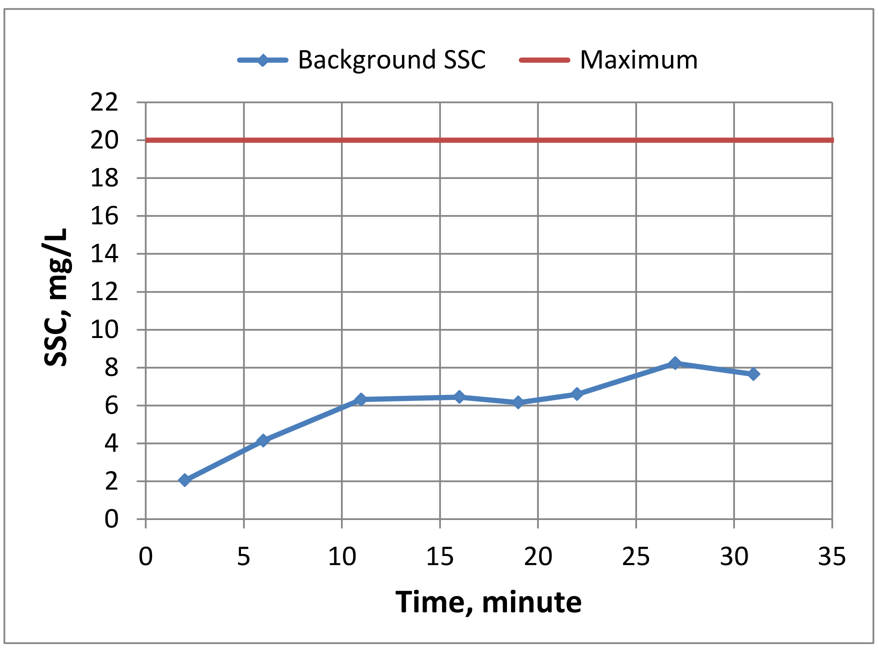


Figure A-18 Monitored Background SSC for 1.50 cfs Experiment

Table A-8 Summary of Results for 1.75 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	785.4	785.7	0.0062	775.9	795.4	0.04
NSBB Sediment Dosing Time, min	23.0					
Sediment Dosing Rate, gram/min	594.5	593.3	0.005	589.1	597.2	-0.20
Mean Influent SSC, mg/L	199.5					
Background SSC, mg/L	20 mg/L max.	8.9	0.30	3.7	12.0	

	gram	lbs.	% in chamber	% Removal Efficiency
Total Sediment Dosed to NSBB	13,647	30.04		
Sediment Captured				
Chamber 1	7,045	15.51	75.8	51.6
Chamber 2	1,883	4.14	20.2	28.5
Chamber 3	371	0.82	4.0	7.9
Total	9,299	20.47	100.0	68.1

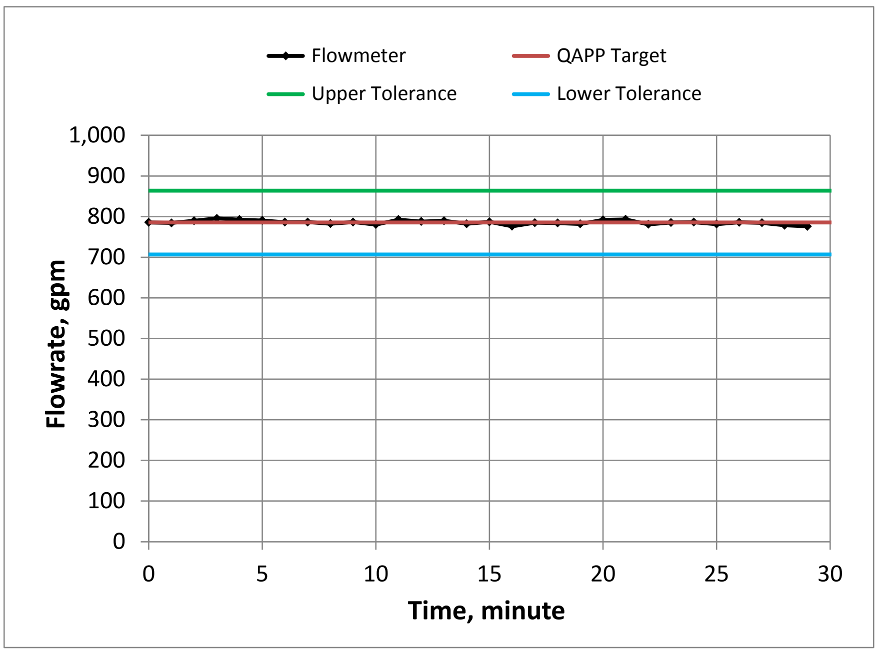


Figure A-19 Monitored Flow Rate for 1.75 cfs Experiment

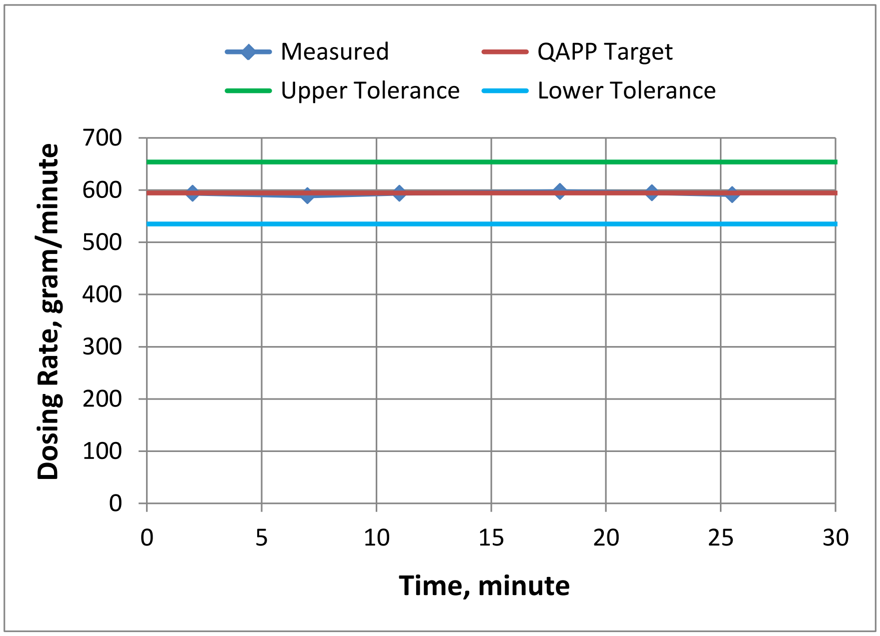


Figure A-20 Monitored Sediment Dosing Rate for 1.75 cfs Experiment

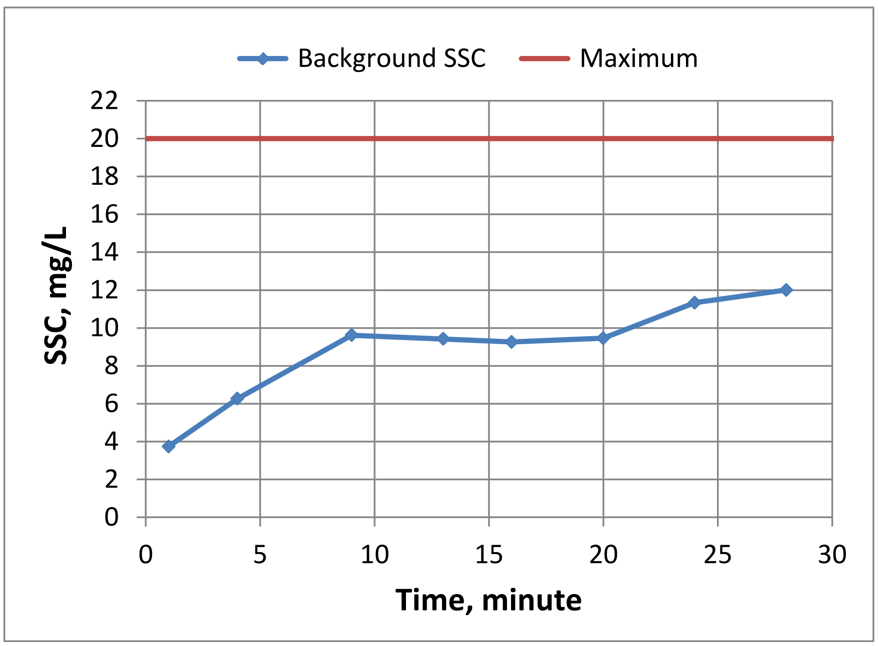


Figure A-21 Monitored Background SSC for 1.75 cfs Experiment

Table A-9 Summary of Results for 2.70 cfs Flow Rate Experiment

	Target	Experiment				Relative Error, %
		Mean	C.V.	Minimum	Maximum	
Flowrate, gpm	1211.8	1219.8	0.0057	1205.0	1235.0	0.67
Sediment Dosing Rate, gram/min	0.0					
Effluent SSC, mg/L	20 mg/L max.	4.8	0.19	3.2	6.6	
Background SSC, mg/L	-	4.4	0.29	2.6	6.6	

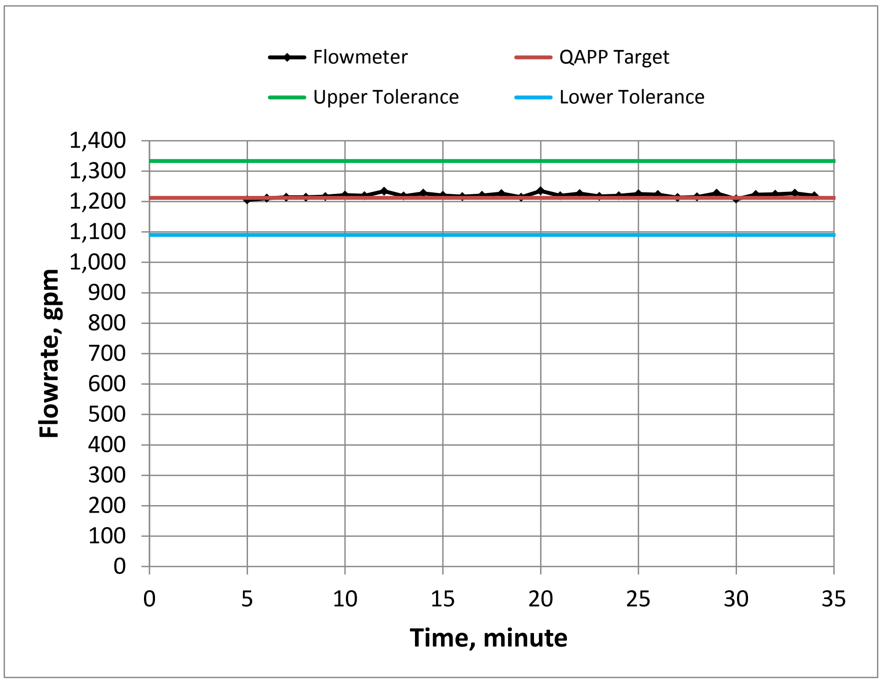


Figure A-22 Monitored Flow Rate for 2.70 cfs Experiment

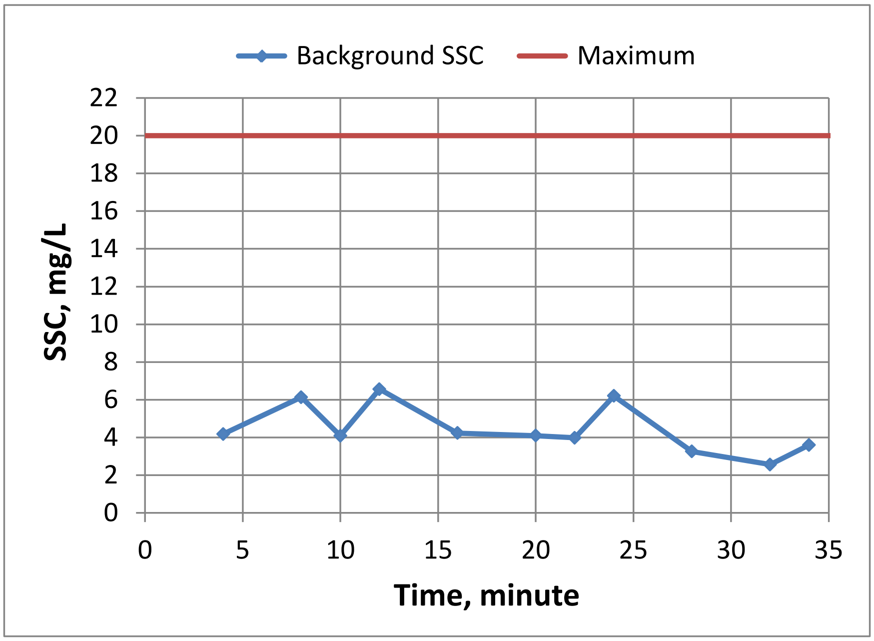


Figure A-23 Monitored Background SSC for 2.70 cfs Experiment

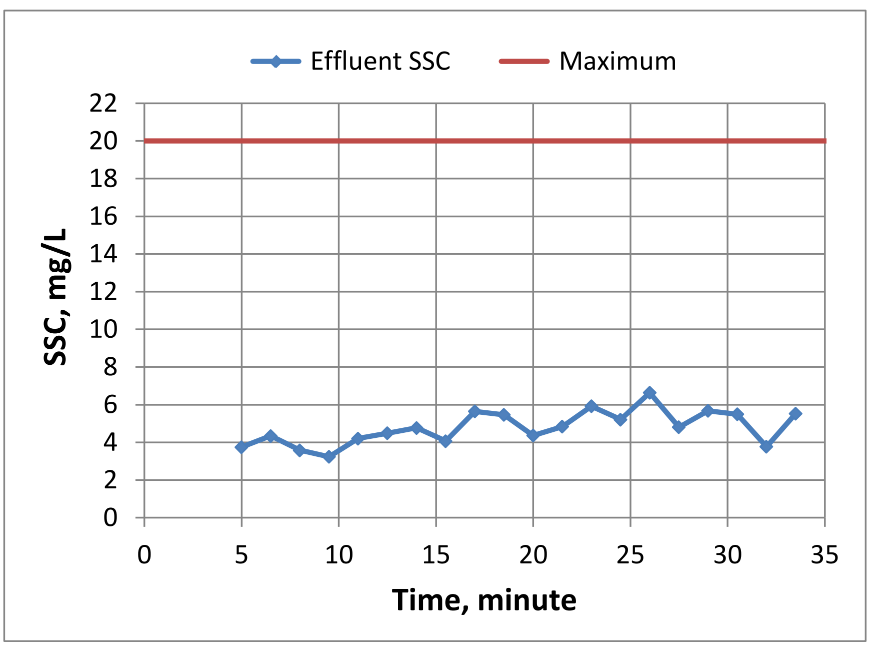


Figure A-24 Monitored Effluent SSC for 2.70 cfs Experiment