New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device

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Contents

1. Overview

This document specifies the laboratory testing procedures required for hydrodynamic sedimentation (HDS) manufactured treatment devices (MTDs) seeking verification in the State of New Jersey, as required by the Stormwater Management Rules, N.J.A.C. 7:8. This document shall be adhered to by manufacturers, New Jersey Corporation for Advanced Technology (NJCAT) and entities performing or overseeing the testing of an HDS MTD to meet that verification requirement.

Any MTD that is verified by NJCAT and certified by the NJDEP through this protocol must be sized to operate at or below the verified maximum treatment flow rate (MTFR) specified in the NJDEP Certification letter for that MTD. Unless Alternate Configuration testing has been completed as noted below, the MTD must be designed in the same configuration, including all internal components, as the tested configuration. Any substantial deviation from the verified/certified sizing or scaling, inlet/outlet configuration, or to the configuration and internal components of the MTD has the potential to substantially alter the MTD's performance, thus negating the resultant verification/certification. Any of these deviations invalidate the NJCAT verified performance and resulting NJDEP certification unless additional testing is completed as described below.

Alternate Configurations

To allow for an installation that differs from the tested inlet/outlet piping configuration specified above, a manufacturer may wish to test different inlet/outlet angles to allow for greater flexibility during design and installation. In such instances, at least one alternate inlet/outlet pipe angle must be tested at 25% and 75% of the manufacturer's target MTFR, and the results must be within +/-5% of the original configuration test results. For example, in the original testing configuration the inlet/outlet pipes were set opposite of each other offset at 180 degrees. In an alternative test, with the inlet pipe and outlet pipe offset by 90 degrees, two data points are tested at 25% and 75% of the manufacturer's target MTFR. If the initial testing found 62% and 56% removal efficiency at 25% and 75% of the target MTFR, the alternate testing must be within 5% of those numbers. If those targets are met, the piping configuration for the NJCAT verification and NJDEP certification for the MTD would be extended to include installations with inlet/outlet pipes offset by up to 90 degrees. Any alternate configuration testing must follow the protocol requirements. Additionally, the use of multiple inlets or grate inlets would require separate testing in accordance with the HDS protocol to be verified and certified.

2. Definitions

Commercially Available

Means available for purchase, with operational components at full size, identical dimensions and configurations, and comprised of materials specified for commercial use, except for the housing or other structural components that do not affect hydraulic performance, which are specifically used to facilitate laboratory testing.

Effective Sedimentation Treatment Area (ESTA)

The entire area within the MTD where sedimentation occurs, including any pretreatment chambers or areas where sediment is known to collect outside of the primary sediment capture and storage location.

Geometrically Proportional

For the purposes of scaling, an MTD is considered geometrically proportional to a reference MTD when the ratios of the inside dimensions of length, width, and depth to false floor are the same as the ratios of the inside dimensions of length, width, and depth to false floor of the reference MTD. As specified below under Section 6, scaling of an MTD depth is determined from the top of the false floor, and not from the physical bottom of the unit.

Maintenance Sediment Storage Depth and Volume

The maintenance sediment storage depth and volume of an HDS MTD represents the amount of sediment that can accumulate in the MTD prior to maintenance, as recommended by the manufacturer and confirmed via scour testing.

Maximum Hydraulic Flow Rate (MHFR)

The maximum hydraulic flow rate (MHFR) of an HDS MTD is the highest flow rate that can be conveyed through the MTD with specified head loss. This value is primarily designed to provide maximum flows that can be safely conveyed through the unit to protect against backup during extreme events where overland flooding is a concern. The MHFR is determined or estimated from hydraulic characterization tests that are described in Section 4.B.6 of this protocol.

Maximum Treatment Flow Rate (MTFR)

The highest flow rate that can be conveyed through an MTD to achieve performance-based claims for total suspended solids (TSS) removal described in this protocol.

Off-line

An MTD configuration in which flow rates up to the MTFR are routed into the treatment chamber of the MTD and all flows in excess of the MTFR are diverted around the treatment chamber of the MTD via an upstream bypass or diversion.

On-line

An MTD configuration in which flow rates in excess of the MTFR are permitted to flow through the treatment chamber of the MTD.

Selected MTFR

The flow rate from the target MTFR removal efficiency curve for MTFR verification of an annualized weighted TSS removal efficiency.

Suspended Sediment Concentration (SSC)

The concentration of sediments in a water column as defined by analytical testing in accordance with ASTM D3977. For the purposes of this laboratory testing protocol, SSC is considered as a surrogate for TSS.

Target MTFR

The MTFR targeted for MTD performance testing to generate a sediment mass capture removal efficiency vs. flow rate curve.

3. Laboratory Testing Criteria

A. Laboratory Qualifications

All analytical methods used for TSS (measured as SSC) samples collection and analyses required by the protocol (i.e., ASTM D2216 ASTM D3977, ASTM D6913, ASTM D7928, and USGS I3765-85) must be conducted by a laboratory certified by an NELAP or ISO recognized accreditation body to conduct the specific test method. NJDEP is recognized as an entity to certify the respective laboratories. However, this protocol does not require an approved laboratory certification from the NJDEP. Information on the NJDEP laboratory certification program can be acquired from the Office of Quality Assurance website at https://www.nj.gov/dep/enforcement/oqa.html. HDS MTD testing can be performed by an independent or in-house NJCAT approved laboratory.

Information regarding laboratory testing qualifications can be found at: http://www.njcat.org/ in the document entitled "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology: For use in accordance with the Stormwater Management Rules, N.J.A.C. 7:8."

B. Laboratory Proficiency

Prior to the start of testing, a laboratory shall demonstrate proficiency in executing ASTM D3977 as follows:

1. In order to ensure analytical laboratories are proficient in analyzing samples in accordance with ASTM Method D 3977, two spiked samples shall be analyzed prior to the start of testing and the reported results shall be within +/- 10% of the known concentration.
2. Spiked SSC samples shall be prepared using the same test sediment prepared for SSC testing. Spiked samples shall be prepared at a concentration of 20 mg/L and 50 mg/L.
3. SSC results for spiked samples shall be +/- 10% of the known concentration to be in compliance.
4. Results of this proficiency testing must be included in the report submitted to NJCAT for verification.

C. Third-Party Observer (In-House Laboratory Testing)

Qualifications of the third-party observer shall include:

- Minimum education requirements: B.E., B.S., or B.A. degree in an engineering-based or science-based curriculum.
- Professional experience: Performed tasks such as hydraulic testing, water quality monitoring and analytical measurements. Demonstrated knowledge and practice of experimental design and setup, sampling methods, handling sample security (i.e., chain of custody), task documentation and data management.
- Relevant experiences: The observer shall have experience in consulting or academia (reporting, general laboratory practices.)

Specific tasks to be performed by the observer shall include:

i. Observe and document the preparation and collection of TSS removal and scour test sediment samples sent out for particle size distribution (PSD) analysis.

ii. Document test setup, including a diagram and key dimensions, such as at a minimum, pipe sizes, slopes, and condition, hopper location and height, false floor elevation, and sediment scour preloading depth and time.

iii. Observe/document influent sediment feed samples, lot numbers, initial and post run feed hopper sediment mass, sample collection and timing. Maintain control over sediment when not under observation, for example, by the use of security seals.

iv. Record times of sediment calibration samples, sediment feed start, feed stop and flow start/stop.

v. Observe and document mass of sediment captured in sump and inlet pipe.

vi. Document/observe specifics of hydraulic testing (flow path, water elevations, bypass, head loss.)

vii. Check sample labeling, management, and security for transportation/shipping.

viii. Ensure calibration of testing devices, such as flow meters, scales, etc. have been performed to the manufacturer's requirement.

ix. Review and confirm calculations, and adherence to the testing protocol.

x. Maintain logbook and documentation of notes, measurements, etc.

D. Analysis of TSS Samples

Analysis of all Total Suspended Solids (TSS) samples, measured as SSC, shall be done in accordance with ASTM D3977 "Standard Test Methods for Determining Sediment Concentrations in Water Samples." TSS is defined as any particulate test sediment that is transported to the MTD during flow conditions.

E. Temperature

The temperature of the water used during all testing shall not exceed 80 degrees Fahrenheit.

F. Background TSS Levels

Background levels of TSS shall be no more than 10% of the target influent concentration in all tests. The maximum allowable background concentration is 20 mg/L. The use of flocculants to reduce background TSS levels is not permitted.

G. MTD Size and Availability

HDS MTDs tested in the laboratory must be full scale, commercially available devices with the same configurations and components as those installed in the field. See Section 6 for the scaling of HDS MTDs.

4. TSS Removal Efficiency

A. Test Sediment Particle Size Distribution

Test sediment particle size distribution (PSD) must be consistent with Column 2 in Table 1: Test Sediment Particle Size Distribution. PSD of the actual test (feed) sediment shall be determined using ASTM D 6913 (Standard Test Methods for Particle -Size Distribution (Gradation) of Soils Using Sieve Analysis) and ASTM D7928 (Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis.) Three samples of the test sediment shall be obtained for PSD analysis and the results reported accordingly. A finer PSD than that of the specified PSD is acceptable but will likely lower the MTD performance. The average of the three samples shall be used to assess compliance with the target PSD.

Table 1: Test Sediment Particle Size Distribution[1]		
	TSS Removal Test PSD	**Scour Test Pre-load PSD**
Particle Size (Microns)	**Target Minimum % Less Than[2]**	**Target Minimum % Less Than[2 and 3]**
1,000	100	100
500	95	90
250	90	55
150	75	40
100	60	25
75	50	10
50	45	0
20	35	0
8	20	0
5	10	0
2	5	0

1. The material shall be hard, firm, and inorganic with a specific gravity of 2.65. The various particle sizes shall be uniformly distributed throughout the material prior to use.
2. A measured value may be lower than a target minimum % less than value by up to two percentage points, (e.g., at least 3% of the particles must be less than 2 microns in size [target is 5%]), provided the measured d_{50} value does not exceed 75 microns for TSS test removal efficiency PSD.
3. This distribution is to be used to pre-load the MTD's sedimentation chamber for off-line and on-line scour testing.

B. TSS Removal Efficiency Testing

TSS Removal Efficiency must be determined through the use of the Mass Capture Test Method. TSS Removal Efficiency testing to determine a 50% sediment removal efficiency shall be performed at constant flow rates of 10%, 25%, 50%, 75%, 100%, 125% and 150% of the MTD's target MTFR and a TSS influent concentration of 200 mg/L. Additional flow rates may be tested if the manufacturer so desires.

For all TSS Removal Efficiency Testing a false floor shall be installed to simulate the 50% sump full condition, but no sediment shall be added to the sump prior to the test run.

All testing must include, at a minimum, the items noted below.

1. Background Sampling
   a. Background TSS samples must be obtained at a pre-determined location upstream from the introduction of the test sediment.
   b. A minimum of eight (8) background samples shall be taken at evenly-spaced intervals during each run. Each sample shall be a minimum of 500 mL.
   c. The time each background sample is collected shall be recorded.
   d. Background TSS concentrations shall not exceed 20 mg/L.
2. Test Sediment Feed

   The test sediment feed must include a method to introduce the test sediment within the following parameters:

a. The test sediment feed rate and total mass of test sediment introduced during each test run must be a known quantity.

b. The test sediment feed rate must be introduced at a rate within 10% of the targeted value of 200 mg/L (180 – 220 mg/L) influent concentration.

c. Test sediment shall be injected using an auger, vibratory hopper, or other suitable means of sediment addition that provides a consistent, calibrated concentration of solids. Six (6) sediment calibration samples (measured to 0.1 g) must be collected, distributed equally, over the course of the testing. Should the testing exceed 6 hours, then one calibration sample per hour shall be collected. Calibration samples shall be collected over a time interval that shall normally not exceed one minute; however, the collection time may be extended to ensure that a minimum sample size of 20 g is collected.

d. The total mass input shall be determined by weighing the hopper feed sediment before and after each run, including any sediment added during the run, and correcting for the six (6) feed sediment calibration samples taken. The coefficient of variance (COV) of the feed rate samples must be ≤ 0.10.

3. Flow Measurements

a. A flow meter or equivalent device must be located upstream of the MTD.

b. The flow meter must be installed directly in/on the inlet pipe at a location where fully developed flow is attained and placed a sufficient distance away from any velocity or turbulence increasing devices (valves, pumps, elbows, flanges, etc.) as required/dictated by the flow meter manufacturer.

c. All flow meters used in this protocol must be calibrated as required by the instrument manufacturer. Copies of flow meter calibrations shall be included in the final report. The flow meter data logger must record flows at a minimum of once per minute and the average flow rate reported.

d. During all test runs, the allowable variation of any of the seven target flow rates listed above shall be +10% for the targeted flow rate. The COV of the flow data shall be ≤ 0.03.

4. Test Unit

a. The inlet pipe diameter must be equal to or smaller than 25% of the inside diameter or inside width (shortest dimension) of the model MTD being tested.

b. Inlet and outlet pipes must be of equal diameter with a minimum slope of 1%.

c. As noted above, a false floor shall be installed in the MTD to simulate the 50% sump full condition.

5. Test Setup

a. The dry sediment feed location must be 3 feet or less upstream from the test unit.

6. Hydraulic Testing

a. At a minimum, flow and corresponding water levels in the inlet and outlet pipes, and upstream of the bypass weir (if so equipped) shall be measured and recorded to establish the head loss across the device. The pipe measurements should be taken approximately one pipe-diameter upstream and downstream of the test tank. The measurements shall cover the span of 10% to 200% of the MTFR and include when the point of bypass occurs. The data collection shall be conducted on a clean MTD unit that is free of sediment, using calibrated instruments. The specific methodology for measuring head losses (pressure transducer, water manometer, etc.) shall be determined by the test laboratory and described clearly in the test report, along with the recorded test data.

C. Mass Capture Test Method

The Mass Capture Test Method compares the total known mass introduced into the flow and the mass collected in the MTD after completion of each test run.

The Mass Capture Test Method procedure is as follows:

1. Dry and determine the moisture content of a well-mixed feed sample in accordance with ASTM D2216, "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass."
2. After attaining a constant targeted flow rate through the test unit, feeding of the sediment shall begin at the target concentration of 200 mg/L.
3. A minimum of 25 lbs (weighed to a precision of 0.02 lbs) of sediment must be fed to the unit or the test duration limited to an 8-hour maximum, whichever criterion is met first.
4. Flow should continue one detention time after sediment feed is stopped to allow for sediment that would not normally be captured to pass through the MTD.
5. Sediment injection point shall be three feet or less from the test unit, along the centerline of the pipe upstream of the inlet to the MTD. Record times of sediment calibration samples, sediment feed start, feed stop and flow start/stop.
6. The test MTD shall be decanted by means of either a sump pump or a drain into storage containers.
7. After sediment is allowed to settle in the storage container(s), the remaining water from the containers shall be filtered directly or decanted and discarded. Additional filtering of discarded water is at the manufacturer's discretion.
8. The residual mixture of water and test sediment shall be removed from the storage container(s) and placed into pre-weighed non-ferrous trays.
9. Trays shall be placed into a vented drying oven at no more than 100ºC (212ºF) until a constant weight is obtained when cooled to room temperature, as determined by two successive measurements taken no less than two hours apart which show no more than a 0.1% difference in measured mass weighed to a precision of 10 grams. Weights obtained for all sediments shall be added.
10. Sediment removal efficiency for that test run shall then be computed as follows:

$$\textbf{Removal Efficiency (\%)} = \left(\frac{\text{Total Mass Collected in MTD}}{\text{Total Mass Input During Run}} \right) \times 100$$

11. Sediment removal efficiencies are to be plotted vs. flow rate to generate a removal efficiency curve from which an MTFR can be selected and an annual weighted removal efficiency can be calculated. Note: Regulatory agencies other than NJDEP could select weighting factors appropriate for their specific rainfall conditions and desired annualized removal efficiency. The curve fitting approach should result in a minimum R^2 of 0.95 and the approach selected should yield the highest R^2. An $R^2 > 0.97$ should be attainable. The maximum polynomial fit is 3rd order.
12. Both the sediment mass captured in the MTD and the inlet pipe must be quantified and reported separately.
13. The inlet pipe must be cleaned out following each flow rate test.

5. Scour Testing

For MTDs intended for off-line installations, the scour testing shall be conducted at a minimum 125% of the maximum treatment flow rate (MTFR.) Testing performed at this flow rate or higher is necessary to ensure that re-suspension and washout of previously captured sediment within the MTD is not excessive. To determine if an MTD can be located on-line, scour testing shall be conducted at a minimum of 200% of the MTFR.

The average effluent concentration must be less than 20 mg/L above the background concentration regardless of which of the above minimum MTFRs is used. However, if this benchmark is achieved during scour testing at a minimum of 200% of the MTFR, separate scour testing at a minimum of 125% of the MTFR is not required.

A. Scour Test Sediment Particle Size Distribution

Test sediment particle size distribution for scour testing must be consistent with Column 3 in Table 1: Test Sediment Particle Size Distribution, noted above.

B. Scour Testing Procedure

This test shall be performed utilizing a full-scale, commercially available MTD. The sedimentation chamber(s) corresponding to the sediment storage sump shall be pre-loaded to 50% of the manufacturer's recommended maximum sediment storage volume to satisfy the scour testing requirement. If an MTD has more than one sediment storage sump, all sumps must be pre-loaded with sediment. The pre-load shall be consistent with the particle size distribution for particles of 50 microns and greater shown in Column 3 in Table 1: Test Sediment Particle Size Distribution. Three samples of the test sediment shall be obtained for particle size distribution (PSD) analysis and the results reported accordingly. The average of the three samples shall be used to assess compliance with the target PSD.

A false floor may be placed in the sedimentation chamber at a level below the 50% maximum sediment storage volume and then covered with sufficient test sediment to achieve 50% of the maximum sediment storage volume. In doing so, the level of the false floor shall be at least four inches below the 50% maximum sediment storage volume. Following pre-load and before commencing the testing, the test sediment layer shall either be leveled or placed in a condition documented to be similar to actual field observations (e.g., cone or favored to inlet side and sloped.) A non-level sediment layer is acceptable if the contoured shape is documented through TSS Removal Efficiency Testing described herein. However, the minimum four inch pre-load depth is still required before contouring.

The MTD shall be filled with clear water to its normal, dry weather operating depth. Clear water is defined as water that is free of test sediment (i.e., with a background TSS concentration of less than 20 mg/L.) Commencement of the scour test shall start within 96 hours of pre-loading of the unit.

Following pre-loading and the addition of clear water, the test shall commence by conveying clear water through the MTD at increasing flow rates up to, but never exceeding, either the minimum 125% or 200% MTFR scour test requirement. Effluent samples shall be collected, and time stamped every two minutes after achieving the target flow rate. A minimum of 15 effluent samples shall be taken over the duration of the test. The flow rate shall be recorded continuously so that the effluent samples can be compared to corresponding flow rate values. The flow rate shall be increased to the target flow rate within three minutes of commencement of the test. The flow rate shall then remain constant at the target flow rate for the remainder of the test duration. Effluent samples are to be taken at 1, 3 and 5 minutes and then every two minutes thereafter for an additional 12 samples (i.e., 7. 9, 11…29 minutes.) All 15 samples are to be used to determine average effluent concentration.

A minimum of eight (8) background samples of the clear water shall be collected at evenly spaced intervals throughout the duration of the target maximum flow rate testing. All samples (background and effluent) shall be analyzed for TSS in accordance with ASTM D3977 "Standard Test Methods for Determining Sediment Concentrations in Water Samples." The maximum allowable background concentration shall not exceed 20 mg/L. If any of the background concentrations exceed 20 mg/L the clear water must be replaced or filtered to reduce background concentration to acceptable levels and the test repeated.

If the minimum 200% MTFR scour testing is conducted subsequent to the minimum 125% MTFR scour testing, the existing sediment bed must be either replaced with fresh sediment or replenished with a minimum of two inches of fresh sediment that is added to the surface of the sediment bed to restore the 50% sediment depth.

C. Sampling Procedures

Effluent samples shall be collected via grab or isokinetic sampling and be a minimum of 500 mL.

D. Scour Testing Results

All effluent sample results from a scour test must be adjusted for background concentration [effluent sample = recorded effluent sample – background (maximum allowable background is 20 mg/L)]. Care must be taken to ensure that the scour effluent be adequately sampled at the high flow rates tested, recognizing splash potential and loss of sediment. This requires using wide mouth bottles or open beakers with handles at a minimum. The time each background and effluent sample is collected shall be recorded. The background data shall be plotted on a curve for use in adjusting the effluent samples for background concentration. All adjusted effluent samples from a scour test shall be included in the calculation of the average effluent TSS concentration. As stated above, there must be a minimum of 15 effluent sample results used to determine the average effluent TSS concentration.

For scour testing using the minimum 125% MTFR, the selected MTFR is deemed acceptable for off-line installation if the average effluent TSS concentration is no more than 20 mg/L above the average background concentration.

For scour testing performed to determine whether an MTD qualifies for on-line installation, the MTD is deemed acceptable for on-line installation if the average effluent TSS concentration is no more than 20 mg/L above the average background concentration. As mentioned previously, the minimum flow rate that must be used for on-line scour testing is 200% of the selected MTFR.

6. Scaling of HDS MTDs

The TSS removal rate determined for the tested full scale, commercially available MTD may be applied to similar MTDs with different maximum treatment flow rates (MTFRs.) Scaling is based on the horizontal footprint of the device; other scaling approaches fall under the alternative approach requiring two (2) models with an MTFR difference of at least 250% to be tested. For the purpose of "scaled geometrically proportional", the depth of the reference (tested) MTD is determined from the top of the false floor utilized during removal efficiency testing, not from the physical bottom of the unit.

Scaling the tested MTD to determine other model sizes and performance without completing additional testing is acceptable provided that:

A. The ratio of the MTFR to the Effective Sedimentation Treatment Area for the similar MTD is the same or less than the tested MTD; **and**

B. For similar MTDs with MTFRs within 250% of the tested unit's MTFR, surface area scaling is acceptable provided that the depth of the similar MTD is equal to or geometrically proportioned within 15% variation of the depth of the tested MTD; **or**

C. For a similar MTD with an MTFR that exceeds 250% of the tested unit's MTFR, the similar MTD must be scaled geometrically proportional to the tested unit; an MTD is considered geometrically proportional to a reference MTD when the ratios of the inside dimensions of length, width and depth is the same as the ratios of the inside dimensions of length, width and depth of the reference MTD; a deviation of 15 % is allowable in any dimension.

If requirements (A) and (B), or (A) and (C) are met, the TSS removal efficiencies of the similar MTD will be equal to the tested MTD's removal efficiency determined in Section 4.

If requirements (A) and (B), or (A) and (C) are not met, then a second full scale, commercially available MTD with an MTFR difference of at least 250% is required to be tested to validate the alternative scaling methodology. Testing of the similar model shall follow the same TSS Removal Efficiency Testing procedures as described in Section 4. The scaling methodology shall be deemed valid if the weighted TSS removal efficiency of the similar MTD is within five percentage points of the weighted TSS removal efficiency of the first tested MTD.

7. Units of Measure

All dimensions must be consistent with the following:

- **Area:** square feet
- **Concentration:** milligrams/liter
- **Flow Rate:** cubic feet per second, gallons per minute
- **Hydraulic Loading Rate:** gallons per minute per square foot
- **Length/Distance:** inches, feet
- **Velocity:** feet per second
- **Volume:** cubic feet, milliliter, liter, gallons

Appendix A - Requirements for HDS MTDs

A. Annualized Weighted TSS Removal Efficiency

The rainfall weighting factors in Table 1 are based on the total volume of annual runoff in an average year in New Jersey. For the selected MTFR from the MTFR removal efficiency curve (4.C.11), the annualized TSS removal rate shall be computed by multiplying the TSS removal efficiency for each flow rate, i.e., 25% MTFR, 50% MTFR, etc. from the MTFR removal efficiency curve for the selected flow rate, by the weighting factors in Table 1.

Table 1	
Tested Flow Rate as a Percentage of Maximum Treatment Flow Rate (MTFR)	**Annual Weighting Factor**
25%	0.25
50%	0.30
75%	0.20
100%	0.15
125%	0.10

B. Sediment Removal Interval Equation

Following determination of the HDS MTD's annualized weighted TSS removal efficiency, the HDS MTD's required sediment removal interval must be computed using the Required Sediment Removal Interval Equation shown below.

$$\text{Sediment Removal Interval (months)} = \frac{(50\%\text{ of HDS MTD Maximum Sediment Storage Volume} * 3.57)}{(\text{MTFR} * \text{TSS Removal Efficiency})}$$

$$\text{Sediment Removal Interval (years)} = \frac{(50\%\text{ of HDS MTD Maximum Sediment Storage Volume})}{(3.366 * \text{MTFR} * \text{TSS Removal Efficiency})}$$

This equation estimates the time required to accumulate a sediment depth and volume equal to 50% of the HDS MTD's maximum sediment storage depth and volume utilizing the HDS MTD's annualized weighted TSS removal efficiency rate, annual average New Jersey rainfall, an estimated runoff coefficient, sediment loading rate, wet sediment density, and an appropriate safety factor. The interval can be no more frequent than twice a year, and the sediment must be removed on or before it reaches a maximum depth of 50% of the MTD's maximum sediment storage depth and volume. For information on the Verification requirements for Maintenance refer to the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology: For use in accordance with the Stormwater Management Rules, N.J.A.C. 7:8."

Appendix B – Sediment Removal Equation Derivation

A. Constants

62.4 lbs/ft^3	Density of Water
2.65	Specific Gravity of Dry Sediment
2	Wet Sediment Bulking Factor
50%	Maximum Available Sediment Storage Volume
400 lbs/acre	Sediment Loading Rate
3.2 in/hr	Maximum Stormwater Quality Storm Rainfall Intensity for 10 Minutes
0.90	HDS MTD Drainage Area Runoff Coefficient
10 minutes	HDS MTD Drainage Area Time of Concentration

B. Volume of Sediment per Acre per Year

Density of Dry Sediment	= (62.4 lbs/ft^3)(2.65)	= 165 lbs/ft^3
Density of Wet Sediment	= (165 lbs/ft^3)/2 Bulking Factor	= 82.5 lbs/ft^3
Annual Sediment Volume per Acre	= (400 lbs/acre)/(82.5 lbs/ft^3)	= 4.85 ft^3/acre
Apply Safety Factor	= (4.85 ft^3/acre)(2 Safety Factor)	= 9.70 ft^3/acre
MTD Drainage Area in Acres	= MTFR/((3.2 in/hr)(0.9))	= (0.347)(MTFR)
Annual Sediment Volume Captured	= (9.70 ft^3/acre)(0.347)(MTFR)(TSS Removal Efficiency)	
	= (3.366)(MTFR)(TSS Removal Efficiency)	