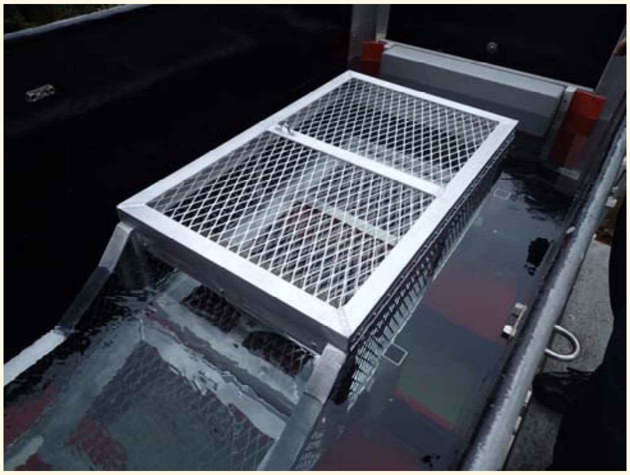
AET Tech

Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT)®

Treatment Capacity Verification

City of Indianapolis/Marion County Stormwater Management District

September 5, 2017



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AET Tech, Tampa, FL 33592-2250

Table of Contents

Page

Table of Contents i
List of Tables ii
List of Figures iii
Summary 1
Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) 2
Suntree Technologies Inc.® 6
Experimental System 8
    Test Facility 8
    NSBB-HVT 3-6 9
    System Configuration and Components 9
Removal Efficiency Evaluation 12
    Test Sediment 12
    Test Duration and Sampling Sequence 14
    Experimental Sequence 16
    Summary of Removal Efficiency Test at 1.35 cfs 16
    Flow Rate 16
    Sediment Dosing and Effective Dosed SSC 18
    Background Influent and NSBB-HVT Discharge SSC 18
    SSC Removal Efficiency 20
    MFR_{80} and Required Pollutant Capture 20
    Surface Loading Rate 21
    Sediment Recovery 21
Flow Rate Scaling of NSBB-HVT Product Line 22
Water Elevations Above Invert 24
Certification 27
References 28

Appendix A Nutrient Separating Baffle Box No. NSBB-HVT 3-6
Appendix B Volumetric Auger Feeder
Appendix C Test Sediment

List of Figures

Page

Figure 1 Nutrient Separating Baffle Box Schematic 2
Figure 2 NSBB-HVT Operation at Low to Medium Flows 5
Figure 3 NSBB-HVT Operation at High Flows 5
Figure 4 Schematic of Experimental System 10
Figure 5 Particle Size Distribution of 100 μm Sediment Samples 13
Figure 6 Comparison of 100 μm Sediment and OK-110 PSDs 13
Figure 7 Flow Rate in Removal Efficiency Test at 1.35 cfs 18
Figure 8 Sediment Dosing Rate in Removal Efficiency Test at 1.35 cfs 19
Figure 9 Discharge and Background SSC in Removal Efficiency Test at 1.35 cfs 19
Figure 10 Adjusted Discharge SSC in Removal Efficiency Test at 1.35 cfs 20
Figure 11 NSBB-HVT Removal Efficiency from 10 to 100% MFR_{80} 21
Figure 12 NSBB-HVT Water Elevations Above Invert.. 26

List of Tables

Page

Table 1 Nutrient Separating Baffle Box-HVT® Commercial Models.......................... 4
Table 2 NSBB-HVT 3-6 Specifications 9
Table 3 Characteristics of Removal Efficiency Test at 1.35 cfs MTFR..................... 14
Table 4 Template for Removal Efficiency Test at 1.35 cfs 15
Table 5 Removal Efficiency Test Summary 17
Table 6 MFR_{80} of NSBB-HVT Models.. 23
Table 7 Water Elevations Above Invert for NSBB-HVT Models 25

SUMMARY

The Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) is a manufactured stormwater quality unit (SQU) supplied by Suntree Technologies Inc.[1]. The NSBB-HVT reduces stormwater pollutant loadings by capturing sediments, gross solids, and associated pollutants. The treatment effectiveness of the NSBB-HVT was assessed through a definitive evaluation that quantified the suspended sediment removal efficiency under controlled conditions. The evaluation of NSBB-HVT followed a Quality Assurance Project Plan that was developed for this testing[7]. The testing was conducted according to the City of Indianapolis/Marion County evaluation criteria to verify the suspended sediment removal effectiveness of SQUs[2]. The criteria include verification of the maximum flowrate (MFR_{80}) at which the SQU can remove 80% of suspended sediment with a specified intrinsic density and particle size distribution.

Testing was conducted using a full-scale NSBB-HVT 3-6 with sedimentation area of 18 ft^2. Test sediment exceeded the testing requirement of Indianapolis/Marion County, with a finer particle size distribution than required (90.7 μm d_{50}; largest particle size of 125 μm). Suspended solids removal efficiency was quantified based on the effective concentration of suspended sediment dosed to the influent and the measured discharge SSC corrected for influent background SSC. The NSBB-HVT achieved 80.5% SSC removal efficiency at a flow rate of 1.35 cfs (606 gpm), equivalent to a Surface Loading Rate of 33.7 gallon/ft^2-min (0.075 ft^3/ft^3-sec). The removal efficiency test results established an MFR_{80} of 1.35 cfs for NSBB-HVT 3-6. The SSC removal efficiency ranged ranging from 80 to 88.2% for flow rates of 10 to 100% of MFR_{80}. MFR_{80} for the NSBB-HVT product line were calculated using scaling criteria of the City of Indianapolis/Marion County and water elevations above NSBB-HVT invert were developed for flow rates of 20 to 100% of MFR_{80}. At the conclusion of the removal efficiency test, sediments captured by the NSBB-HVT were removed, dried and weighed. Sediment mass recovery was 96.8%, which is highly acceptable considering the nature and scale of testing. To our knowledge, this NSBB-HVT removal efficiency test is the first submitted to Indianapolis/Marion County that provides a true mass balance confirmation of removal efficiency results. This NSBB-HVT test demonstrates that it is practically achievable to provide mass balance confirmation of SQU removal efficiency and mass balance should be mandatory for all SQU technology vendors.

Third party testing and verification was conducted at the AET Tech Test Facility, 10809 Cedar Cove Drive, Thonotosassa, Florida 33592-2250 under the direction of Dr. Daniel P. Smith, P.E., BCEE, President, AET Tech (Phone: 813-716-2262). Dr. Smith is a licensed Professional Engineer in Florida (PE #58388) and New Jersey (PE #24GE03765900). The need for *third-party testing* of stormwater treatment devices by qualified verification entities was cited by the STEPP working group of the Water Environment Federation[4]. The experimental testing conducted to verify MFR_{80} for the NSBB-HVT fully met the standards for true *Third Party Testing*. This contrasts with an in-house testing model in which the experiments and measurements are conducted by the manufacturer and where the observer may have limited experience and qualifications.

NUTRIENT SEPARATING BAFFLE BOX WITH HYDRO-VARIANT TECHNOLOGY (NSBB-HVT)

The Nutrient Separating Baffle Box-HVT is a subsurface rectangular vault MTD that is placed on-line in the stormwater collection system (Figure 1). The NSBB-HVT is

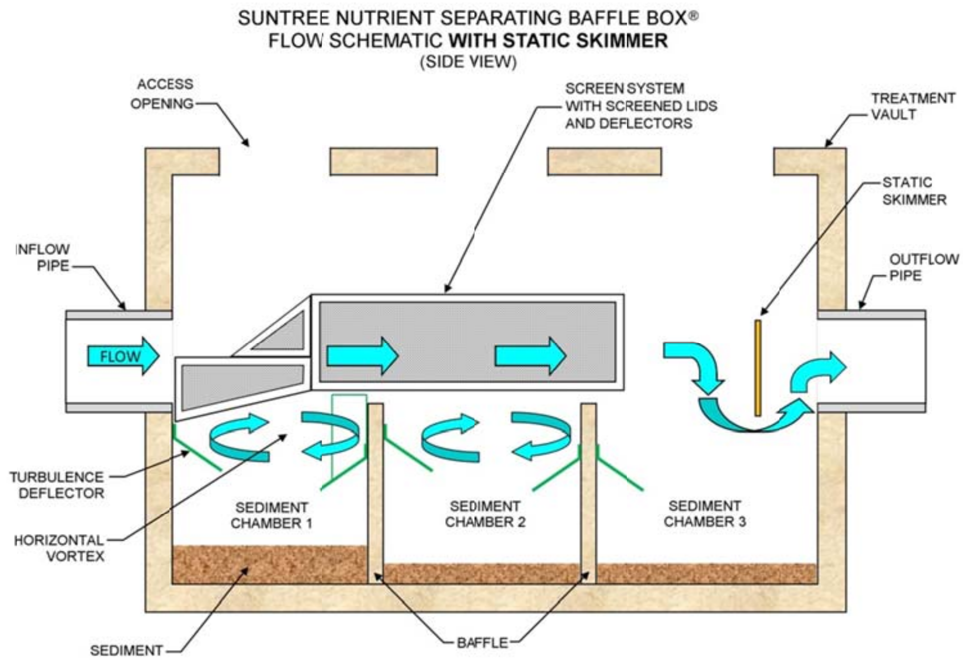

Figure 1 Nutrient Separating Baffle Box® Schematic

engineered to be able to remove solids from stormwater flowing through stormwater pipes and other types of water conveyances. NSBB-HVT treatment removes suspended sediment as well as larger floatable solids including foliage, detritus, and liter. Details of the NSBB-HVT can be found on the Suntree Technologies Inc. website (4). The NSBB-HVT is available in a range of commercial sizes, depending on watershed size, anticipated flowrates and other site factors. A list of commercial NSBB-HVT models is presented in Table 1. A drawing of a commercial NSBB-HVT model (NSBB-HVT 3-6) is included in Appendix A.

The NSBB-HVT vault is subdivided into a series of chambers by vertical baffles that extend from the bottom of the chamber to a common height (Figure 1). As water enters the NSBB-HVT the width of flow increases and the linear velocity decreases, making conditions more favorable for particle sedimentation. Multiple internal components are contained within the NSBB-HVT vault, with a primary objective of calming the water and enabling finer solids to settle out of the flow in the lower settling chambers. Deflectors in the NSBB-HVT settling chambers are strategically arranged and uniquely designed and sized to capture finer particles in the settling chambers, while preventing their resuspension during high flowing storm events. The deflectors create a horizontal vortex at the top of the first and second settling chambers, which is located above the deflectors and below the bottom of the screen system (Figure 1). This hydrodynamic characteristic enhances the ability of gravity to act on particles, enhancing their retention in the settling chambers. In addition, the deflector system isolates the sediments captured in the settling chambers from turbulence and limits the potential for re-suspension.

The NSBB-HVT also incorporates a basket screen that is located above the top of the chamber baffles (Figure 1). A primary objective of the internal screen is to collect and retain floatables such as foliage, liter and detritus. As flowrate declines, the water level in the NSBB-HVT decreases to its static level and the materials captured in the screen system are separated from the underlying water level . Screen-captured materials remain above and out of the water column during non-flow periods. The screen also retains finer sediment that is attached to the larger screen-captured solids, which can collect sediments through straining and filtration.

The unique hydraulic design of the NSBB-HVT provides *upper level conveyance* of flow in the region that lies above the chamber baffles. Upper layer stormwater flow does not have to pass through the screen system but can pass through the NSBB-HVT® vault by flowing around the screen. The horizontal cross sectional area of conveyance around the screen system is always sized to be equal to or greater than the conveyance area of the inflow and the outflow pipes. During high flows, when the water level may be higher than the top of the screen system, screened lids across the top of the screen system prevent floatables from escaping through overtopping and washout. In addition, specialized deflectors within the screen system prevent floatables from being lost through the screen's bypass, which is adjacent to the inflow. These unique hydraulic features enable the NSBB-HVT to be easily retrofitted to existing storm pipes with only a minimal headloss impact and without compromising the hydrology of the water shed.

The Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) is an evolution of the fixed-skimmer NSBB that contains a performance-enhancing feature called SkimBoss MAX (Figures 2,3). SkimBoss MAX is *a hydro-variant* skimmer that is located adjacent to the vault outflow. The SkimBoss MAX system automatically adjusts its level in response to stormwater flow and water level, providing a variant level hydraulic conveyance feature. During low to medium flows, the lower level of the SkimBoss Max system optimizes detention time and reduces turbulence in the vault to maximize the removal efficiency of finer particles (Figure 2). During high flows, when flooding may be a concern, SkimBoss MAX rises vertically to reduce the headloss of the treatment system and provide the higher conveyance that is needed (Figure 3). The SkimBoss MAX adjusts its height automatically with flowrate and water level; operator attention is not required.

Table 1 Nutrient Separating Baffle Box-HVT® Commercial Models

NSBB Model #	Inside Width, ft.	Inside Length, ft.	Baffle Height, in.	Sedimentation Area, ft^2
2-4-60	2	4	24	8.0
3-6-72	3	6	36	18.0
3-8-84	3	8	36	24.0
4-8-84	4	8	36	32.0
5-10-84	5	10	36	50.0
6-12-84	6	12	36	72.0
8-12-84	8	12	36	96.0
8-12-100	8	12	40	96.0
7-14-100	7	14	40	98
8-14-100	8	14	40	112
8-16-100	8	16	44	128
9-18-100	9	18	40	162
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

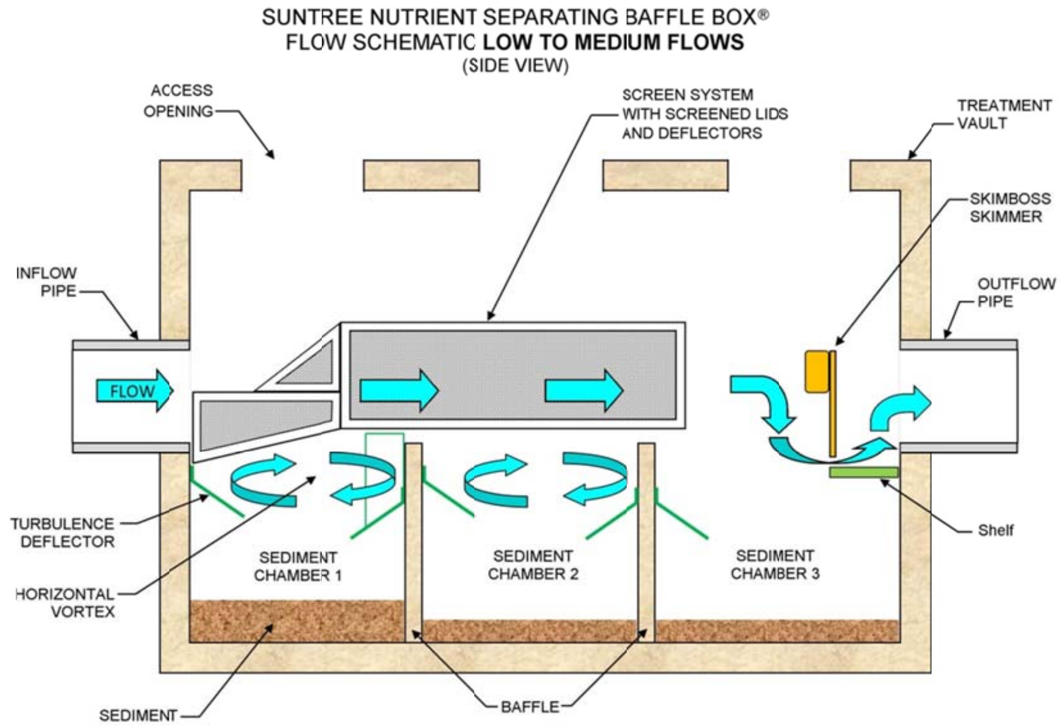

Figure 2 NSBB-HVT Operation at Low to Medium Flows

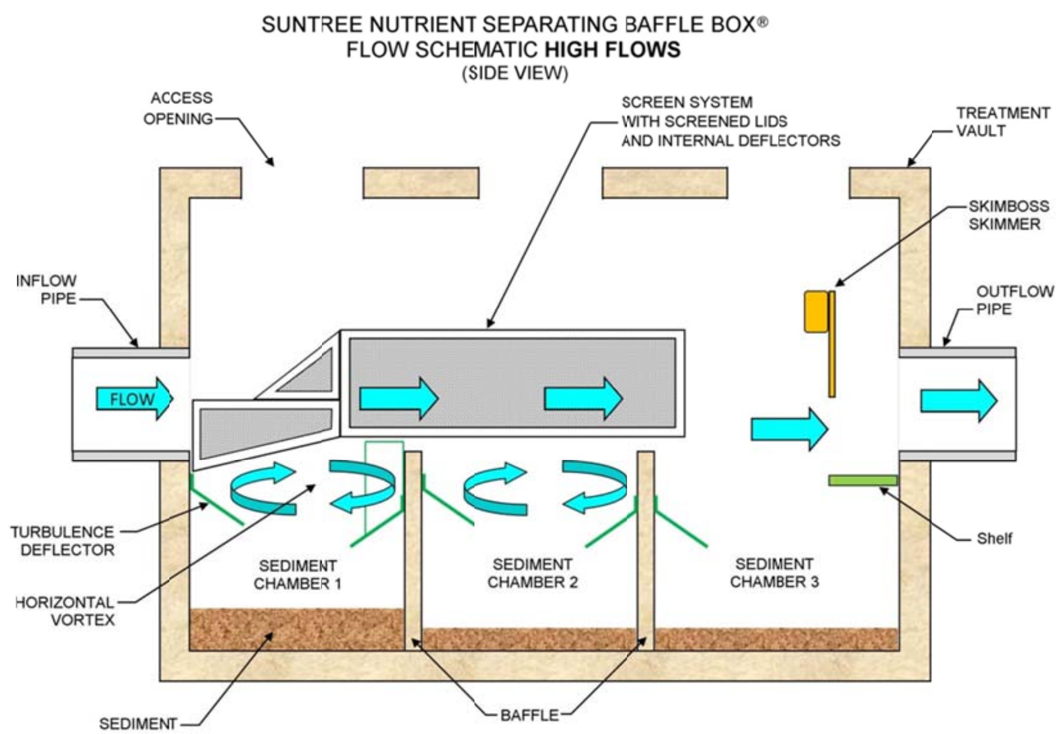

Figure 3 NSBB-HVT Operation at High Flows

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-HVT was installed in 1999, and NSBB-HVT® 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-HVT® 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 2,000 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-HVT 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 NSBB as a gross pollutant removal device prior to stormwater outfalls, application has since been expanded to a pretreatment option prior to underground detention, exfiltration fields, filtration systems, wetlands, 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-HVT®. The unique design of the Nutrient Separating Baffle Box-HVT results in minimal head loss through the treatment structure. As a result, the NSBB-HVT® can be installed in either an inline or offline configuration, making for an easy retrofit within existing water sheds. The Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) is an evolution of the NSBB that incorporates design features to enhance sediment removal performance.

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	9,534,368

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

NSBB-HVT vaults and specialized internal components are constructed of concrete, marine grade aluminum, stainless steel, and fiberglass. Structural components are designed to have a life span of many decades. The NSBB-HVT will typically last as long as the drainage system in which it is installed and is expected to perform as intended for at least 75 years without major overhall.

The vault that makes up the Nutrient Separating Baffle Box and the Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) 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 the Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT), 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 or the Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT).

EXPERIMENTAL SYSTEM

Test Facility Verification testing was conducted at the AET Tech Research Facility (AET-TF) in Hillsborough County, Florida. AET-TF is located on a 4-acre site that is dedicated to the evaluation of water treatment technologies, with electric power, water supply, shop and pilot support facilities, and an analytical laboratory.

The physical address is:

AET Tech LLC
10809 Cedar Cove Drive
Thonotosassa, Florida 33592-2250

The AET Tech contact is:

Dr. Daniel P. Smith, P.E., DEE, President
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Dr. Daniel Smith is President of AET Tech and an environmental and water resources engineer with over thirty years' experience in water quality, treatment and modeling. Dr. Smith received a Ph.D. in Environmental Engineering and Science from Stanford University and has taught at three universities. He is a registered Professional Engineer (P.E.) in Florida (#58388) and New Jersey (#24GE03765900) and a Diplomat and Board Certified Environmental Engineer (BCEE) of the American Academy of Environmental Engineers and Scientists (AAEES). Dr. Smith has previously conducted three NJCAT criteria verification studies at AET-TF, each of which has received NJCAT verification:

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.

Smith, D. (2013) Nutrient Separating Baffle Box: SWEMA Hydrodynamic Criteria Evaluation with 100 μm Sediment Particles. Submitted to New Jersey Corporation for Advanced Technology, Newark, New Jersey, May 30, 2013.

Smith, D. (2016) Nutrient Separating Baffle Box with Hydro-Variant Technology, NJDEP Hydrodynamic Criteria Evaluation, Submitted to New Jersey Corporation for Advanced Technology, Newark, New Jersey, March 28, 2016.

NSBB-HVT 3-6 Testing was conducted using the full-scale commercially available NSBB-HVT 3-6. Physical specifications of the NSBB-HVT 3-6 are summarized in Table 2. A drawing of the NSBB-HVT 3-6 is included in Appendix A.

Table 2 NSBB-HVT 3-6 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
Depth from bottom at 100% capture capacity, inch	12
Maintenance Sediment Storage Volume, ft^3	18.0
Depth from bottom at 50% capture capacity, inch	6
Screen box length, inch	51
Screen box width, inch	21

The Maintenance Sediment Storage Volume (MSSV) of the NSBB-HVT 3-6 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. For removal efficiency testing, a false floor was placed at 6 in. depth above the bottom of the chambers as an alternative to pre-loading of test sediment to the 6 in. depth.

System Configuration and Components The configuration of the experimental system is shown in Figure 4. The general configuration of the test system and individual components have been successfully used in previous NJCAT verification testing. The test system consisted of a NSBB-HVT 3-6 and Water Supply Recycle Reservoir (WSRR), connected by an influent pump (IP) that recycles water from the WSSR to the NSBB-HVT (Figure 4). The WSRR was pre-charged with AET-TF groundwater which was of circumneutral pH and virtually free of suspended sediment. Water was aerated and cleaned prior to testing. A valve for fine flowrate control was located downstream of the influent pump and was adjacent to an inline flow meter. This arrangement enabled a single operator to iteratively adjust flowrate to achieve and maintain target values. Water pumped from the WSRR was directed to a pre-chamber to reduce

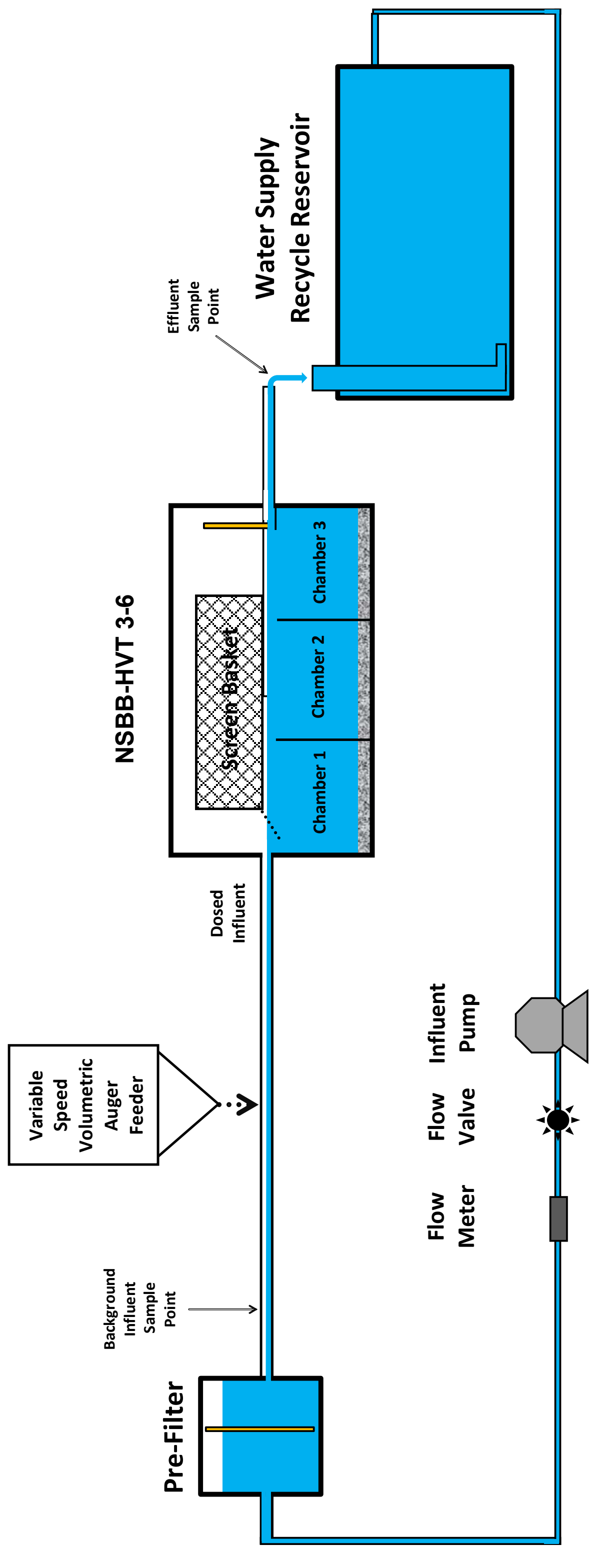


Figure 4 Schematic of Experimental System

Background SSC through media filtration. Background SSC was maintained below 20 mg/L through the duration of the entire test. Water exited the pre-chamber chamber and proceeded into and through the feed pipe that leads to the NSBB-HVT 3-6. Discharge from the pre-chamber chamber proceeded by gravity through the remainder of the test system. The feed channel was an 18 in. diameter pipe with an upper slot in the crown for background SSC sampling, sediment dosing, and visual observation. Test sediment was dosed into the feed pipe using a variable speed volumetric feeder that dispenses dry materials from a hopper at a selected mass rate (Model VF-2, IPM Systems, Lee's Summit, MO). The VF-2 employs a direct drive auger delivery system which is stated by the manufacture to provide feed rates that are accurate to within 2% (Appendix B; www.ipm-sys.com). The point of sediment dosing was 234.5 inch (> 10 pipe diameters) upstream from the NSBB-HVT entrance. NSBB-HVT 3-6 discharge entered a discharge channel and then proceed through a free pipe outfall into the WSRR. The discharge channel contained an open slot along the crown for visual observation. NSBB-HVT discharge samples were collected from the free pipe outfall by upward vertical sweep sampling along the horizontal centerline of flow. Sampling containers had a circular opening of 4 in. diameter and 0.5 gallon volume. Background SSC samples were collected from the 18 in. pipe downstream of the pre-filter and before sediment dosing using the same sampling containers that were used in discharge sampling. Background sampling was conducted by inserting a sample container into the pipe with opening facing upstream, with closed opening, rapidly opening and closing the container to a partially full volume, removing the container from the pipe flow, and screwing the threaded opening tightly. The vertical placement of background sample bottles placed the center of the opening at ca. two thirds of the depth of water depth in pipe. For all background and discharge samples, the determination of SSC used the entire collected sample volume (no sub-sampling).

The WSRR had a working volume of ca. 13,000 gallon and served to settle and remove suspended solids prior to recycling. Solids removal was aided by bottom horizontal entry the NSBB-HVT 3-6 of discharge and tangential withdrawal, which created a circular flow regime. These features was augmented by upper level withdrawal from a baffled WSRR sub-chamber. The reservoir temperature during the test was 79-80F.

Flow to the experimental system was provided by a John Deere diesel powered vacuum well point pump (Model 6VW-DJDST-45D-M or equivalent, Thompson Pump Co., Sarasota, FL), which has been employed previously. The pump was connected by 6 inch tubing to a PVC withdrawal pipe in the Water Recycle Reservoir that extended below the water surface. The pump has a variable speed control to adjust the flow rate. 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. Flowrate was measured with a Porta flow PTFM 1.0 Inline Portable Transit Time Flow Meter, which uses clamp-on ultrasonic sensors and has measurement accuracy within 1% (Germline Instruments Inc., Massena, N.Y.). Flow was recorded continuously during removal efficiency and resuspension testing at a frequency of one minute or less. The NSBB-HVT testing employed a new flowmeter and included calibration certificate.

The experimental system components were pre-tested individually and in combination prior to initiation of testing. Pre-testing included pump operability and capacity, flow controllability and measurement, sediment dosing, and the effectiveness of sediment removal by the WSRR and Pre-Filter.

REMOVAL EFFICIENCY EVALUATION

Test Sediment The test sediment was processed Fairmount Best Sand 110 (Appendix C), referred to as "100 μm sediment". Best Sand 110 is 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 implemented to narrow the PSD. 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.

Three composite samples of 100 μm sediment were assembled by collecting an equal mass of sediment from five randomly selected 5 gallon buckets, placing the sediment samples in a sealed dry container, and mixing. The three composite samples were transported to the laboratory for PSD analysis. PSD analyses were conducted by a certified laboratory (BTL Engineering Services, 5802 North Occidental Street, Tampa, FL 33614) according to ASTM D 422[5]. The PSDs of the three 100 μm sediment composite samples were in close agreement as shown in Figure 5. The d_{50} of three 100 μm composites were 87.2, 92.5 and 92.4 μm, with a mean d_{50} of 90.7 μm. The BTL laboratory reports are included in Appendix C.

The mean PSD of 100 μm sediment is plotted in Figure 6. Also shown in Figure 6 is the PSD of OK-110, which is based on the OK-110 data sheet contained in Appendix C. OK-110 is specified in the testing criteria of the City of Indianapolis/Marion County[2]. As seen in Figure 6, 100 μm sediment has a finer PSD than that of OK-110. Use of the 100μm sediment would therefore provide a more rigorous removal efficieny test that using OK-110 (which is no longer available).

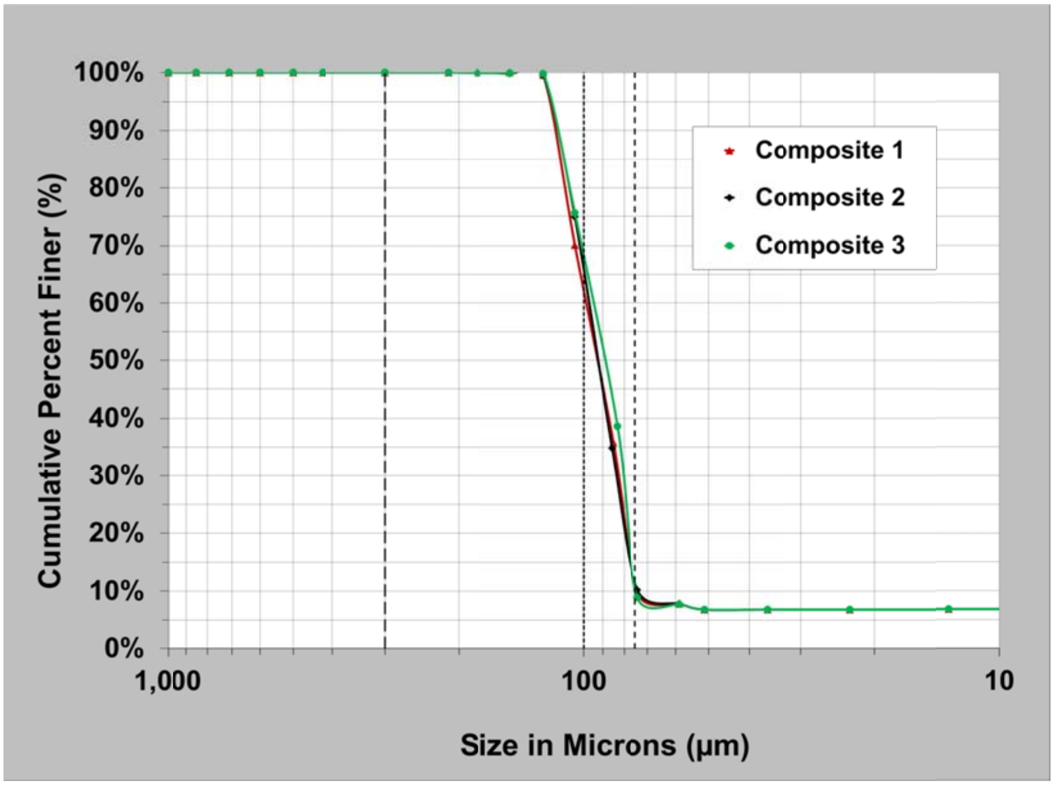


Figure 5 Particle Size Distribution of 100 μm Sediment Samples

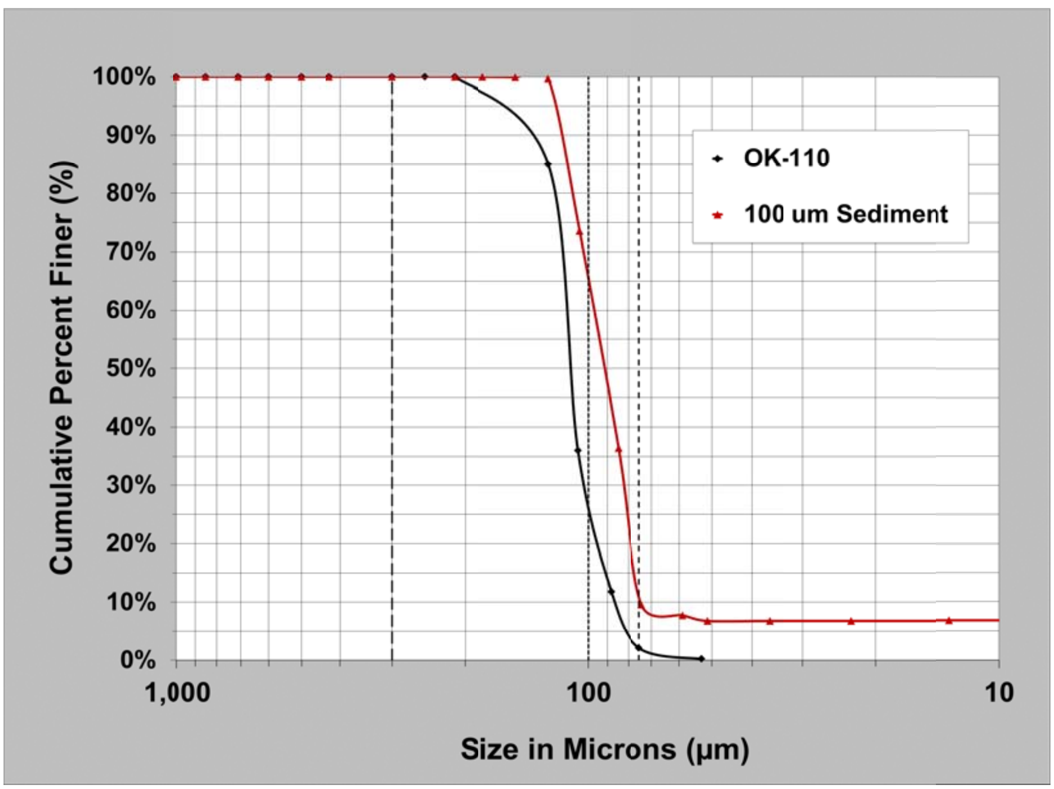


Figure 6 Comparison of 100 μm Sediment and OK-110 PSDs

Test Duration and Sampling Sequence Removal efficiency test characteristics at an example test flow rate of 1.35 cfs are listed in Table 3. The test duration was 44 minutes at target flow rate of 606 gallon per minute and sediment dosing rate of 449 gram per minute. A test template with sample times is shown in Table 4. Effluent sampling was conducted only after a minimum of three hydraulic residence times elapsed after the end of each sediment dose sampling event of one minute duration.

Table 3 Characteristics of Removal Efficiency Test at 1.35 cfs MTFR

Flow Rate, cfs	1.35
Flow Rate, gallon/minute	606
Surface Overflow rate, cfs/ft^2	0.0750
Surface Overflow rate, gallon/ft^2-min.	33.7
Hydraulic Residence Time, min	0.67
Sediment Dose Rate, g/min	459
Duration, min	44

Table 4 Template for Removal Efficiency Test at 1.35 cfs

AET Tech Research Facility (AET-RF)
NSBB-HVT 3-6

08/16/17

Event	Test Time, minute	Sediment Dose	Background SSC	Discharge SSC
Pump On	-6			
	-4			
	-2			
Initiate Sediment Dosing	0			
	1	1		
	2			
	3			
	4		1	1
	5			
	6			2
	7			
	8		2	3
	9	2		
	10			
	11			
	12			4
	13			
	14		3	5
	15			
	16			6
	17	3		
	18			
	19			
	20		4	7
	21			
	22			8
	23			
	24		5	9
	25	4		
	26			
	27			
	28			10
	29			
	30		6	11
	31			
	32			12
	33	5		
	34			
	35			
	36		7	13
	37			
	38			14
	39			
	40		8	15
	41	6		
	42			
Pump Off	43			

Experimental Sequence The experimental sequence was:

- Prepare SSC filters on by rinsing, drying, cooling, and measuring tares
- Prepare and label all sample containers
- Tare sediment dose containers
- Clean NSBB-HVT 3-6 and conveyance channel
- Add sediment to top off sediment feeder
- Measure water temperature in WSRR
- Place all sample bottles with closed lids into appropriate positions
- Start influent pump and adjust and stabilize flow rate
- Initiate sediment dosing and record start time
- Initiate experimental timing for synoptic sampling
- Operate at steady flow and sediment dosing test duration
- Record flowrate at least once per minute over duration of test
- Perform six sediment dosing measurements, spaced evenly over test duration
- Collect fifteen discharge samples evenly spaced over test duration
- Collect eight background influent samples at the same time as every other discharge sample
- Turn off sediment feeder
- Turn off water pump
- Clean and close up all system components
- Weight sediment dose samples
- Perform SSC analyses on samples
- Quantify mass of captured sediment

Summary of Removal Efficiency Test at 1.35 cfs Salient metrics of the removal efficiency test and results are summarized in Table 5.

Flow Rate The flow rate was continuously logged and manually monitored once per minute. Flow rate is plotted in Figure 7. The mean flow rate of 604.7 gallon per minute was within 0.2% of the target flow rate, with a Coefficient of Variation (COV = standard deviation/mean) of 0.009.

Table 5 Removal Efficiency Test Summary

AET Tech Research Facility (AET-RF)
Indianapolis/Marion County

Test Results 8/16/2017

Flow Rate, cfs	1.35			
Flow Rate, gpm	606			
Sediment Dose Rate, g/min	459			
	Target	Mean	C.V.	% Relative Error
Flowrate, gpm	605.9	604.7	0.009	-0.20
Sediment Dosing Rate, gram/min	458.7	473.2	0.006	3.18
Effective SSC Dose, mg/L	200.0	206.8		3.39
	Mean	Maximum		
Background SSC, mg/L	0.88	2.0		
	Mean			
Discharge SSC, mg/L	41.2			
Corrected Discharge SSC, mg/L	40.4			
	%			
SSC Removal Efficiency	80.5			
	minute			
Total Time of Sediment Dosing Period	42.8			
Total Time of Sediment Sampling	6.0			
Time of Sediment Dosing to NSBB-HVT	36.8			
	gallon			
Total dosed volume	22,252			
Sediment Mass Balance				
	gram	lbs.		
Total Sediment Dosed	20,255	44.58		
Sediment Sampled	2,839	6.25		
Net Sediment Dose to NSBB-HVT	17,415	38.33		
Sediment Captured in NSBB-HVT	13,460	29.63		
Sediment in Discharge	3,399	7.48		
Sediment Captured + Discharged	16,859	37.11		
% Mass Recovery	96.8			

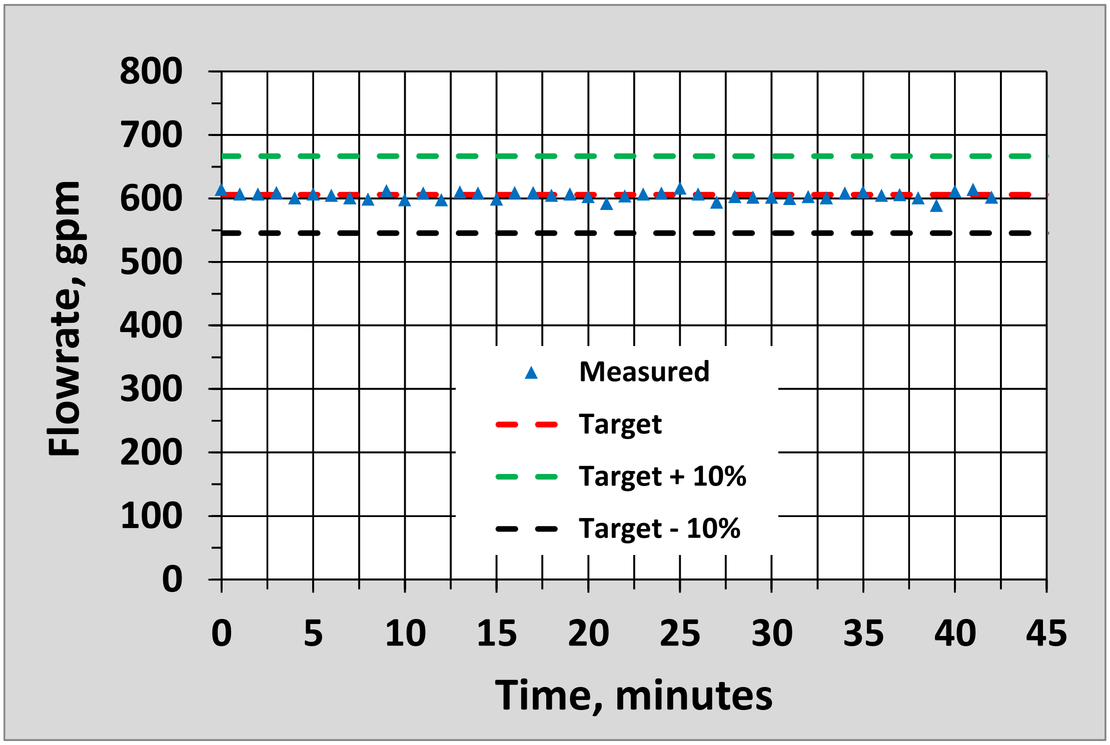


Figure 7 Flow Rate in Removal Efficiency Test at 1.35 cfs

Sediment Dosing and Effective Dosed SSC The sediment dosing rate was measured six times over the period of sediment dosing. The measurement of sediment mass addition rate was conducted by placing a clean, dry and tared sediment collection container in the outlet channel of the volumetric feeder and collecting 100% of dosed solids for exactly 60 seconds. Sediment mass addition rates were calculated using Equation 1. Sediment dosing rate is plotted in Figure 8. The mean sediment dosing

$$\text{Sediment mass added/time} = \text{Mass collected} \div \text{Collection time} \qquad \text{Eq. 1}$$

rate was 473.2 gram/minute, with a COV of 0.006. The effective dosed SSC was 206.8 mg/L as calculated using Equation 2. The low COV of both measured flow rate and measured sediment dosing rate indicate that the experimental procedures that were employed provided the conditions for a valid SSC removal efficiency test.

$$\text{Effective Dosed SSC} = \frac{\text{Sediment mass added/time}}{\text{Volume of water/time}} \qquad \text{Eq. 2}$$

Background Influent and NSBB-HVT Discharge SSC The SSC concentrations in background and NSBB-HVT discharge are plotted in Figure 9. The mean and maximum background SSC were 0.88 and 2.0 mg/L respectively. Background SSC was well below the level of 20 mg/L that is a considered a maximum level for a valid removal efficiency test. Background SSC was very consistent and enabled time-interpolation of background SSCs values between samples. NSBB-HVT discharge SSC had a mean value of 41.2 mg/L and ranged from 22.9 to 53.8 mg/L (Figure 9).

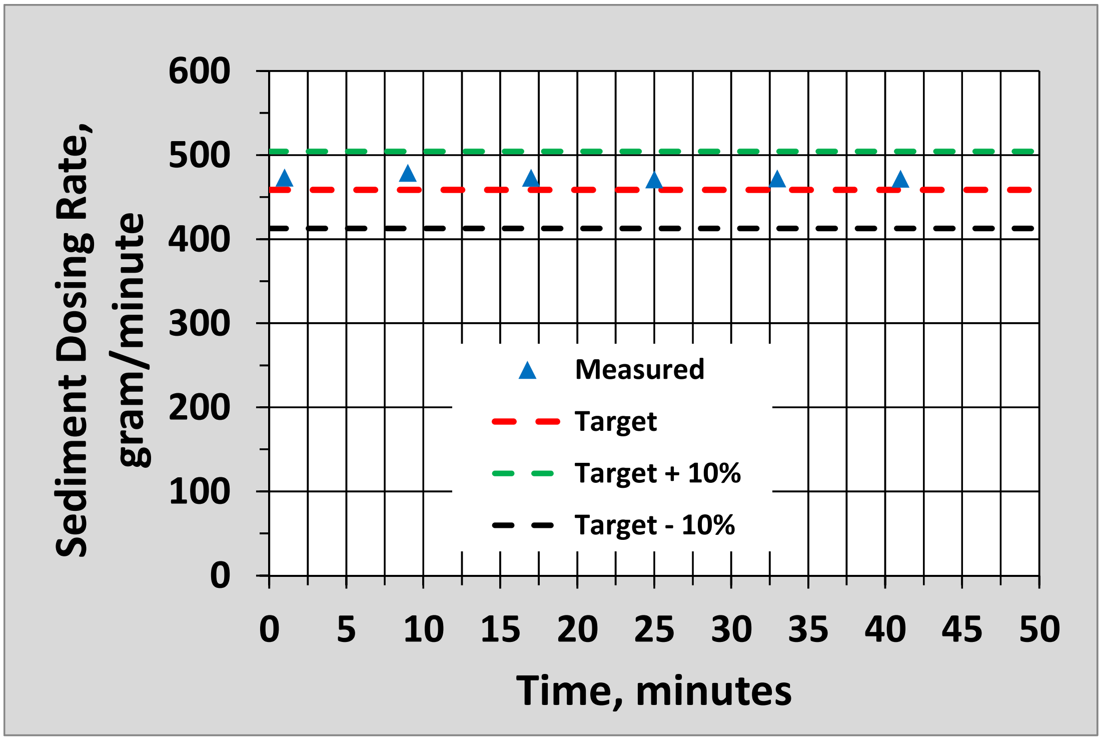


Figure 8 Sediment Dosing Rate in Removal Efficiency Test at 1.35 cfs

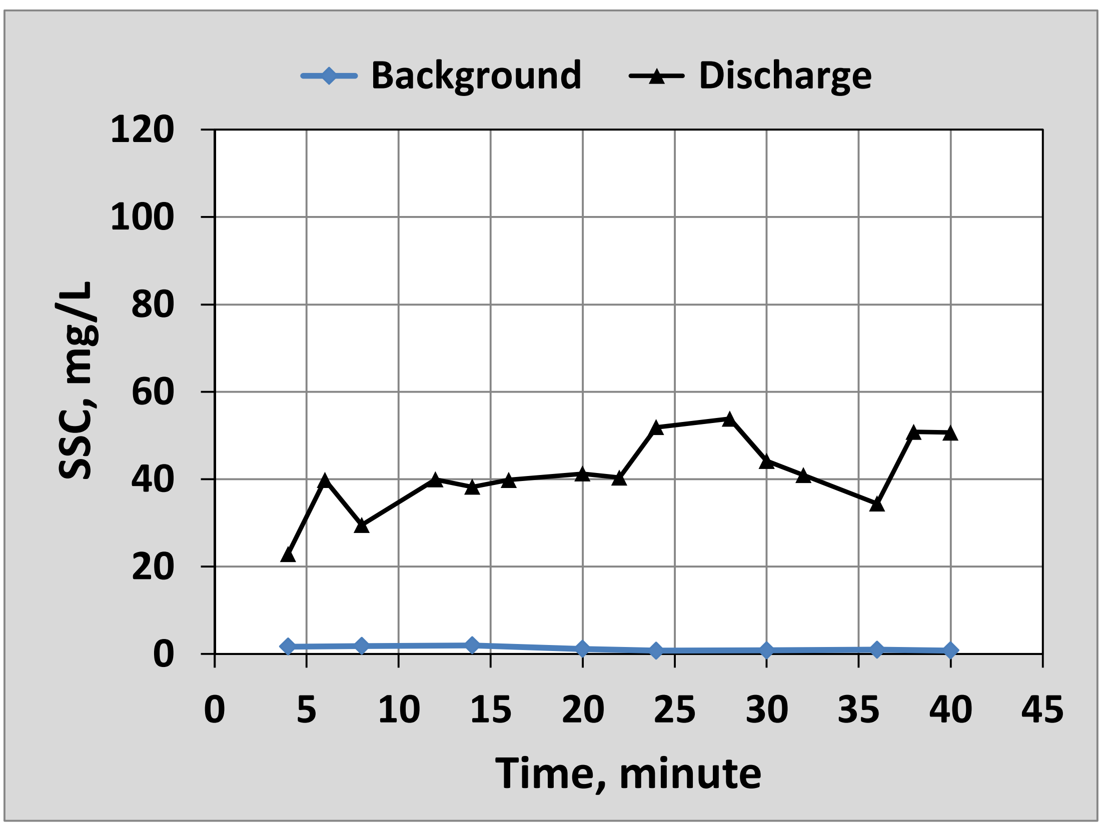


Figure 9 Discharge and Background SSC in Removal Efficiency Test at 1.35 cfs

SSC Removal Efficiency Adjusted discharge SSC was calculated by subtracting background SSC from the measured discharge SSC, where background SSC was the measured SSC at the same time as the discharge SSC sample or a background SSC calculated by linear time-interpolation at the discharge sample time. Adjusted NSBB-HVT discharge SSC had a mean value of 40.4 mg/L and ranged from 21.2 to 53.4 mg/L (Figure 10). Adjusted discharge SSC closely followed the measured discharge SSC due to the low background SSC concentrations measured throughout the test. SSC removal efficiency (RE) was calculated by Equation 3:

$$\mathrm{RE}\ (\%) = \frac{\text{Effective Dosed Influent SSC} - \text{Mean Discharge SSC}}{\text{Effective Dosed Influent SSC}}\ \mathrm{x}\ 100 \qquad \text{Eq. 3}$$

The SSC removal efficiency of NSBB-HVT 3-6 was 80.5% at a flow rate of 1.35 cfs.

$\mathbf{MFR_{80}}$ and Required Pollutant Capture The Indianapolis/ Marion County *BMP Testing Criteria* requires determination of maximum flow rate that achieves an 80% removal efficiency of 110 μm d_{50} sediment. The MFR_{80} of NSBB-HVT 3-6 is 1.35 cfs, at which flow rate NSBB-HVT 3-6 achieved 80% removal of 110 um d_{50} sediment. The removal efficiency for 110 μm d_{50} sediment was estimated for flow rates of 10 to 100% of MFR_{80} using a previously developed correlation (7). Removal efficiencies range from 80 to 88.2% and decrease monotonically with increasing flow rate (Figure 11).

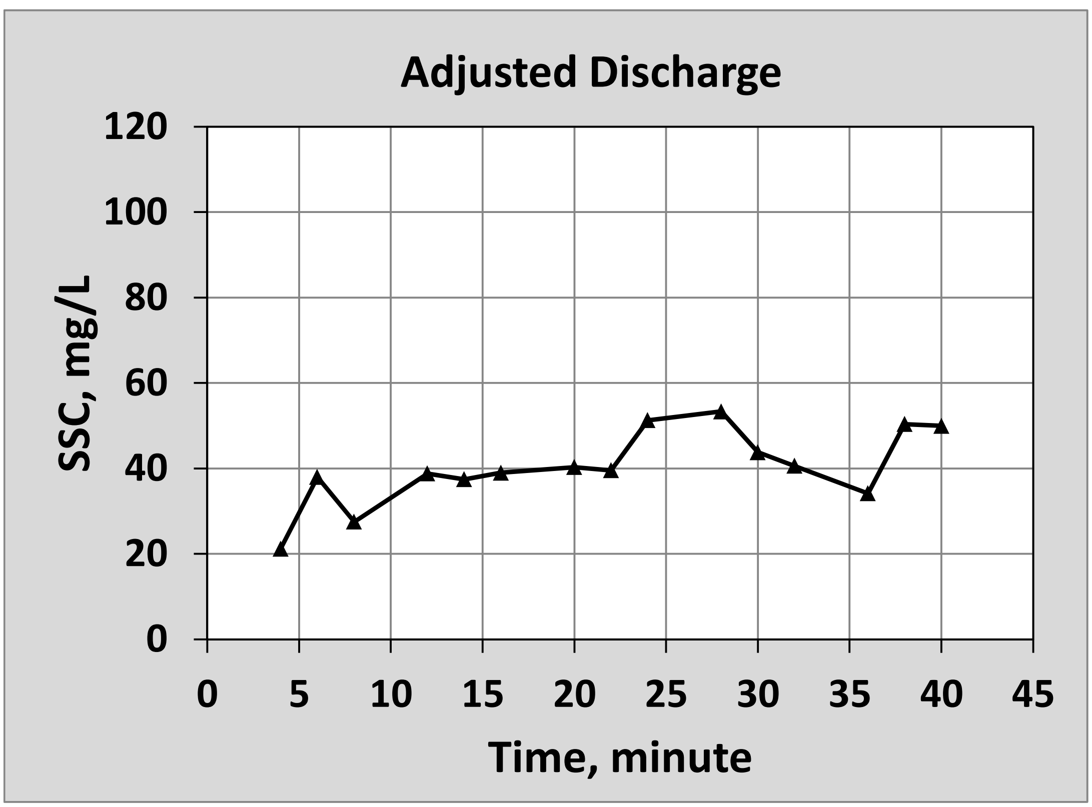


Figure 10 Adjusted Discharge SSC in Removal Efficiency Test at 1.35 cfs

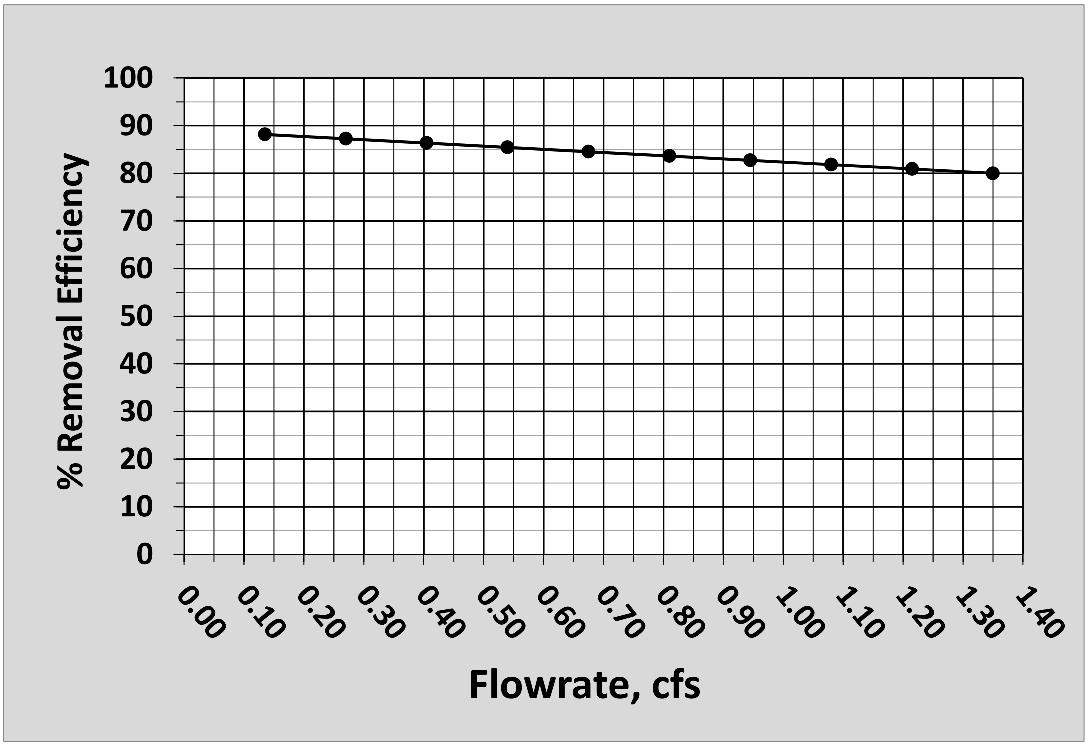


Figure 11 NSBB-HVT Removal Efficiency from 10 to 100% MFR_{80}

Surface Loading Rate At the 80% SSC removal efficiency flow rate (MFR_{80}), the surface loading rate (flow rate per sedimentation area) to the NSBB-HVT 3-6 is 1.35 cfs/18 ft^2, or 0.0750 cfs/ft^2 (33.7 gal./ft^2-min).

Sediment Recovery The mass of sediment captured by the NSBB-HVT was quantified at the end of the removal efficiency test. The NSBB-HVT chambers were partially drained and sediments that had accumulated in the influent pipe were flushed into NSBB-HVT Chamber 1. All sediment was removed from the chambers and passed through tared filters which were then dried to determine the total dry mass of captured sediment. The mass of sediment captured by NSBB-HVT 3-6 was 13,460 grams (Table 5). A mass balance calculation was performed using Equation 4.

$$\text{Net Dosed Mass} = \text{Volume x Discharge SSC} + \text{Mass Captured} \qquad \text{Eq. 4}$$

The net dosed mass of sediment was determined as the total sediment mass dosed over the 42.8 minute dosing period corrected for the sediment mass collected during the six one minute dosing rate samplings. The discharge sediment mass was calculated as the product of the treated volume and mean adjusted discharge SSC, where treated volume was corected for the six one minute sediment dose samplng periods (Table 5). The mass balance calculation for the removal efficiency test yielded a sediment mass recovery of 96.9%, which is considered highly satisfactory considering the size and magnitude of the testing.

FLOW RATE SCALING OF NSBB-HVT PRODUCT LINE

Dimensions of the NSBB-HVT product line are listed in Table 1. The *BMP Testing Criteria*[2] Appendix II applied the sedimentation surface area of NSBB-HVT as the basis of flow rate scaling. Flow rate scaling is presented in Table 6. NSBB-HVT models were scaled from the maximum treatment flow rate of 1.35 cfs to NSBB-HVT 3-6 for 80% removal of 110 μm d_{50} sediment (MFR_{80}). Scaling used the following equation from *BMP Testing Criteria*[2] Appendix II:

$$Flow\ Rate_{Model} = Flow\ Rate_{Prototype}\ x\ \frac{Model\ Diameter}{Prototype\ Diameter}^{2.5} \qquad \text{Eq. 5}$$

To apply Eq. 5, its circular-based SQU geometry was adapted to the rectangular geometry of NSBB-HVT using surface area. For circular SQU, the surface area is proportional to the square of the diameter:

$$Surface\ Area_{Circ.\ Model} = Surface\ Area_{Circ.\ Prototype}\ x\ \left[\frac{Model\ Diameter}{Prototype\ Diameter}\right]^{2.0} \qquad \text{Eq. 6}$$

Combining Eqs. 5 and 6 give equivalent scaling for the rectangular NSBB-HVT:

$$Flow\ Rate_{Model} = Flow\ Rate_{Prototype}\ x\ \left[\frac{Surface\ Area_{Model}}{Surface\ Area_{Prototype}}\right]^{1.25} \qquad \text{Eq. 7}$$

The MFR_{80} for each NSBB-HVT model, scaled with Eq. 7, are listed in Table 6. MFR_{80} of NSBB-HVT models increase with increasing surface area. Geometric scaling of NSBB-HVT models has been previously presented[7].

Table 6 MFR_{80} of NSBB-HVT Models

NSBB-HVT Model No.	Inside Length (L), ft	Inside Width (W), ft	Treatment Zone Depth (D), ft	Settling Area, ft^2	MFR_{80}, cfs
3-6	**6.0**	**3.0**	**1.00**	**18**	**1.35**
2-4	4.0	2.0	0.60	8	0.49
3-8	8.0	3.0	1.14	24	1.93
4-8	8.0	4.0	1.25	32	2.77
5-10	10.0	5.0	1.50	50	4.84
6-12	12.0	6.0	1.80	72	7.64
6-13.75	13.8	6.0	2.20	83	9.1
7-14	14.0	7.0	2.00	98	11.2
7-15	15.0	7.0	2.20	105	12.2
8-14	14.0	8.0	2.30	112	13.3
8-16	16.0	8.0	2.30	128	15.7
9-18	18.0	9.0	2.60	162	21.0
10-17	17.0	10.0	2.90	170	22.4
10-20	20.0	10.0	2.90	200	27.4
12-21	21.0	12.0	3.50	252	36.6
12-24	24.0	12.0	3.50	288	43.2

WATER ELEVATIONS ABOVE INVERT

A predictive discharge equation for NSBB-HVT 3-6 based on the measured water elevation difference between the upstream water surface and horizontal shelf, the area of the flow constriction, and a discharge coefficient[7]:

$$Q = C_d \ A \ (2 \ g \ (h_{upstream} - D_{shelf})^{0.50} \qquad \text{Eq. 8}$$

where Q = NSBB-HVT discharge, C_d = discharge coefficient, A = area of flow constriction, g = gravitational constant, $h_{upstream}$ = NSBB-HVT water elevation upstream of SkimBossMax, and D_{shelf} = elevation of horizontal shelf underlying SkimBossMax. Measured water elevations were used for $h_{upstream}$ and D_{shelf} equals the elevation of the horizontal shelf (1.625 in below inlet invert in NSBB-HVT 3-6). The constriction area equals the constriction width multiplied by the constriction height. Constriction width equaled the internal width of the NSBB-HVT 3-6 minus the track displacements on each side of SkimBossMax. Constriction height equaled the difference between the SkimBossMax bottom elevation and the top of the horizontal shelf, with a flow convergence correction factor applied for height less than 1 in. Eq. 8 was used to calculate discharge/water elevation relationships for the entire NSBB-HVT product line. For each NSBB-HVT model, water elevations ($h_{upstream}$) were derived for flow rates of 20, 40, 60, 80, and 100% of MFR_{80}. D_{shelf} was 1.625 in. below inlet invert for all models and C_d of 0.46 was used in all simulations. Water elevation/discharge relationships for the NSBB-HVT product line are summarized in Table 7.

Table 7 Water Elevations Above Invert for NSBB-HVT Models

NSBB-HVT Model No.	Flow Rate % of MFR_{80}				
	20	40	60	80	100
2-4	9.92	10.41	10.80	11.14	11.46
3-6	13.22	13.86	14.36	14.81	15.23
3-8	13.54	14.16	14.80	15.38	15.92
4-8	15.11	15.78	16.37	16.93	17.46
5-10	18.46	19.21	19.98	20.67	21.31
6-12	18.67	19.51	20.42	21.23	22.00
6-13.75	18.68	19.77	20.79	21.72	22.58
7-14	18.68	19.84	20.88	21.84	22.73
7-15	18.68	19.99	21.10	22.12	23.07
8-14	23.51	24.62	25.66	26.61	27.49
8-16	23.51	24.90	26.08	27.14	28.14
9-18	23.66	25.23	26.55	27.75	28.88
10-17	23.60	25.11	26.38	27.54	28.62
10-20	28.56	30.29	31.74	33.06	34.29
12-21	28.68	30.51	32.06	33.47	34.78
12-24	28.91	30.96	32.71	34.30	35.79

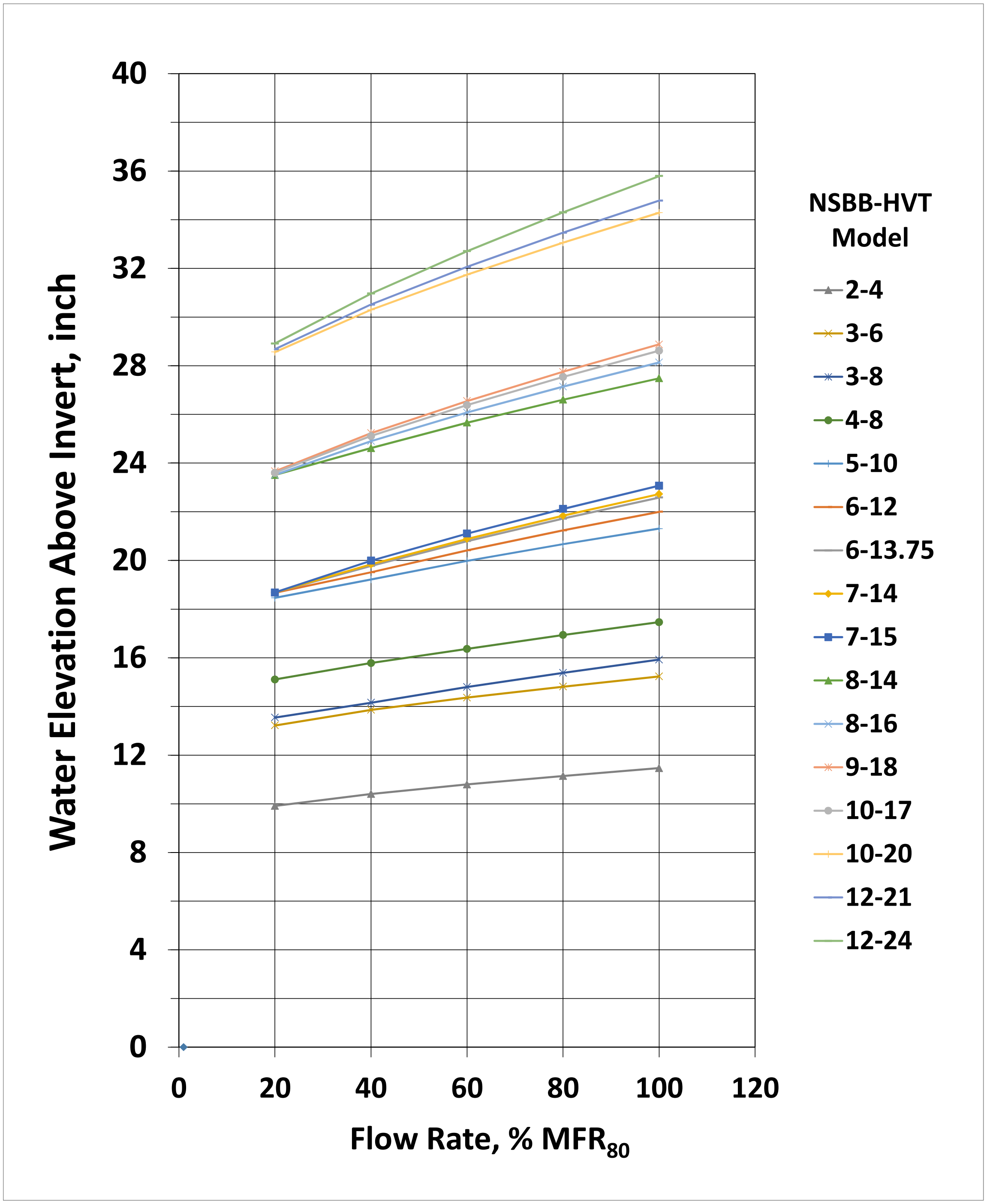


Figure 12 NSBB-HVT Water Elevations Above Invert

CERTIFICATION

AET Tech LLC

10809 Cedar Cove Drive Thonotosassa Florida 33592-2250 813 716 2262

September 5, 2017

TO: City of Indianapolis/Marion County Stormwater Management District
New Products Committee

RE: Certification Statement by Professional Engineer
Nutrient Separating Baffle Box with Hydro-Variant Technology
Suntree Technologies Inc.

CC: Tom Happel, President, Suntree Technologies Inc., Cocoa, Florida
Gary Moody, WISE Hydrology, Hendersonville, TN

AET Tech LLC conducted third-party testing of the Nutrient Separating Baffle Box with Hydro-Variant Technology , a Stormwater Quality Unit (SQU) manufactured by Suntree Technologies, Inc., 798 Clear Lake Road, Cocoa, Florida 32922. Third-party testing was conducted by Dr. Daniel P. Smith of AET Tech LLC. The testing determined the maximum treatment flow rate for 80% removal efficiency of 110 µm d_{50} sediment. Testing was conducted at the AET Tech Test Facility, 10809 Cedar Cove Drive, Thonotosassa, Florida 33592-2250. Dr. Daniel P. Smith conducted and acted as third party observer for all aspects of removal efficiency testing. Dr. Smith conducted, directly supervised, or observed all activities over the full duration of all testing, including design of removal efficiency and resuspension tests (pump operation, flow rate monitoring, sediment preparation and dosing, and background and discharge sampling schedules, sediment submittal to laboratories for PSD analyses, temperature measurement, collection methods for sediment dosing rate, background and discharge SSC sampling, collection and quantification of accumulated solids in NSBB/NSBB-HVT chambers, all laboratory SSC analyses and QA/QC activities, all data and records management, all data assessment calculations, and reporting.

I certify that the information provided to the City of Indianapolis/Marion County Stormwater Management District NPR Consultant, NPR Program Manager or their designated representative(s) pertaining to the Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT) stormwater quality treatment system is accurate and correct and was obtained as required by the testing protocol specified by the City of Indianapolis. AET Tech has no financial relationship, including an ownership interest or investment interest, with the manufacturer involved in this test or any affiliate of the manufacturer. I further certify that I have been compensated only for my time and effort related to this testing certification and I will receive no other compensation for the actions related to this certification.

Daniel P. Smith

Daniel P. Smith, Ph.D., P.E., BCEES
President, AET Tech LLC

Florida PE #58388 ▪ New Jersey PE #24GE03765900

Daniel P. Smith
September 5, 2017

REFERENCES

1. Suntree Technologies Inc. (2015) *http://www.suntreetech.com/Products/Nutrient+Separating+Baffle+Box/default.aspx*
2. City of Indianapolis/Marion County (2017) *Manufactured Stormwater Quality Evaluation Criteria* under *BMP Testing Criteria* at http://www.indy.gov/eGov/City/DPW/Business/Specs/Documents/BMP_Testing_Criteria_R3%202016%2010%2011.pdf.
3. AET Tech (2017) Suntree Technologies Inc. Nutrient Separating Baffle Box with Hydro-Variant Technology, New Product Review Program, City of Indianapolis/ Marion County Stormwater Management District, April 4, 2017.
4. Water Environment Federation (2014) Investigation into the Feasibility of a National Testing and Evaluation Program for Stormwater Products and Practices A White Paper by the National Stormwater Testing and Evaluation of Products and Practices (STEPP) Workgroup Steering Committee February 6, 2014 STEPP Workgroup.
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.
6. American Society for Testing and Materials (2007) Standard Test Methods for Determining Sediment Concentrations in Water Samples. D3977-97 (Reapproved 2007), ASTM, Philadelphia, PA.
7. AET Tech (2017) Nutrient Separating Baffle Box with Hydro-Variant Technology (NSBB-HVT)®, Laboratory Treatment Capacity Verification Quality Assurance Project Plan, City of Indianapolis/Marion County Stormwater Management District, July 18, 2017.

APPENDIX A

NUTRIENT SEPARATING BAFFLE BOX-HVT® NO. 3-6

SUNTREE TECHNOLOGIES INC.® NUTRIENT SEPARATING BAFFLE BOX®
MODEL NO: NSBB-3-6-72

FLOW & BY-PASS SPECIFICATIONS FOR THE BIOMASS SEPARATING SCREEN SYSTEM, SEDIMENT STORAGE, AND SKIMMER SPECIFICATIONS.

1. Inflow Pipe Area (18" PVC AS SHOWN) ——— 1.33 sq.ft.

SCREEN SPECIFICATIONS:

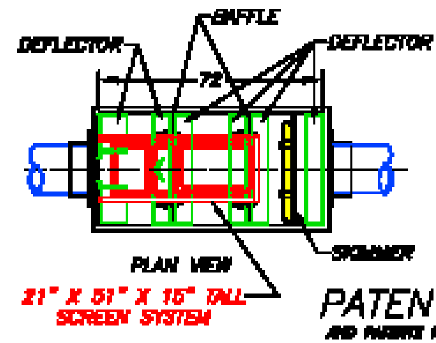
2. Open orifice area in screen system ——— 8.10 sq.ft.
3. Open orifice area in screen system with 50% blockage ——— 4.5 sq.ft.
4. Open orifice area in screen system with 75% blockage ——— 2.38 sq.ft.
5. By-pass through screen system below the ceiling of the pipe. ——— 1.33 sq.ft.
6. Minimum by-pass around screen system below the ceiling of the pipe. ——— 1.88 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 ——— 18.50 cu.ft.
10. Volume of third chamber ——— 18.00 cu.ft.
11. Volume of total sediment storage ——— 52.50 cu.ft.

SKIMMER SPECIFICATIONS:

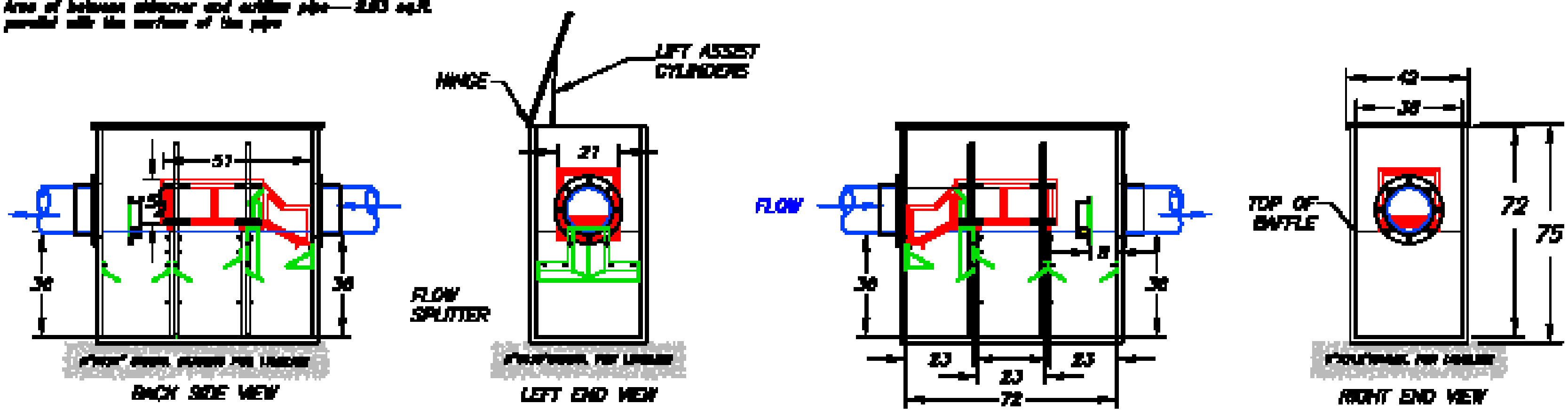
12. Flow area under skimmer ——— 2.65 sq.ft.
13. Area of pipe in line with skimmer ——— 1.33 sq.ft.
14. Area of between skimmer and outflow pipe parallel with the surface of the pipe ——— 2.83 sq.ft.



PATENTED
AND PATENTS PENDING

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 BAFFLE.
4. THE BOTTOM OF THE SKIMMER SHOULD BE 4" BELOW THE INVERT OF THE OUTFLOW PIPE.
5. INVERT OF THE INFLOW PIPE SHOULD ALSO BE BELOW THE INVERT OF THE OUTFLOW PIPE.



FRONT VIEW

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 VAULT. PIPES CAN NOT INTRUDE INTO THE VAULT.
4. TOP OF VAULT TO BE HINGED WITH STAINLESS STEEL PIANO HINGE ALONG ONE LONG SIDE OF THE VAULT.
5. LIFT SUPPORT CYLINDER TO INCORPORATED TO HELP WITH HOLDING UP THE TOP COVER OF THE VAULT.
6. PYLON AND PIVOTING PANEL TO BE INCORPORATED AS SHOWN INTO THE BODY OF THE SCREEN SYSTEM.
7. TURBULENCE DEFLECTORS TO BE INCORPORATED AS SHOW TO REDUCE TURBULENCE INSIDE SETTLING CHAMBERS.
8. RECOMMENDED PIPE SIZE TO RANGE FROM 12" TO 18".

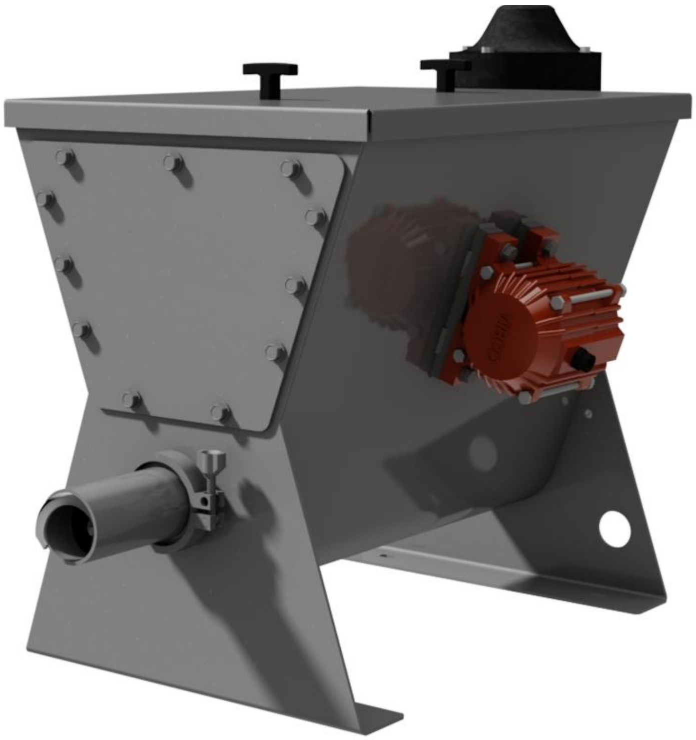
SUNTREE TECHNOLOGIES, INC. 798 CLEARLAKE RD. SUITE #2 COCOA, FL 32922		2-01-31-13-01
NUTRIENT SEPARATING BAFFLE BOX® MODEL NO: NSBB-3-6-72		NSBB-3-6-72
DATE: 05/25/05	SCALE: = 27.6	
DRAFTER: T.H.H.	UNITS =INCHES	

APPENDIX B

VOLUMETRIC AUGER FEEDER

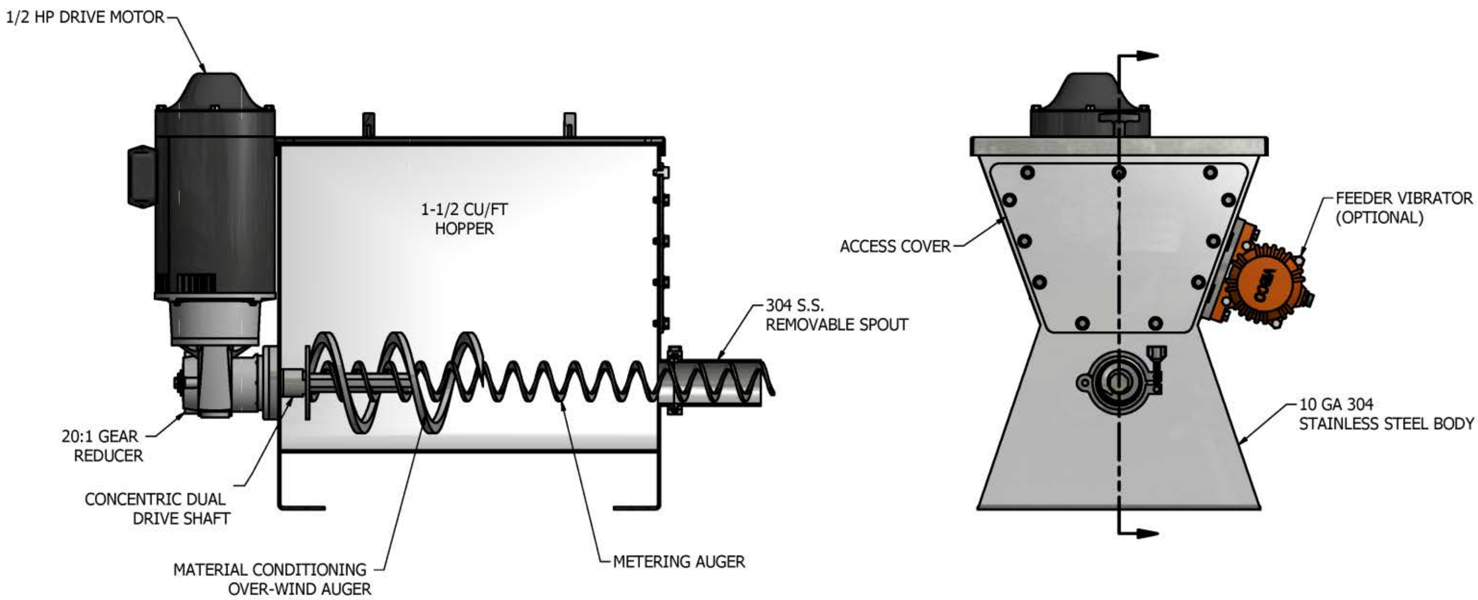
MODEL VF-2

Dry Material Metering



- **Used to dispense powders, pellets, chips, and flakes.**
- **Constructed of 304 Stainless Steel (316 S.S. Available)**
- **Designed with a direct drive**
- **Small footprint**
- **Engineered for reliability with the use of many products**
- **1-2% accuracy within desired feed rate**
- **Easily change out auger and discharge**

Contact us for more information:
Phone: 855.328.9200
Email: sales@ipm-sys.com



Standard Instrument Features:

- 304 Stainless Steel Construction
- Lid if needed
- Motor
- Gear Box
- Auger and Spout
- 1 ½ cubic foot hopper

Design Specifications:

- Floor Dimensions: 20-3/4 x 15-1/4 inches
- Height: 20 inches
- Hopper Opening: 15-3/16 x 12-3/8 inches
- Feed Rates: 0.02-11.5 Cu. Ft. per hour
- Auger Tooling: 3/8" to 2" Diameter
- Feeder Motor: ½ HP
- Electrical Requirements: 120/240 VAC
- Shipping Weight: 250 lbs

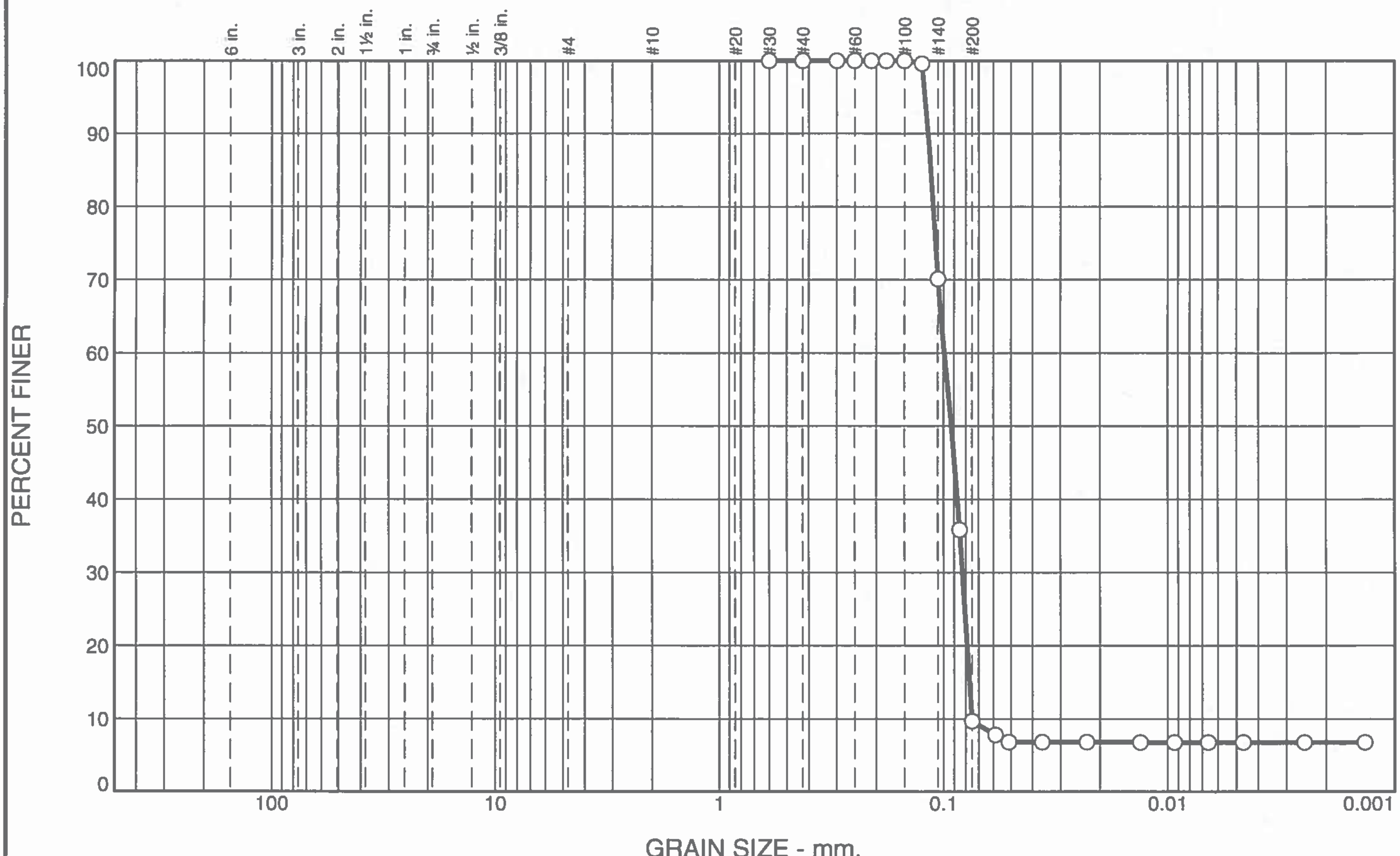
Accessories:

- Solution Tanks (15,35,50 Gallon Sizes)
- Liquid Level Control (on tanks)
- Mixer (on tanks)
- Bag Unloader (304 S.S.)
- Bulk Bag Frame
- Feeder Stand (304 S.S.)
- Drum Inverter
- Dust Collector
- Explosion Proof Motors
- Knife Gate

APPENDIX C

TEST SEDIMENT PSD

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	90.3	2.9	6.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#40	100.0		
#50	100.0		
#60	100.0		
#70	100.0		
#80	100.0		
#100	100.0		
#120	99.6		
#140	70.1		
#200	9.7		

* (no specification provided)

Material Description

Pale Brown F/S

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1172 D_{85}= 0.1143 D_{60}= 0.0994
D_{50}= 0.0924 D_{30}= 0.0827 D_{15}= 0.0773
D_{10}= 0.0752 C_u= 1.32 C_c= 0.92

Classification

USCS= AASHTO=

Remarks

Location: #7

Date: 1/27/16

BTL Engineering, Inc.

Tampa, FL

Client: Suntree Technologies Inc.
Project: NJ Cat Testing

Project No: 5241-15 **Figure**

Tested By: T.H. **Checked By:** Chris Haley

GRAIN SIZE DISTRIBUTION TEST DATA

1/27/2016

Client: Suntree Technologies Inc.
Project: NJ Cat Testing
Project Number: 5241-15
Location: #7
Material Description: Pale Brown F/S
Date: 1/27/16
Tested by: T.H.
Checked by: Chris Haley

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.00
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.00	0.00	#30	0.00	0.00	100.0
		#40	0.00	0.00	100.0
		#50	0.00	0.00	100.0
		#60	0.00	0.00	100.0
		#70	0.00	0.00	100.0
		#80	0.00	0.00	100.0
		#100	0.00	0.00	100.0
		#120	0.40	0.00	99.6
		#140	29.50	0.00	70.1
		#200	60.40	0.00	9.7

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =100
Hygroscopic moisture correction:
Moist weight and tare = 32.74
Dry weight and tare = 32.73
Tare weight = 6.62
Hygroscopic moisture = 0.0%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = 0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
0.25	23.5	35.0	35.8	0.0131	35.0	10.6	0.0850	35.8
0.75	23.5	7.0	7.8	0.0131	7.0	15.1	0.0588	7.8
1.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0512	6.8
2.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0362	6.8
5.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0229	6.8
15.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0132	6.8
30.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0094	6.8
60.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0066	6.8
120.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0047	6.8
420.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0025	6.8
1440.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0013	6.8

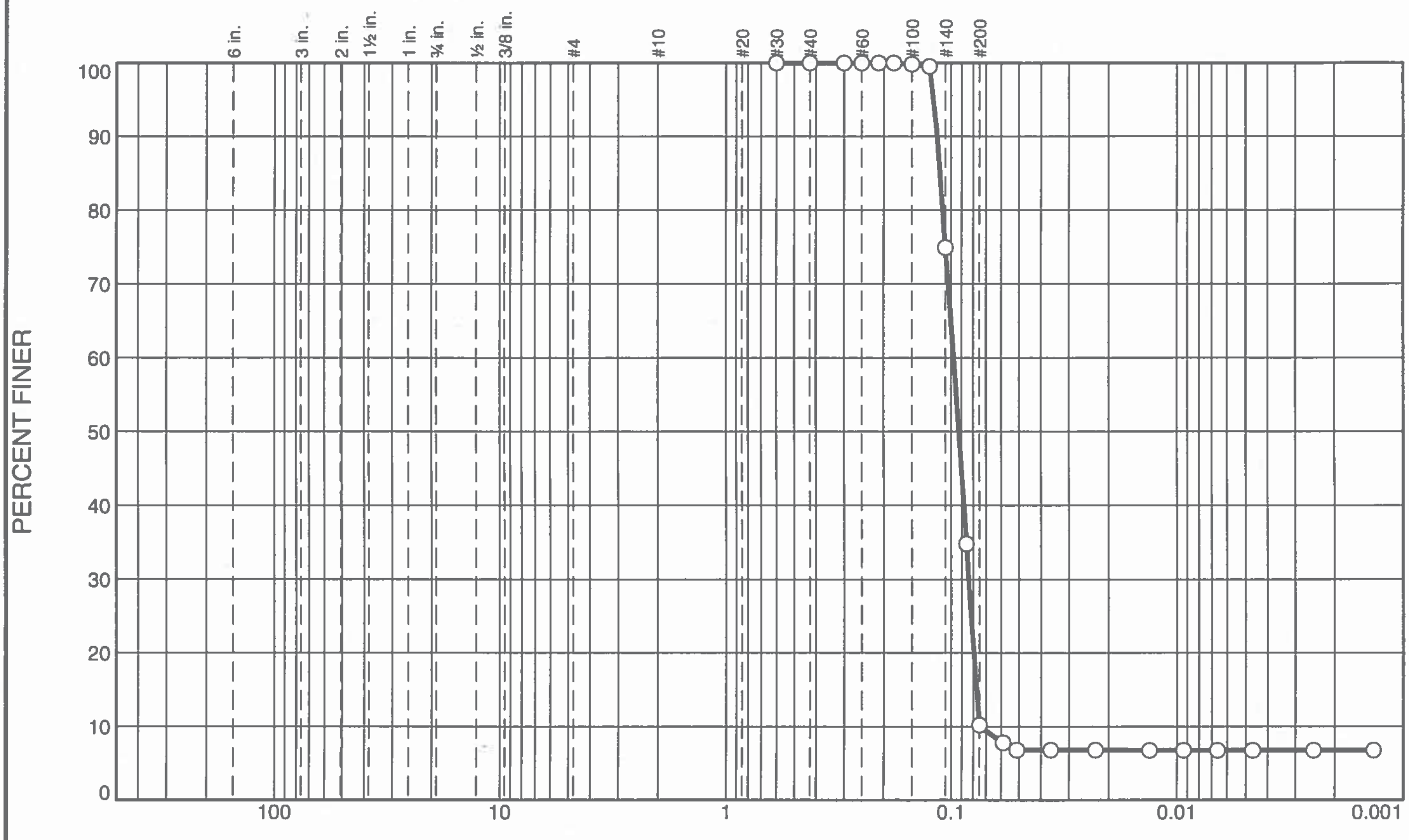
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	90.3	90.3	2.9	6.8	9.7

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0752	0.0773	0.0792	0.0827	0.0868	0.0924	0.0994	0.1115	0.1143	0.1172	0.1207

Fineness Modulus	C_u	C_c
0.00	1.32	0.92

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	89.8	3.4	6.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#40	100.0		
#50	100.0		
#60	100.0		
#70	100.0		
#80	100.0		
#100	99.8		
#120	99.5		
#140	74.9		
#200	10.2		

* (no specification provided)

Material Description

Pale Brown F/S

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1155 D_{85}= 0.1121 D_{60}= 0.0976
D_{50}= 0.0925 D_{30}= 0.0837 D_{15}= 0.0775
D_{10}= 0.0738 C_u= 1.32 C_c= 0.97

Classification

USCS= AASHTO=

Remarks

Location: #8

Date: 1/27/16

BTL Engineering, Inc.

Tampa, FL

Client: Suntree Technologies Inc.
Project: NJ Cat Testing

Project No: 5241-15 **Figure**

Tested By: T.H. **Checked By:** Chris Haley

GRAIN SIZE DISTRIBUTION TEST DATA

1/27/2016

Client: Suntree Technologies Inc.
Project: NJ Cat Testing
Project Number: 5241-15
Location: #8
Material Description: Pale Brown F/S
Date: 1/27/16
Tested by: T.H.
Checked by: Chris Haley

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.10
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.10	0.00	#30	0.00	0.00	100.0
		#40	0.00	0.00	100.0
		#50	0.00	0.00	100.0
		#60	0.00	0.00	100.0
		#70	0.00	0.00	100.0
		#80	0.00	0.00	100.0
		#100	0.20	0.00	99.8
		#120	0.30	0.00	99.5
		#140	24.60	0.00	74.9
		#200	64.80	0.00	10.2

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =100.1
Hygroscopic moisture correction:
Moist weight and tare = 53.97
Dry weight and tare = 53.96
Tare weight = 6.60
Hygroscopic moisture = 0.0%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = 0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: $L = 16.294964 - 0.164 \times Rm$

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
0.25	23.5	34.0	34.8	0.0131	34.0	10.7	0.0856	34.8
0.75	23.5	7.0	7.8	0.0131	7.0	15.1	0.0588	7.8
1.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0512	6.8
2.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0362	6.8
5.00	23.5	6.0	6.8	0.0131	6.0	15.3	0.0229	6.8
15.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0132	6.8
30.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0094	6.8
60.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0066	6.8
120.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0047	6.8
420.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0025	6.8
1440.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0013	6.8

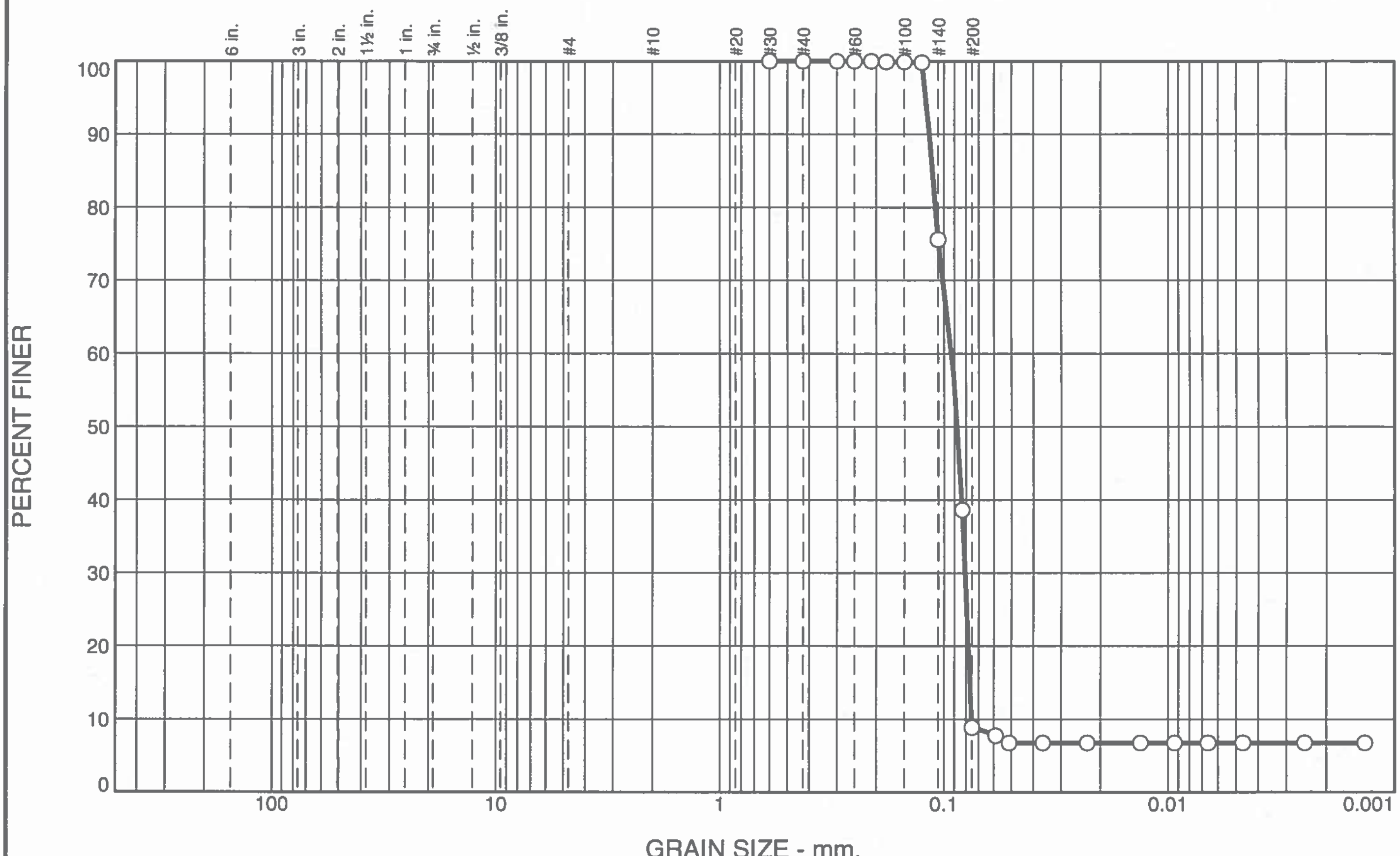
Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	89.8	89.8	3.4	6.8	10.2

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0738	0.0775	0.0797	0.0837	0.0878	0.0925	0.0976	0.1090	0.1121	0.1155	0.1196

Fineness Modulus	C_u	C_c
0.00	1.32	0.97

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.0	91.1	2.1	6.8

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#30	100.0		
#40	100.0		
#50	100.0		
#60	100.0		
#70	100.0		
#80	99.9		
#100	99.9		
#120	99.8		
#140	75.6		
#200	8.9		

* (no specification provided)

Material Description

Pale Brown F/S

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1159 D_{85}= 0.1124 D_{60}= 0.0929
D_{50}= 0.0872 D_{30}= 0.0807 D_{15}= 0.0769
D_{10}= 0.0754 C_u= 1.23 C_c= 0.93

Classification

USCS= AASHTO=

Remarks

Location: #9

Date: 1/27/16

BTL Engineering, Inc.

Tampa, FL

Client: Suntree Technologies Inc.
Project: NJ Cat Testing
Project No: 5241-15 **Figure**

Tested By: T.H. **Checked By:** Chris Haley

GRAIN SIZE DISTRIBUTION TEST DATA

1/27/2016

Client: Suntree Technologies Inc.
Project: NJ Cat Testing
Project Number: 5241-15
Location: #9
Material Description: Pale Brown F/S
Date: 1/27/16
Tested by: T.H. **Checked by:** Chris Haley

Sieve Test Data

Post #200 Wash Test Weights (grams): **Dry Sample and Tare =** 100.40
Tare Wt. = 0.00
Minus #200 from wash = 0.0%

Dry Sample and Tare (grams)	Tare (grams)	Sieve Opening Size	Weight Retained (grams)	Sieve Weight (grams)	Percent Finer
100.40	0.00	#30	0.00	0.00	100.0
		#40	0.00	0.00	100.0
		#50	0.00	0.00	100.0
		#60	0.00	0.00	100.0
		#70	0.00	0.00	100.0
		#80	0.10	0.00	99.9
		#100	0.00	0.00	99.9
		#120	0.10	0.00	99.8
		#140	24.30	0.00	75.6
		#200	67.00	0.00	8.9

Hydrometer Test Data

Hydrometer test uses material passing #10
Percent passing #10 based upon complete sample = 100.0
Weight of hydrometer sample =100.4
Hygroscopic moisture correction:
Moist weight and tare = 40.00
Dry weight and tare = 39.98
Tare weight = 6.58
Hygroscopic moisture = 0.1%
Automatic temperature correction
Composite correction (fluid density and meniscus height) at 20 deg. C = 0
Meniscus correction only = 0.0
Specific gravity of solids = 2.65
Hydrometer type = 152H
Hydrometer effective depth equation: L = 16.294964 - 0.164 **x Rm**

Elapsed Time (min.)	Temp. (deg. C.)	Actual Reading	Corrected Reading	K	Rm	Eff. Depth	Diameter (mm.)	Percent Finer
0.25	23.4	38.0	38.8	0.0131	38.0	10.1	0.0831	38.6
0.75	23.4	7.0	7.8	0.0131	7.0	15.1	0.0588	7.7
1.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0512	6.8
2.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0362	6.8
5.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0229	6.8
15.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0132	6.8
30.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0094	6.8
60.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0066	6.8
120.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0047	6.8
420.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0025	6.8
1440.00	23.4	6.0	6.8	0.0131	6.0	15.3	0.0013	6.8

Fractional Components

Cobbles	Gravel			Sand				Fines		
	Coarse	Fine	Total	Coarse	Medium	Fine	Total	Silt	Clay	Total
0.0	0.0	0.0	0.0	0.0	0.0	91.1	91.1	2.1	6.8	8.9

D_5	D_{10}	D_{15}	D_{20}	D_{30}	D_{40}	D_{50}	D_{60}	D_{80}	D_{85}	D_{90}	D_{95}
	0.0754	0.0769	0.0782	0.0807	0.0835	0.0872	0.0929	0.1091	0.1124	0.1159	0.1198

Fineness Modulus	C_u	C_c
0.00	1.23	0.93