IOWA STORMWATER MANAGEMENT MANUAL

5.05 HYDRODYNAMIC SEPARATORS

IOWA Department of Natural Resources

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Refer to the glossary for words in **bold black text.**
Some items of emphasis are in **bold blue text.**

5.05-1 LAYOUT AND DESIGN

A. SUMMARY

Hydrodynamic separators (HDS) are flow-through structures that are designed to remove sediments and pollutants from stormwater runoff. They are often used as **pretreatment** to protect downstream stormwater **best management practices** (BMPs). HDS devices are typically installed underground and therefore work well in sites with limited space, including **redevelopment** sites. Pollutants are removed from stormwater in HDS devices either by swirl action, baffles or plates to promote settling (1). HDS devices remove **settleable solids** and can also include features to remove trash, other floating debris, grease and oils. Different configurations exist to address most urban site constraints and devices can be customized to meet specific pollutant concerns. HDS devices can greatly improve the appearance of the downstream BMPs by keeping out **floating material.**

ISWMM recognizes testing protocols developed by the State of New Jersey Department of Environmental Protection (NJDEP) and the related American Society for Testing and Materials (ASTM) standards that are currently under development . Devices should be verified by New Jersey Corporation for Advanced Technology (NJCAT). Performance should be certified through the NJDEP, as manufactured HDS devices are often proprietary and previously lacked standardized requirements for testing and reporting. HDS systems should be designed using the NJDEP published treatment flow rates.

An access hatch or manhole lid provides access for a vacuum device, or other method of material removal to be used to remove collected materials. To keep the device functional, an inspection and maintenance schedule and procedure should be followed.

DESIGN PROCESS OVERVIEW

1. Complete Site Evaluation and Planning
2. Determine Watershed Subareas and Identify Locations for BMPs
3. Locate Pretreatment Practices
4. Develop Maintenance Plan
5. Integrate into Stormwater Plan

MAINTENANCE REQUIREMENTS

1. Designate Responsible Parties for Maintenance
2. Complete Construction Sequencing
3. Routinely Remove Accumulated Sediment and Debris from HDS
4. Perform Regularly Occurring Maintenance

NOTE

Previously, ISWMM had separate chapters for hydrodynamic and gravity separator devices. As the sizing and testing of these systems is the same, this revised section covers both types of devices.

Sources:
(1) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

NOTE

See ISWMM Section 3.01 for more information about the USC.

NOTE

Refer to Part 5.05-1.C for information on using HDS devices to meet WQv requirements.

B. APPLICATIONS

HDS devices are often used as **pretreatment** devices but may be used to address **Water Quality volume** (WQv) requirements if certain conditions are met. HDS systems will not reduce runoff rates significantly, so they do not address the larger storm event elements within the Iowa Stormwater Management Manual's (ISWMM) **Unified Sizing Criteria** (USC).

HDS systems are most effective at removing debris, total suspended solids (TSS) and total phosphorus (TP). They are expected to be less effective at removal of bacteria, nitrogen and metals (2). Designers should consider downstream **water quality impairments** when considering stormwater management approaches. BMPs other than HDS systems may be needed depending on which pollutants are of greatest concern at a given site.

HDS system being installed.

NOTE

This section outlines ISWMM's recommendations for use of HDS systems for pretreatment or as a water quality BMP. Each local jurisdiction may choose to amend when these systems are used for these purposes.

NOTE

The list on the NJDEP lists HDS units in either GI (green infrastructure) and Non-GI categories.

ISWMM recommendations don't require HDS units to be on the GI approved list to be considered a WQ practice, as long as it has a certified TSS removal rate of 80% on the NJDEP list.

C. DESIGN ELEMENTS AND CRITERIA

GENERAL BACKGROUND

To use a specific HDS device as a pretreatment BMP, the device should be verified by the New Jersey Corporation for Advances Technology (NJCAT) and certified for at least 50% TSS removal. ESSENTIAL

To use a specific HDS device as a water quality BMP, the device should be verified by the New Jersey Corporation for Advances Technology (NJCAT) and certified for at least 80% TSS removal. ESSENTIAL

Verification by NJDEP means that the device has been tested using standardized methods to verify the device's hydraulic characteristics and TSS removal efficiency. An additional requirement within the verification process is that a device have an individualized inspection and maintenance plan, which can be found in the certification report.

Sources:

(2) International Stormwater BMP database – 2020 Summary Statistics, 2020.

The NJDEP device testing methods include standards for test set up, measurement accuracy and data collection, and tests the device using a set up to reflect actual field installation parameters to the greatest degree possible. These testing methods are currently being developed into ASTM standards, which are in draft form at the time this publication was prepared.

ASTM C1745 describes the method to test **the device's hydraulic characteristics** by measuring parameters including flow, water elevation (or pressure head) and water temperature. Testing results from ASTM C1745 are then used to create a function describing the flow patterns and turbulence characteristics within the unit that can be applied to a wider range of conditions.

ASTM C1746 describes the **method for measuring TSS removal efficiency** of devices such as HDS devices. Parameters measured within ASTM C1746 standard help describe the device's range of removal efficiency and include discharge, particle-size distribution, particle density and flow viscosity (water temperature).

ASTM C1893 defines the **method for laboratory verification of HDS devices for the removal of suspended solids**. This standard sets requirements on laboratory qualification, the specifics of test operation, scaling results to additional devices and reporting, among others.

The State of New Jersey maintains a list of currently certified manufactured HDS devices, or manufactured treatment devices (MTD), which can be found at the below link:

https://dep.nj.gov/stormwater/stormwater-manufactured-treatment-devices/

FLOW RATE

All HDS systems on New Jersey's certified list will include a **Maximum Treatment Flow Rate** (MTFR) within their **certification letter.** To achieve the certified level of TSS removal, HDS devices should be selected so that the peak flow rate directed through the system during the Water Quality event (WQv) is not expected to exceed the certified MTFR for the selected unit. When calculating the WQv peak flow rate, the entire contributory drainage area to the HDS should be considered, including "off-site" areas. ESSENTIAL

The certification letter may also list specific limitations related to the HDS certification, which should be understood when selecting the HDS unit and the connected stormwater conveyance systems.

Figure 5.05-2-1: Example of MTFR listing from a New Jersey certification letter for 50% TSS removal

Table A-1 Cascade Separator™ Models and Associated MTFRs

Model	Manhole Diameter (ft)	MTFR (cfs)	50% Maximum Sediment Storage Area Volume (ft^3)
CS-3	3	1.02	5.3
CS-4	4	1.80	9.4
CS-5	5	2.81	14.7
CS-6	6	4.05	21.2
CS-8	8	7.20	37.7
CS-10	10	11.3	58.9
CS-12	12	16.2	84.8

Sources:

(3) ASTM C1745/C1745-M

(4) ASTM C1746/C1746M - 19

(5) ASTM C1893 - 23

(6) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

Figure 5.05-2-2: Example of MTFR listing from a New Jersey certification letter for 80% removal

Table 1. Aqua-Filter™ Stormwater Filtration System Model MTFRs and Maximum Allowable Drainage Area

Aqua-Filter™ Model	Number of Filter Bags	Effective Filtration Treatment Area (ft^2)	MTFR (cfs)[1]	Maximum Allowable Drainage Area (acres)
AF-2.1	12	12	0.21	0.21
AF-3.2	24	24	0.42	0.42
AF-4.3	36	36	0.64	0.63
AF-5.4	48	48	0.85	0.84
AF-6.5	60	60	1.06	1.05
AF-7.6	72	72	1.27	1.26
AF-7.7	84	84	1.49	1.47
AF-8.8	96	96	1.70	1.68
AF-8.9	108	108	1.91	1.89
AF-8.10	120	120	2.12	2.10
AF-8.11	132	132	2.34	2.31
AF-9.12	144	144	2.55	2.52
AF-9.13	156	156	2.76	2.73
AF-10.14	168	168	2.97	2.94
AF-10.15	180	180	3.19	3.15
AF-10.16	192	192	3.40	3.36
AF-11.17	204	204	3.61	3.57
AF-11.18	216	216	3.82	3.78
AF-11.19	228	228	4.04	3.99
AF-12.10 Twin	240	240	4.25	4.20
AF-12.11 Twin	264	264	4.67	4.62
AF-13.12 Twin	288	288	5.10	5.04
AF-13.13 Twin	312	312	5.52	5.46

1 Calculated based on 7.93 gpm/ft^2 (0.0177 cfs/ft^2) of effective filtration treatment area.

It is recommended that the HDS unit be designed in an "offline" configuration, where a diversion structure is used to limit the rate of flow allowed to enter the HDS. In this configuration, higher flow rates would bypass the HDS to reduce the potential for **resuspension.** HDS systems are not always tested for resuspension potential, as most testing systems are limited in the amount of flow that can be passed through the device (7). TARGET

Future connections to a system that includes an HDS device should not be allowed if those additional connections would cause the MTFR or the hydraulic capacity of the device to be exceeded. ESSENTIAL

DEPTH

HDS devices are manufactured systems, which may limit the range of depths that inflow and outflow pipes can be set at. The designer should consult with the manufacturer to understand these limitations to ensure that the selected device can be installed with the desired depths of the connected storm sewer system.

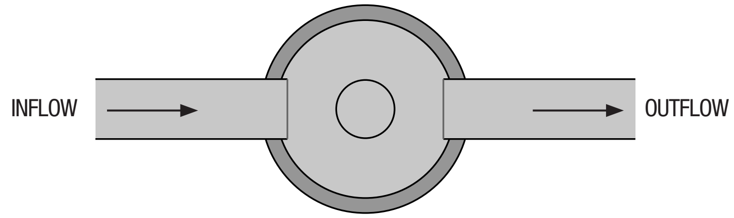
CONFIGURATION

The HDS should be designed and installed with the same configuration utilized during the testing for verification. For example, if the device was only tested with inlets and outlets in a 180-degree configuration (inlet and outlet pipes would be along a straight line passing through the system), then the designed HDS unit should match that configuration. Unless other angles are specifically tested during the verification, only inlet and outlet pipes of 180 degrees (straight line) are acceptable. Some units have been tested in different configurations, so the designer needs to understand the basis of approval for the HDS device they intend for use. ESSENTIAL

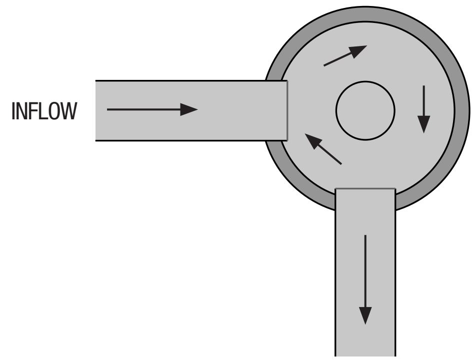
The full reports of each test, including details of the testing process and configurations can be downloaded from New Jersey Technology Verification Database.

NJCAT.org - Technology Verification Database

HDS devices may not include grate inlets that convey surface runoff directly into the unit unless the device was specifically tested and certified with a matching type of inlet. ESSENTIAL



180 degree configuration



90 or 270 degree configuration

To use the HDS system as an inlet or a structure to change pipe alignment, the HDS system should have been tested and certified using the configuration being proposed by the designer.

NOTE

See Part 5.05-2 of this Section for additional information on calculation of the peak flow rate.

Sources:

(7) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

STRUCTURAL CONSIDERATIONS

The recommended separation from the **seasonal high-water table** is dependent upon the HDS that is chosen. Refer to the certification letter and manufacturer's design guidance as applicable. All joints and connections should be watertight.

All HDS devices which are subject to vehicular loading should be designed for at least HS-20 traffic loading at the surface (8). Higher design standards may be needed in cases where higher loadings from traffic or maintenance vehicles are expected. ESSENTIAL

OUTFLOW

Any connection from the HDS device to downstream storm sewers or stormwater management systems should include provisions for access to the pipe network such as a manhole, storm inlet, or outfall to allow for inspection and maintenance. A direct subsurface connection to an enclosed pipe or culvert is not recommended. TARGET

TAILWATER

Any effects of **tailwater** conditions listed within the manufacturer's recommendations for the HDS device should be observed. TARGET

ACCESS REQUIREMENTS

Collected trash, sediments and other pollutants are typically removed by a vacuum truck or other maintenance vehicle. The HDS unit should be placed within or close enough to a drivable access path to reach the depth within HDS unit where collected materials are to be removed. The access path should be clear of obstructions and be wide enough to accommodate the anticipated maintenance vehicle. The designer should consult with the owner or party responsible for maintenance to understand the type of maintenance equipment that is expected to be used and to locate the access path with the proper location, width and grades (9). ESSENTIAL

D. SPECIAL CASE ADAPTATIONS

TRASH COLLECTION

Some HDS devices are designed to increase the interception of floatable materials and trash, but the effectiveness of these systems will vary. If trash collection is a priority, the designer should refer to the manufacturer's design guidance.

If a higher standard is desired for trash collection, the State of California has developed very stringent standards related to the interception of trash. These standards are focused on trapping all particles that are greater than five (5) millimeters in size (10). The screening devices used to meet these standards often reduce the capacity of the trash capture unit to very low levels. There are very few HDS units that are capable of meeting both the NJDEP certifications and the California trash capture certifications. So, if that level of trash capture is desired, there may be a limited selection of units to choose from, or separate units for TSS and trash removal would be needed.

At the time of this publication, there are no jurisdictions in Iowa with requirements like the California standard. However, this information is provided for reference in the case that such high levels of trash capture are desired for a specific project. The California standards can currently be viewed at the link below:

https://www.waterboards.ca.gov/water_issues/programs/stormwater/trash_implementation.html

NOTE

H-20 traffic loading is as defined by the American Association of State Highway Transportation Officials (AASHTO). It is based on a wheel loading of 8 tons or a axle loading of 16 tons.

NOTE

There are state and federal training and safety requirements that need to be observed if personnel have to enter confined spaces for maintenance.

Sources:

(8 and 9) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

(10) Certified Trash Full Capture Systems, November 2023.

HOTSPOTS OR OIL CAPTURE

Some HDS units include or allow for inserts and/or sorbent pads that increase the capture of floatable pollutants such as oils and gasoline. Refer to manufacturer's guidance when selecting HDS systems for the purpose of capturing these types of pollutants.

OUTFALL RETROFITS

If an HDS device is being considered for an outfall retrofit, it should be sized based on the peak flow rate for the WQv event for the entire drainage area that is being routed through the device. **ESSENTIAL**

PRACTICES IN SERIES

As mentioned previously, HDS systems are most effective at reducing levels of TSS and phosphorus. If it is a project goal to target other pollutants such as bacteria, nitrogen and/or metals, other BMPs could be employed to act in series to develop a train of treatment practices. Passing stormwater through multiple BMPs can better address a wider array of pollutant types.

5.05-2 SIZING CALCULATIONS

A. CALCULATION PROCEDURE

1. **Determine the watershed area for which the HDS is expected to provide pretreatment or water quality management.** Assess the parameters of that area, including total area, impervious cover, soil type and level of soil quality restoration (or existing soil quality).

2. **Determine the required WQv volume and peak flow rate expected to pass through the HDS device during the WQv storm event.**

3. **Review the NJDEP certification letters and the manufacturer's guidance materials for the proposed HDS device, and ensure that all criteria are met,** including the peak flow rate for the WQv event is less than the HDS device maximum treatment flow rate (MTFR) (11).

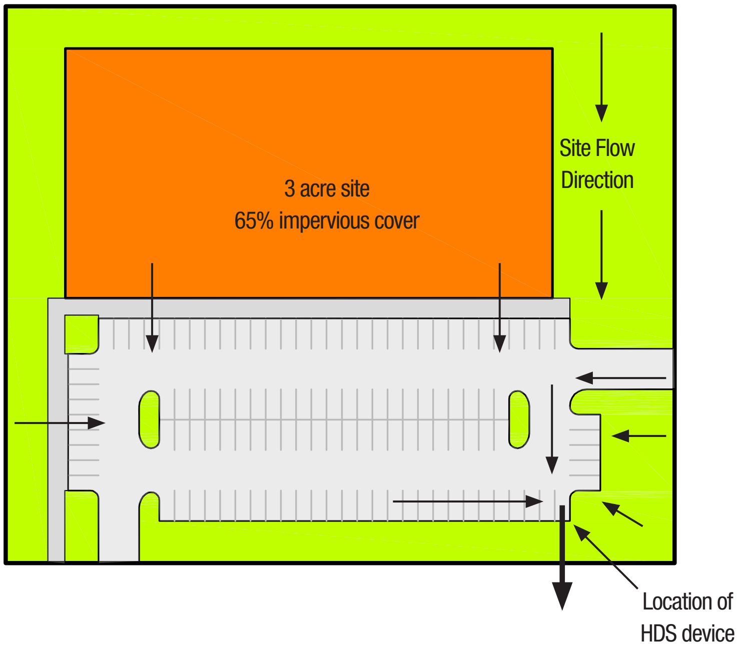
4. **Design the diversion structure, if applicable.**

B. DESIGN EXAMPLE

DESIGN EXAMPLE #1 – USING HDS AS A PRETREATMENT PRACTICE

Step 1: Determine the watershed area for which the HDS is expected to provide pretreatment. Assess the parameters of that area, including total area, **impervious cover,** soil type and level of **soil quality restoration** (or existing soil quality).

- A HDS device is being considered to meet the pretreatment requirements for a 3-acre commercial site, with 65% impervious cover.
- The site has **Hydrologic Soil Group** B type soils, based on county soil map data obtained through the NRCS Web Soil Survey website.
- Topsoil is to be stripped and respread to a depth of 8" across all open space areas so that open spaces can be considered in good condition for determining **Curve Numbers**, as per ISWMM's Soil Quality Management and Restoration Section.
- The **time of concentration** has been computed to be 10-minutes (this would typically be calculated, but is given for this example).



Sources:

(11) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

Step 1A: **Calculate the Runoff Coefficient used for Water Quality volume calculations.** The formula to be used is from the ISWMM Small Storm Hydrology Section.

Rv = 0.05 + 0.009 (I) **Equation 5.05-2-1**

Where:

Rv = runoff coefficient for WQv event

I = impervious cover (%)

Rv = 0.05 + 0.009 (65) = 0.635

Step 1B: **Calculate the runoff volume expected to be generated by the WQv (1.25") event.**

Qa = Rv x P **Equation 5.05-2-2**

Where:

Qa = runoff volume generated by the WQv event

Rv = runoff coefficient from Step 1a

P = rainfall from WQv event (1.25 inches)

Q_a = 0.635 x 1.25 inches = 0.794 watershed-inches

Step 1C: **Calculate the adjusted Curve Number (CN) to use to determine peak flows from the Water Quality event.** This formula is taken from the ISWMM Small Storm Hydrology Section.

$$CN = \frac{1000}{[10 + 5P + 10Q_a] - 10(Q_a{}^2 + 1.25Q_aP)^{\frac{1}{2}}}$$ **Equation 5.05-2-3**

Where:

CN = Adjusted CN for the WQv event

P = rainfall from WQv event (1.25 inches)

Q_a = runoff volume generated by the WQv event from Step 1b

$$CN = \frac{1000}{[10 + 5(1.25) + 10\,(0.794)] - 10 * [(0.794)^2 + 1.25(0.794)(1.25)]^{\frac{1}{2}}}$$

$$CN = \frac{1000}{10.511}$$

CN = 95

Step 2: Determine the required WQv volume to be routed through the HDS device and the peak flow rate expected to pass through the HDS device during the WQv storm event.

Step 2A: **Calculate the Water Quality volume to be treated by the WQv (1.25”) event (in cubic feet).**

WQv = Qa x A /12 **Equation 5.05-2-4**

Where:

WQv = water quality volume (in acre-feet)

Qa = runoff volume generated by the WQv event (in watershed inches, from Step 1b)

A = watershed area (in acres)

Qa = 0.794 watershed-inches x 3 acres / (12 inches/foot) = 0.1985 acre-feet

Converting acre-feet to cubic feet (CF):

0.1985 acre-feet x 43,560 (CF / acre-feet) = 8,647 CF

Step 2B: **Calculate the peak flow rate in cubic feet per second (cfs) generated by the WQv event.**

The NRCS TR-55 method will be used to calculate the peak flow rate. For this example, Hydraflow Hydrographs Extension from AutoDesk was used to perform the TR-55 calculations. For the WQv event, the input parameters were:

Area = 3 acres

Time of Concentration = 10 minutes

Shape Factor = 484

Adjusted Curve Number = 95 (from Step 1C)

Simulation Time Step Interval = 1 minute

WQv event Rainfall = 1.25”

Results: WQv peak flow rate = 3.7 cfs

WQv runoff volume = 8,540 CF

Note that the runoff volume calculated in this step is similar to the value solved in Step 2A (only about 1% difference). **This is a good way to double check that the adjusted CN value used is correct.**

Step 3: Review the NJDEP certification letters and the manufacturer's guidance materials for the proposed HDS device, and ensure that all criteria are met, including that the peak flow rate for the WQv event is less than the HDS device maximum treatment flow rate (MTFR). **To be used as a pretreatment practice, the certified removal rate for the selected HDS system must be at least 50%.**

The designer can review the systems certified at the link previously noted.

https://dep.nj.gov/stormwater/stormwater-manufactured-treatment-devices/

One example that is listed as meeting the criteria (as of the date of the publication of this section) would be the First Defense® Optimum Vortex Separator by Hydro International. It is certified to have a TSS Removal Rate of 50%. The certified MTFR is as noted in Figure 5.05-2-1. To treat the WQv peak rate of 3.7 cfs (from Step 2B), the model with a 6-foot manhole diameter would be required (MTFR = 4.07 cfs).

Figure 5.05-2-1: Certification Letter Table Example

Table 1. FD Optimum Model and MTFRs

FD Optimum Model	Manhole Diameter (ft)	MTFR (cfs)
3-ft	3	1.02
4-ft	4	1.81
5-ft	5	2.83
6-ft	6	4.07
7-ft	7	5.53
8-ft	8	7.23
10-ft	10	11.33

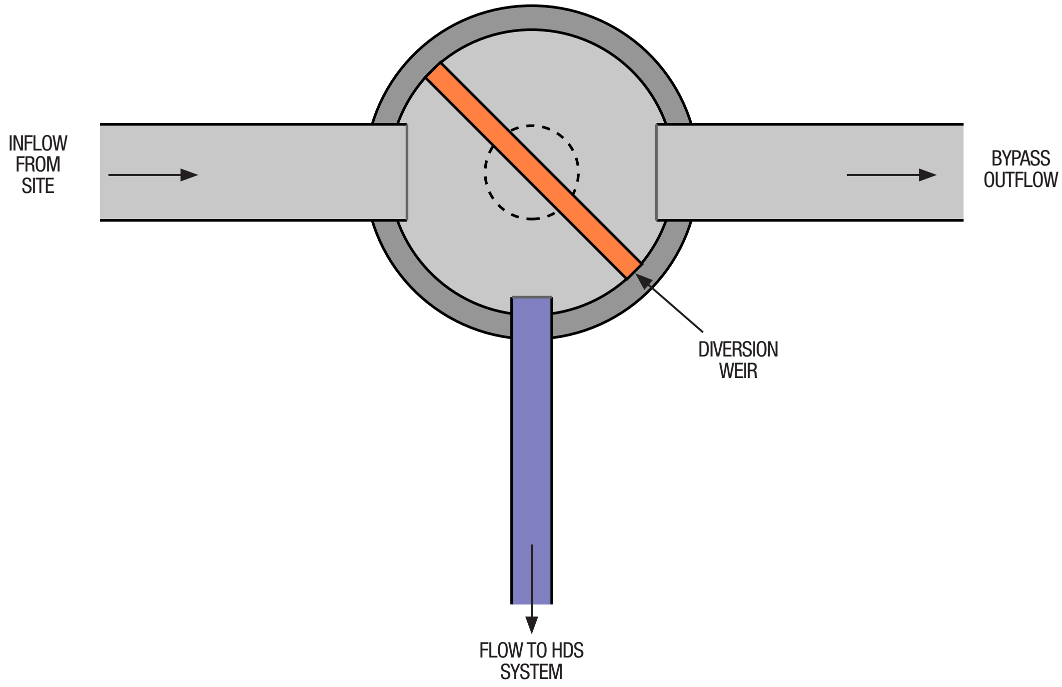
Device selected for this example

Step 4: **Design the diversion structure, if applicable.**

To reduce the potential for resuspension and to make sure the HDS device does not impede the storm sewer capacity to convey larger storm events, a bypass structure will be used in this example.

The diversion structure is designed to direct the entire WQv flow through the HDS device, but allow higher flow raters caused by larger storm events to bypass the unit.

Note: If the system was being designed with an online configuration, the entire design flow would have to pass through the HDS device. The designer would skip the step of sizing the diversion structure but would need to check that the unit has the hydraulic capacity to pass that level of flow.



Step 4A: **Find the peak flow rate expected for the rain event used to size the storm sewer system that is connected to the HDS device.**

For this example, it will be assumed that the local jurisdiction requires the storm sewer network to be designed to convey the 10-year storm event.

Either TR-55 or the rational method could be used to calculate the peak flow for the 10-year storm event.

For TR-55, the typical Curve Number used for storms at the 1-year event level or larger needs to be calculated. These are found by using the CNs listed in the TR-55 reference manual information, which are included in the related ISWMM Section.

For this example, with HSG B soils, 65% impervious cover and 8" topsoil applied to open spaces, the weighted CN (CNw) would be:

CN = 98 (impervious surfaces), 61 (open spaces in GOOD condition, since 8" topsoil is provided)

CNw = 65% x 98 + 35% x 61 = 85

The runoff rate and volume expected to be caused by a 10-year storm event is calculated using the same TR-55 method as used in Step 2B, except that the standard CNw (85) is used and the rainfall volume of 4.46"(for a site located in Region 5, Central Iowa).

Results: 10-year peak flow rate = 13.6 cfs 10-year runoff volume = 31,300 CF

If the rational method were used, refer to the methods and runoff coefficient values listed in the SUDAS Section 2.

Table 2B-4.01 of Section 2B-4 (Runoff and Peak Flow) lists the following runoff coefficients to use for the 10-year event for HSG B soils:

C = 0.95 (impervious surfaces), 0.20 (open spaces in GOOD condition, since 8" topsoil is provided)

The weighted value for runoff coefficient (Cw) would be calculated as:

Cw = 65% x 0.95 + 35% x 0.20 = 0.69

In Section 2B-2 (Rainfall and Runoff Periods), the design rainfall intensity (I) use in the rational method equation for Central Iowa with a time of concentration of 10 minutes is 5.08 inches per hour.

Using the rational method equation:

$$Q = C \times I \times A$$ **Equation 5.05-2-4**

Where:

Q = peak flow rate (cfs)

C = rational method runoff coefficient

I = rainfall intensity (inches per hour)

A = watershed area (acres)

Q = 0.69 x 5.08 inches/hour x 3 acres = 10.5 cfs

Note that in this example, the value calculated using the rational method is 23% less than the value solved using the TR-55 method.

For this example, we will assume that the designer is choosing to use the more conservative, or higher, design flow solved using the TR-55 method (13.6 cfs).

Step 4B: **Size the opening to the HDS device, using the orifice equation.**

$$Q = CA\,(2gh)^{1/2}$$ **Equation 5.05-2-5**

Where:

Q = WQv flow rate to route to the HDS device (cfs), from Step 2B

C = orifice coefficient (0.60)

A = cross-sectional area of the orifice or pipe opening (square feet)

g = gravitational acceleration constant (32.2 ft/s^2)

h = head, which is the elevation difference between the expected elevation of the diversion wall and the center of the orifice or pipe opening to the HDS device (feet)

This may require some iteration or trial and error to find the right balance between the desired orifice or pipe opening size and the elevation of the diversion weir.

NOTE

Rational method calculations are listed here, as it is a method commonly used for storm sewer system design for small watersheds.

In this example, the designer could also choose to adjust the rational method runoff coefficient (C) so that the calculated peak flow matches the value found using TR-55. In this way, the storm system upstream would be sized to match the flow rates calculated using TR-55.

In this case, if C were adjusted to 0.89, then Q = 13.6 cfs.

If the designer were to try a 10-inch orifice or pipe opening, with a desired head (h) of 2 feet:

The cross-sectional area of a circular opening would be found from the formula:

$$A = \frac{\pi d^2}{4}$$ **Equation 5.05-2-6**

Where:

A = cross-sectional area of the orifice or pipe opening (square feet)

d = opening diameter (feet)

$$A = \frac{\pi \left(\frac{10}{12} feet\right)^2}{4}$$

$$A = 0.55\ square\ feet$$

Use that value of A to solve for the capacity of the opening, with "h" chosen to be 2.0 feet as noted above:

$$Q = CA\,(2gh)^{1/2}$$

$$Q = (0.60)(0.55)\,(2 * 32.2 * 2.0)^{1/2}$$

$$Q = 3.8\,cfs$$

Since the capacity of the opening (3.8 cfs) is greater than the WQv peak flow event (3.7 cfs), this design will work.

For a factor of safety, it might be wise to raise the top of the weir wall a few inches to account for construction tolerances. So, moving forward, the head difference (h) between the center of the opening and the crest of **the diversion weir will be set at 2.25 feet.**

Step 4C: **Size the length of the weir needed to convey the bypass flow.** The weir should be wide enough that the design flow for the storm sewer that exceeds the flow being directed to the HDS device can physically pass over the weir within the structure and not cause significant backflow in the upstream storm system.

Flow over a weir can be solved by the following equation:

$$Q = C\ L\ H^{3/2}$$ **Equation 5.05-2-7**

Where:

Q = Flow to pass over the weir (cfs)

C = weir coefficient (3.3 for a sharp-crested weir)

L = length of the weir, measured perpendicular to flow over the wall (feet)

H = head, which is the elevation difference between the expected high-water elevation of water immediately upstream of the weir and the top elevation of the weir (feet)

So, if the 10-year storm event design flow is 13.6 cfs (from Step 4A) and the flow we are diverting through the HDS device is 3.7 cfs, then the bypass flow is found to be:

Q = 13.6 cfs – 3.7 cfs = 9.9 cfs

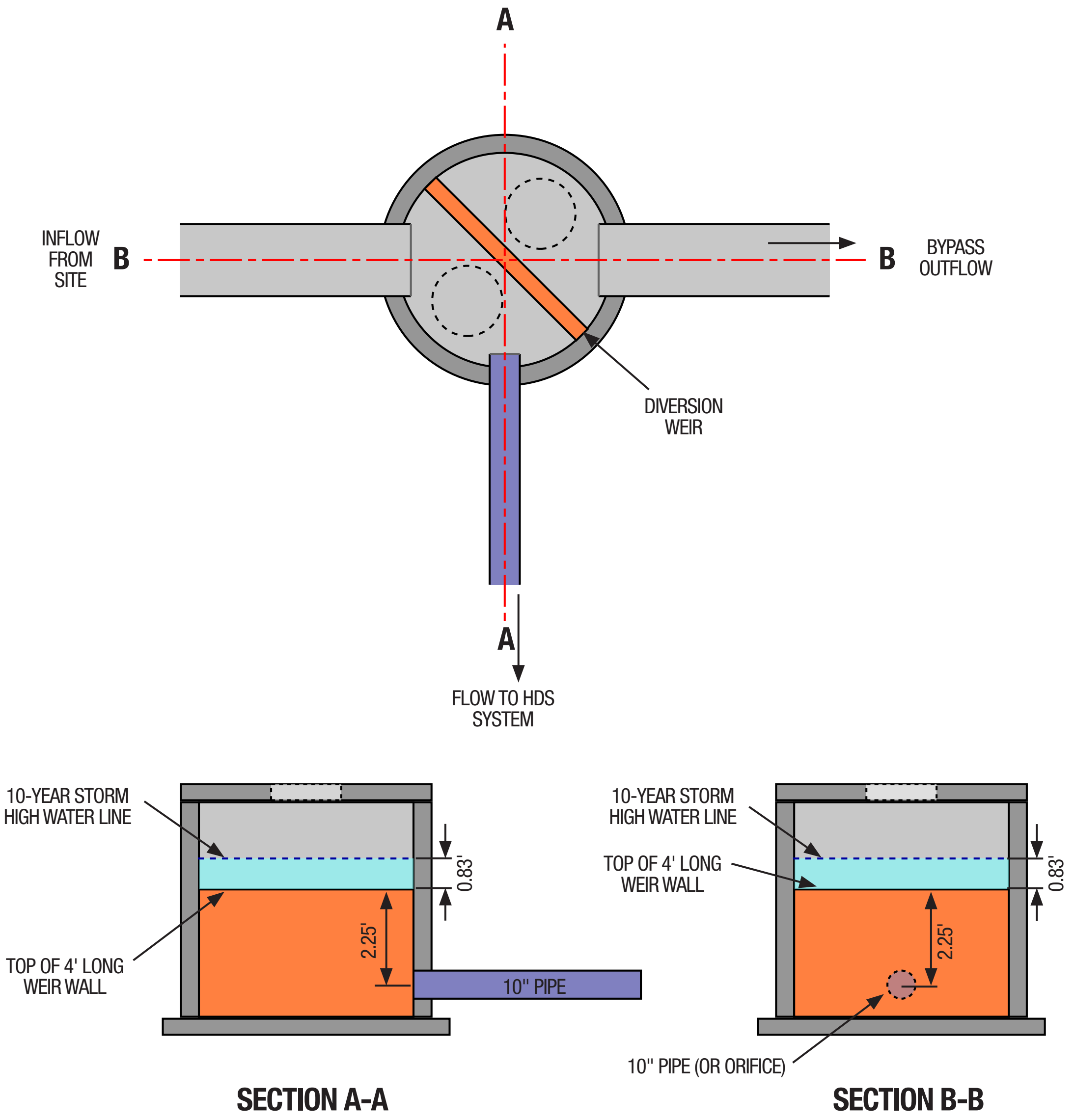
Again, this step may require some iteration or trial and error to find the right balance between the desired weir length and the high-water depth above the weir.

If the designer were to try a 4-foot long weir, with a head of 0.83 feet:

$$Q = (3.3)\ (4\ ft)(0.83\ ft)^{3/2}$$

$$Q = 10.0\ cfs$$

Since the capacity of over the weir (10.0 cfs) is greater than the expected bypass flow for the design event (9.9 cfs), this design will work. The designer should also recheck that this design high-water level will not create a tailwater condition for the upstream storm network that would prevent it from being able to convey the design storm event.



NOTE

In Step 4B, the final distance (h) from the center of the orifice to the top of the weir wall was set at 2.25 feet.

In Step 4C, the expected high water elevation flowing over the bypass weir was found to be 0.83 feet.

Step 4D: **Recheck the expected flow through the HDS device during the design event, to make sure the HDS system will not exceed its capacity or experience resuspension.** In this case, the values from Step 4B can be used, except that the head (h) will be the elevation difference from the center of the orifice height to the high-water elevation above the weir during the design event.

h = (elevation from center of opening to top of weir) + (elevation from top of weir to high-water elevation above weir)

h = 2.25 feet (from Step 4B) + 0.83 feet (from Step 4C)

h = 3.08 feet

$$Q = CA\,(2gh)^{1/2}$$

$$Q = (0.60)(0.55)\,(2 * 32.2 * 3.08)^{1/2}$$

$$Q = 4.6\,cfs$$

The designer should double check the manufacturer's specifications and product information to verify that this increased flow will not cause resuspension or that the unit itself has the capacity to convey that flow.

DESIGN EXAMPLE #2 – USING HDS AS A WATER QUALITY TREATMENT PRACTICE

Step 1: Determine the watershed area for which the HDS is expected to be used as a water quality practice. Assess the parameters of that area, including total area, impervious cover, soil type and level of soil quality restoration (or existing soil quality).

This example will use the same site parameters as design example #1.

- A HDS device is being considered to meet the Water Quality volume requirements for a 3-acre commercial site, with 65% impervious cover.
- The site has Hydrologic Soil Group B type soils, based on county soil map data obtained through the NRCS Web Soil Survey website.
- Topsoil is to be stripped and respread to a depth of 8" across all open space areas so that open spaces can be considered in good condition for determining Curve Numbers, as per ISWMM's Soil Quality Management and Restoration Section.
- The time of concentration has been computed to be 10-minutes (this would typically be calculated, but is given for this example).

The calculations for Steps 1 and 2 would be the same as shown for Design Example #1.

NOTE

The list on the NJDEP lists HDS units in either GI (green infrastructure) and Non-GI categories.

ISWMM recommendations don't raequire HDS units to be on the GI approved list to be considered a WQ practice, as long as it has a certified TSS removal rate of 80% on the NJDEP list.

Step 3: Review the NJDEP certification letters and the manufacturer's guidance materials for the proposed HDS device, and ensure that all criteria are met, including that the peak flow rate for the WQv event is less than the HDS device maximum treatment flow rate (MTFR). To be used as a water quality BMP, the certified removal rate for the selected HDS system must be at least 80%.

The designer can review the systems certified at the link previously noted.

https://dep.nj.gov/stormwater/stormwater-manufactured-treatment-devices/

One example listed as meeting that criteria (as of the date of publication of this section) would be the Aqua-Filter™ Stormwater Filtration System with Perlite Media by AquaShield, Inc. It is certified to have a TSS Removal Rate of 80%. The certified MTFR is as noted in Figure 5.05-2-2. To treat the WQv peak rate of 3.7 cfs (calculated in Step 2B, from Design Example #1), Model AF-11.18 would be needed (MTFR = 3.82 cfs).

Figure 5.05-2-2: Certification Letter Table Example

Table 1. Aqua-Filter™ Stormwater Filtration System Model MTFRs and Maximum Allowable Drainage Area

Aqua-Filter™ Model	Number of Filter Bags	Effective Filtration Treatment Area (ft^2)	MTFR (cfs)[1]	Maximum Allowable Drainage Area (acres)
AF-2.1	12	12	0.21	0.21
AF-3.2	24	24	0.42	0.42
AF-4.3	36	36	0.64	0.63
AF-5.4	48	48	0.85	0.84
AF-6.5	60	60	1.06	1.05
AF-7.6	72	72	1.27	1.26
AF-7.7	84	84	1.49	1.47
AF-8.8	96	96	1.70	1.68
AF-8.9	108	108	1.91	1.89
AF-8.10	120	120	2.12	2.10
AF-8.11	132	132	2.34	2.31
AF-9.12	144	144	2.55	2.52
AF-9.13	156	156	2.76	2.73
AF-10.14	168	168	2.97	2.94
AF-10.15	180	180	3.19	3.15
AF-10.16	192	192	3.40	3.36
AF-11.17	204	204	3.61	3.57
AF-11.18	216	216	3.82	3.78
AF-11.19	228	228	4.04	3.99
AF-12.10 Twin	240	240	4.25	4.20
AF-12.11 Twin	264	264	4.67	4.62
AF-13.12 Twin	288	288	5.10	5.04
AF-13.13 Twin	312	312	5.52	5.46

1 Calculated based on 7.93 gpm/ft^2 (0.0177 cfs/ft^2) of effective filtration treatment area.

Device selected for this example (AF-11.18)

DESIGN EXAMPLE #3 – PRACTICES IN SERIES

If other water quality BMPs are employed upstream of a HDS system to manage part of the Water Quality volume requirements, the WQv peak flow rate may be reduced by the proportion of the WQv volume treated by those practices.

- For example, if water quality BMPs are proposed that are sized to manage 60% of the WQv requirements from the area draining to the HDS unit, the WQv peak flow rate to be routed through the HDS unit can be reduced by 60%.
- **If this were the case for Design Examples #1 and #2, the peak rate expected to be routed through the HDS system during the WQv storm event would be:**

  3.7 cfs (from Step 2B) x (100% - 60%) = 3.7 cfs x 40% = 1.48 cfs

- **In such a case, Steps 3 and 4 would be performed based on this adjusted WQv flow rate.**
- Keep in mind, when using multiple water quality BMPs, **individual BMPs should only take credit for up to the WQv volume expected to flow through that practice.** Oversized practices should not be given “extra credit” to offset for untreated flows that don’t pass through that practice, or to take credit for WQv volumes that have already been treated by another BMP upstream.
- The peak flow rates calculated for larger storm events (1-year storm and larger) should not be adjusted based on upstream BMPs, unless such practices serve a stormwater detention function. In that case, stormwater detention routing could be modeled to determine the reduced peak flow rates.

5.05-3 CONSTRUCTION

A. EROSION AND SEDIMENT CONTROL

If the HDS is part of a project whose total disturbed area exceeds one acre (including all parts of a common plan of development) a stormwater pollution prevention plan (SWPPP) is required by state and federal law to be prepared.

Prior to construction, coverage under the State of Iowa's NPDES General Permit No. 2 shall be obtained (or, if required, coverage through an individual permit).

The SWPPP document will meet state and local regulatory requirements and will detail the structural and non-structural pollution prevention best management practices (BMPs) that are to be employed at the site.

HDS devices are intended to capture sediments and pollutants from post-construction stormwater conditions. They are not intended to act as a sediment control device for active construction sites or other land used where large, disturbed areas are present (such as agricultural fields). Upstream erosion and sediment control measures should be put into place to protect the HDS device until all disturbed areas are fully stabilized in a post-construction condition.

B. CONSTRUCTION SEQUENCING

HDS systems are typically installed late in project construction, or constructed in a fashion where flow can be restricted from entering the device until the upstream area is stabilized. If a diversion structure is being used, this could be accomplished by plugging the smaller opening that directs flow into the HDS device. Until the plug is removed, all flow will pass over the diversion weir, bypassing the HDS unit.

HDS system being installed.

C. CONSTRUCTION OBSERVATION

A designated representative of the owner should observe construction operations on a frequent basis to confirm the following:

- The HDS device delivered to the site matches the product type, size and elevations as included on design plans and that the inflow and outflow points are placed in the correct orientation.
- Evaluate the condition of the HDS to make sure there are not any cracks, other defects present that might occur prior to or after installation.
- Storm sewer and pipe structures are installed to the dimension, location and elevations specified on the plans. Verify that proper installation techniques and trench compaction techniques have been followed. (Compaction tests are often performed by a geotechnical engineer and provided for owner review.)
- The dimensions and elevations of the diversion structure, including pipes, openings and weirs matches the plans.
- As applicable, delay installation of the HDS device or block flow entry to the HDS while major construction activities are ongoing. Once the upstream areas are fully stabilized, remove the flow blockage.
- Proper compaction around all storm structures should be verified.
- Storm facilities should be kept free of sediment and debris during construction and inspected again at a final site walk-through. Inspect the HDS device when the flow blockage is removed (if applicable) and prior to final acceptance to make sure sediment or debris has not accumulated in the device. Remove any such materials prior to final acceptance.
- Complete a walk-through with the designer and contractor to identify any items which are not in compliance with project requirements. Document said issues in a punch list and confirm when all such items are installed.
- As needed by the local jurisdiction, author a letter of acceptance noting either conformance with construction documents, or any allowed deviation thereof.

HDS device being maintained using a vacuum truck.

If the project is required to be permitted under the State of Iowa's NPDES General Permit No. 2, qualified personnel shall be employed to complete the following until final establishment:

- Maintain and update the SWPPP document and retain records.
- Conduct site inspections as required by the general permit.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- Verify that exterior sediment and erosion BMPs are in place prior to initiation of site disturbing activities.
- Observe that interior BMPs are implemented as site work progresses.
- Complete site inspection reports, make recommendations for additional BMPs as necessary.
- Upon final establishment of permanent vegetation (as defined by the permit), recommend to the owner that the site Notice of Discontinuation be completed and submitted to the Iowa Department of Natural Resources (DNR).

D. POST-CONSTRUCTION DOCUMENTATION

During construction, records should be kept by the contractor (and site observer) that will allow record drawings of constructed improvements to be provided to the owner. To demonstrate that the project has complied with contract documents, these records should include, but not be limited to, the following:

- The horizontal and vertical position of the HDS device and adjacent storm sewer pipes, manholes, inlets and diversion structures.

5.05-4 MAINTENANCE

ROUTINE OR LONG-TERM MAINTENANCE ACTIVITIES

Regular and effective maintenance is needed to ensure that the HDS device can perform as intended. These units are installed below grade, so there is a danger of the "out of sight, out of mind" mentality. Debris and sedimentation in a forebay or other pretreatment practice that is installed on the surface of the land may be more easily seen. With HDS devices, the device needs to be opened and inspected to see what has been collected and how full the unit is.

If the collection areas within the devices are full, the device's ability to intercept and trap additional pollutants will be severely limited. A detailed maintenance plan should be developed for each HDS device installed, based on the maintenance plan provided by the manufacturer. Designers should refer to any information within the New Jersey certification letter and the manufacturer's guidance materials. The methods of maintenance and frequency will vary depending on the type of structure selected. The maintenance plan should clearly define the expected frequency of maintenance and indicate the allowable levels of oil, sediment and debris accumulation.

The developed maintenance plan should be provided for the owner's review before final selection of the HDS unit. The owner needs to understand what maintenance activities are required, how frequently they should be performed and what equipment will be necessary. The final maintenance plan should be developed into a checklist that the owner can use to schedule and verify that required maintenance has been completed. Some jurisdictions require that maintenance records be kept for water quality and/or pretreatment practices. Records should be kept by the owner as necessary to meet any reporting requirements that a local jurisdiction may have.

Trash collection inside an HDS unit.

In addition to the manufacturer's recommendations, the following maintenance activities should be performed:

Table 5.05-4-1 – Maintenance Activity Schedule Template

Activity	Schedule
Inspect structural components for cracking, settling, erosion and deterioration.	At least once annually.
Inspect collection areas expected to receive and/or trap debris and sediment for clogging.	At least twice annually, as well as after every storm exceeding 1.25 inch of rainfall.
During inspections, examine the HDS device for standing water. If standing water is present in the device, and standing water is not expected as part of its design, take corrective action and revise the maintenance plan to prevent standing water in the future.	Whenever device is inspected.
If the device is being used to reduce nutrient pollution, maintenance should be performed after fall leaf drop and before spring snowmelt.	As noted, as applicable.
Sediment removal activities should be performed when all runoff has drained from the HDS.	As per manufacturer's guidelines or as otherwise specified in certification letters.
Dispose of debris, trash, sediment and other waste material in compliance with all applicable local, state and federal waste regulations.	Whenever collected sediments, debris or pollutants are removed.
Repair any surrounding plants, landscape areas or paved surfaces damaged during access for maintenance activities.	When observed.

[12] Adapted from the New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

Sources:

(12) New Jersey Stormwater BMP Manual, Chapter 11.3, July 2023.

5.05-5 SIGNAGE RECOMMENDATIONS

Signage could be provided as an educational tool to detail the purpose and function of the HDS to the general public. Signage can also be used to advise maintenance staff on the location of the HDS device and of its maintenance requirements.

Educational sign installed at a HDS unit.

5.05-6 GLOSSARY

Best Management Practice (BMP)	A feature designed to meet stormwater water quality or quantity management goals.
Certification letter	An official letter written by the State of New Jersey Department of Environmental Protection (NJDEP) that outlines the approval parameters for various HDS systems.
Curve Number	A parameter used in NRCS Technical Release 20 or 55 (TR-20 or TR-55) that is used to estimate the rate and volume of stormwater runoff that will be created from rainfall, based on the soil types and land uses at a given location. Values range from around 30 to 100, with higher values resulting in more runoff being predicted from the equations used by TR-20 and TR-55 methods. See the NRCS TR-55 Methodology section of ISWMM for more information.
Floating material	Debris and materials that are buoyant or typically float in stormwater runoff.
Hotspot	Land uses or activities that have the potential to generate higher pollutant loads than typical urban land uses. Gas stations and some industrial sites are examples of hotspots.
Hydrologic Soil Group (HSG)	Categories shown on County Soils Maps that describe the runoff potential of common soil groups. HSG categories range from A to D, with HSG A soils generating the least amount of runoff from rainfall events and HSG D soils generating the most.
Impervious cover	Surfaces on the landscape that do not allow water to pass through, such as roofs and paved surfaces.
Maximum Treatment Flow Rate (MTFR)	The maximum flow rate (often listed in cubic feet per second) listed in certification letters where the desired level of TSS removal is expected to be achieved.
Pretreatment	Use of practices or features to capture the heaviest sediment particles, trash or debris out of stormwater flows before it can enter a downstream BMP.
Redevelopment	Construction of site improvements on a parcel of land where buildings, roads, parking areas or other site improvements already exist or previously existed.
Resuspension	When collected sediments or debris that were previously captured by a pretreatment or other water quality BMP are picked up and carried by moving water.
Time of concentration	The length of time it takes stormwater runoff to pass from the farthest upstream point in a drainage area to the outlet after runoff from rainfall has started.
Seasonal high-water table	The highest level of groundwater indicated by soil tests or geotechnical investigations.
Settleable solids	Particles that are large enough to fall out of still or slowly moving water, due to gravitational effects.
Soil Quality Restoration (SQR)	Creating a healthy soil profile through methods of respreading topsoil materials, or using blends of compost and sand to improve soil properties. (See the Soil Quality Management and Restoration Section of ISWMM.)
Tailwater	Elevated water levels at the downstream end of a pipe network or stream which can impede the ability of water to pass through a system.
Unified Sizing Criteria (USC)	The set of stormwater management quality and quantity goals recommended by ISWMM.
Water quality impairments	When the essential functions of rivers, streams or lakes are not supported because of pollutant levels which are measured to be above an accepted allowable standard.
Water Quality Volume (WQv)	One of ISWMM's USC, defined as the runoff generated by a 1.25 inch rainfall event. Over 90% of all rainfall events in Iowa are at or less than this amount of rain.
Weighted Curve Number (CNw)	When multiple land surface covers exist in a drainage area, this value represents the average value of all curve numbers which are weighted by the percentage that each surface cover exists in that specific area.

5.05-7 RESOURCES

ASTM C1745/C1745M - 18. ASTM International. West Conshohocken, PA.

ASTM C1746/C1746M - 19. ASTM International. West Conshohocken PA.

ASTM C1893 - 23. ASTM International. West Conshohocken PA.

Certified Trash Full Capture Systems Available to the Public. State Water Resources Control Board, California Water Boards. (2023)

Clary, Jane et al. *International Stormwater BMP Database: 2020 Summary Statistics*. (2020) The Water Research Foundation.

Manufactured Treatment Devices, BMPs Requiring a Waiver or Variance (Chapter 11.3). (2023) New Jersey Stormwater Best Management Practices Manual.

5.05-8 APPENDIX

KEY DESIGN PARAMETER CHECKLIST

There are important aspects of this manual to consider when jurisdictions seek to create stormwater ordinances or policies that reference or adopt this manual. The Iowa Department of Natural Resources (IDNR) is responsible for the creation and maintenance of this manual, working with a technical committee of local volunteers. However, regulation and enforcement of post-construction stormwater management is primarily left to local jurisdictions.

Therefore, the IDNR does not enforce as requirements, the sizing and design criteria set for this document. For this reason, the language used within this manual has purposefully been written as a guideline, rather than a standard. This means certain language that conveys something is required (i.e. shall, must, etc.) is generally avoided. This has the potential to leave “gray areas” as to what may be interpreted to be required and what is recommended or optional, if this manual is adopted and referenced by local jurisdictions as a standard.

Throughout this section, different design parameters or considerations have been grouped into key categories:

ESSENTIAL

An element of the design of a BMP seen as critical to its proper performance, operation or aesthetics. **These aspects should be most important for inclusion and compliance and should rarely be deviated from.**

TARGET

An element of the design of a BMP seen as important to its proper performance, operation or aesthetics. **These aspects should be included in designs, if at all possible.** However, there is more flexibility to allow deviations if it can be demonstrated that it is infeasible to meet the requirement at a given location, or if a certain requirement is in conflict with other requirements. **Designers should explain any reason for deviation from targets, for the consideration of the jurisdiction as part of their review.**

IDEAL

An element of the design of a BMP seen as the recommended approach for its proper performance, operation or aesthetics. Designers are encouraged to include these in designs as best practice. However, these items are seen as less critical as those noted as essentials or targets.

CAUTION

These are notes or design guidance to highlight items for the designers’ careful consideration.

ADVISORY

These are practices, techniques or potential deviations from the design ethic that should be avoided in most circumstances.

Within this section, the following items have been listed under the categories described above:

ESSENTIAL

1. To use a specific HDS device as a pretreatment BMP, the device should be verified by the New Jersey Corporation for Advances Technology (NJCAT) and certified for at least 50% TSS removal. (page 2)
2. To use a specific HDS device as a water quality BMP, the device should be verified by the New Jersey Corporation for Advances Technology (NJCAT) and certified for at least 80% TSS removal. (page 2)
3. To achieve the certified level of TSS removal, HDS devices should be selected so that the peak flow rate directed through the system during the Water Quality event (WQv) is not expected to exceed the certified MTFR for the selected unit. When calculating the WQv peak flow rate, the entire contributory drainage area to the HDS should be considered, including "off-site" areas. (page 3)
4. Future connections to a system that includes an HDS device should not be allowed if those additional connections would cause the MTFR or the hydraulic capacity of the device to be exceeded. (page 5)
5. The HDS should be designed and installed with the same configuration utilized during the testing for verification. (page 5)
6. HDS devices may not include grate inlets that convey surface runoff directly into the unit unless the device was specifically tested and certified with a matching type of inlet. (page 5)
7. All HDS devices which are subject to vehicular loading should be designed for at least HS-20 traffic loading at the surface. Higher design standards may be needed in cases where higher loadings from traffic or maintenance vehicles are expected. (page 6)
8. The HDS unit should be placed within or close enough to a drivable access path to reach the depth within HDS unit where collected materials are to be removed. The access path should be clear of obstructions and be wide enough to accommodate the anticipated maintenance vehicle. The designer should consult with the owner or party responsible for maintenance to understand the type of maintenance equipment that is expected to be used and to locate the access path with the proper location, width and grades. (page 6)
9. If an HDS device is being considered for an outfall retrofit, it should be sized based on the peak flow rate for the WQv event for the entire drainage area that is being routed through the device. (page 7)

TARGET

1. It is recommended that the HDS unit be designed in an "offline" configuration, where a diversion structure is used to limit the rate of flow allowed to enter the HDS. (page 5)
2. Any connection from the HDS device to downstream storm sewers or stormwater management systems should include provisions for access to the pipe network such as a manhole, storm inlet, or outfall to allow for inspection and maintenance. A direct subsurface connection to an enclosed pipe or culvert is not recommended. (page 6)
3. Any effects of tailwater conditions listed within the manufacturer's recommendations for the HDS device should be observed. (page 6)