Enhancing Understanding of Permanent Stormwater Treatment Statewide: A Unique Educational Partnership

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May 16, 2024

Municipal Wet Weather Stormwater Conference

Auburn, AL

Agenda

- Review History of New NPDES Permit
- Detail Critical New Elements of Permit
- Identify Key Partners
- Explore Lessons Learned
- Q&A

NDPES MS4 Phase 2's General Permit History

2003

1st Permit: Establishing Stormwater Quality Program

2010

2nd Permit: Implementation of post-construction requirements were postponed

Difficult to implement requirements.

2016

3rd Permit: Post-construction requirements were appealed by home builders association and environmental groups

Maximum Extent Practicable was contested.

2018

The settlement defined Maximum Extent Practicable (MEP) for TN and required rulemaking for post-construction

2022

4th Permit: Rulemaking was completed. Permit was issued. Petition for rule revision.

Current post construction standards were issued in the permit on 8/2022.

2024

Rules revised. Permit Modified. Permit Issued.

4th Permit Modified: Effective April 1, 2024 modifications to roof runoff exemption. Roof runoff must be included in the water quality treatment volume to be treated onsite.

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Water Quality Treatment Volume (WQTV)

- a portion of the runoff generated from impervious surfaces at a new development or redevelopment project by the design storm
- It is a calculated volume specific to rainfall in that location

Water Quality Treatment Volume and the Corresponding SCM Treatment Type for the 1-year, 24-hour design storm		
SCM Treatment Type	WQTV	Notes
infiltration, evaporation, transpiration, and/or reuse	runoff generated from the first 1 inch of the design storm	Examples include, but are not limited to, bioretention, stormwater wetlands, and infiltration systems.
biologically active filtration, with an underdrain	runoff generated from the first 1.25 inches of the design storm	To achieve biologically active filtration, SCMs must provide minimum of 12 inches of internal water storage.
sand or gravel filtration, settling ponds, extended detention ponds, and wet ponds	runoff generated from the first 2.5 inches of the design storm or the first 75% of the design storm, whichever is less	Examples include, but are not limited to, sand filters, permeable pavers, and underground gravel detention systems. Ponds must provide forebays comprising a minimum of 10% of the total design volume. Existing regional detention ponds are not subject to the forebay requirement.
hydrodynamic separation, baffle box settling, other flow-through manufactured treatment devices (MTDs), and treatment trains using MTDs	maximum runoff generated from the entire design storm	Flow-through MTDs must provide an overall treatment efficiency of at least 80% TSS reduction. Refer to 4.2.5.20

Statewide Design Storm Defined

- 1-year, 24-hr
- NOAA Atlas 14 Precipitation Frequency Data Server
  - Site specific intensities and depths are available from NOAA
- https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=tn
- The permit specifies how much runoff from the storm event to be treated not the amount of direct rainfall to be treated

NOAA Atlas 14, Volume 9, Version 2
Location name: Auburn, Alabama, USA*
Latitude: 32.6091°, Longitude: -85.4817°
Elevation: 694 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

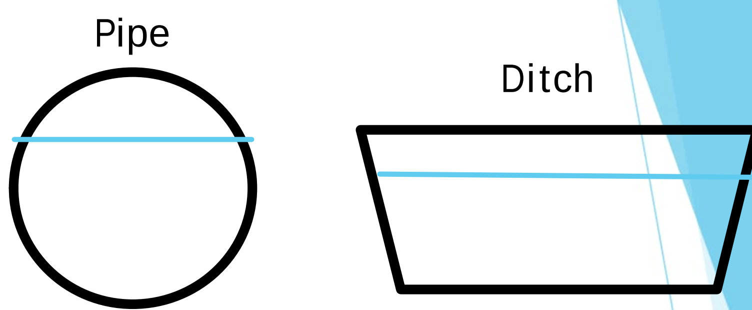
PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

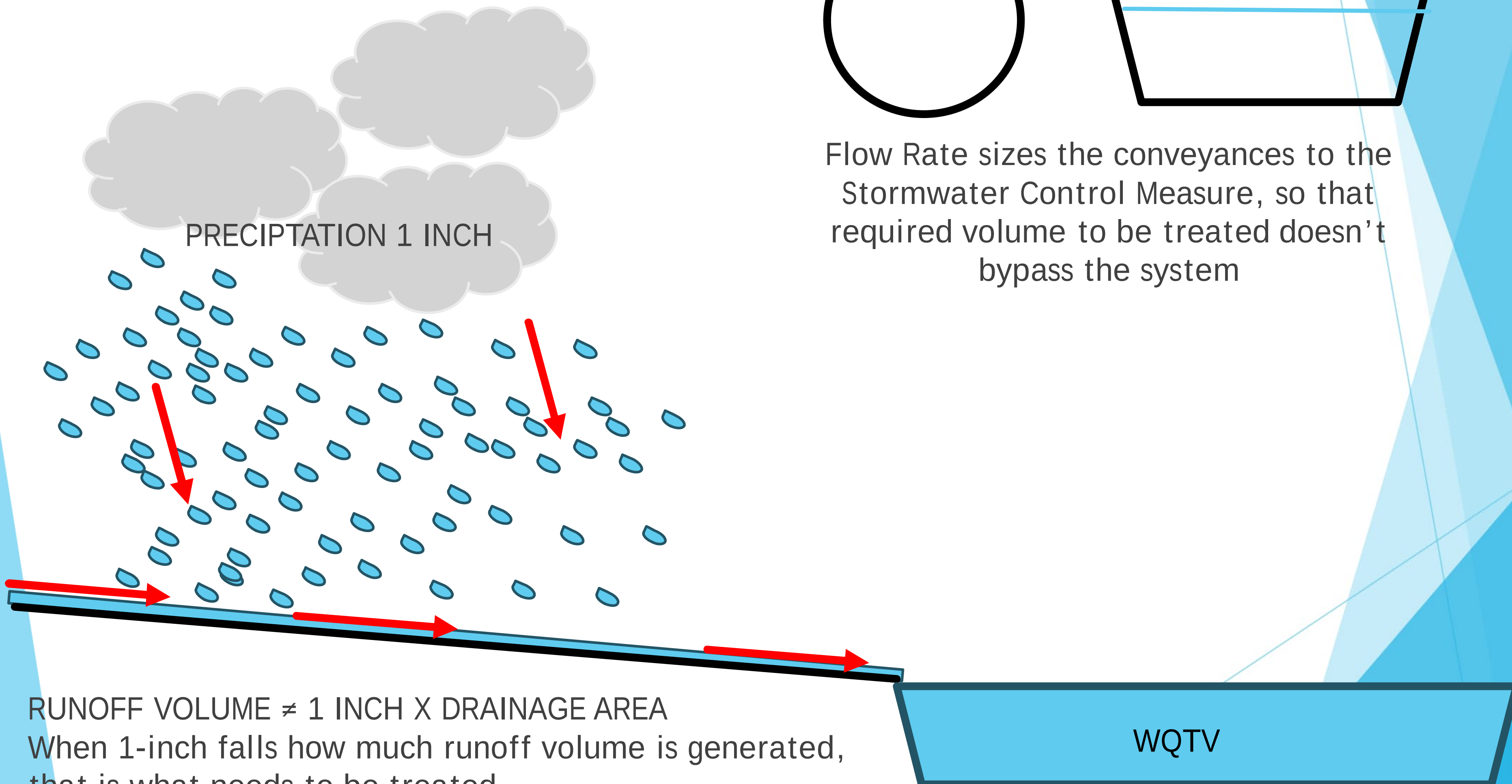
PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.436 (0.372-0.516)	0.501 (0.427-0.593)	0.606 (0.515-0.719)	0.691 (0.585-0.822)	0.806 (0.681-0.975)	0.892 (0.719-1.09)	0.977 (0.765-1.21)	1.06 (0.802-1.34)	1.17 (0.855-1.51)	1.25 (0.895-1.63)
10-min	0.638 (0.545-0.755)	0.734 (0.626-0.869)	0.887 (0.755-1.05)	1.01 (0.857-1.20)	1.18 (0.968-1.43)	1.31 (1.05-1.60)	1.43 (1.12-1.78)	1.55 (1.17-1.96)	1.71 (1.25-2.21)	1.83 (1.31-2.39)
15-min	0.778 (0.664-0.921)	0.895 (0.763-1.06)	1.08 (0.920-1.28)	1.24 (1.04-1.47)	1.44 (1.18-1.74)	1.59 (1.28-1.95)	1.74 (1.37-2.17)	1.89 (1.43-2.40)	2.09 (1.53-2.69)	2.23 (1.60-2.92)
30-min	1.12 (0.955-1.32)	1.29 (1.10-1.53)	1.56 (1.33-1.86)	1.79 (1.51-2.13)	2.08 (1.71-2.52)	2.31 (1.86-2.82)	2.53 (1.98-3.14)	2.74 (2.07-3.47)	3.02 (2.21-3.89)	3.22 (2.31-4.21)
60-min	1.49 (1.27-1.76)	1.70 (1.45-2.01)	2.04 (1.74-2.42)	2.33 (1.97-2.77)	2.72 (2.23-3.29)	3.02 (2.43-3.69)	3.31 (2.60-4.12)	3.61 (2.73-4.57)	4.00 (2.93-5.17)	4.29 (3.08-5.62)
2-hr	1.86 (1.59-2.18)	2.11 (1.81-2.48)	2.52 (2.16-2.97)	2.87 (2.44-3.39)	3.35 (2.77-4.04)	3.72 (3.02-4.53)	4.10 (3.23-5.07)	4.48 (3.41-5.64)	4.98 (3.68-6.40)	5.37 (3.88-6.98)
3-hr	2.10 (1.81-2.46)	2.38 (2.05-2.78)	2.84 (2.43-3.32)	3.22 (2.75-3.79)	3.76 (3.13-4.53)	4.19 (3.42-5.09)	4.63 (3.67-5.71)	5.08 (3.89-6.38)	5.68 (4.22-7.28)	6.15 (4.46-7.96)
6-hr	2.56 (2.22-2.97)	2.90 (2.51-3.37)	3.47 (3.00-4.04)	3.96 (3.40-4.62)	4.65 (3.90-5.56)	5.20 (4.27-6.26)	5.76 (4.60-7.06)	6.34 (4.89-7.91)	7.13 (5.33-9.07)	7.74 (5.66-9.95)
12-hr	3.05 (2.66-3.51)	3.50 (3.05-4.04)	4.26 (3.70-4.91)	4.89 (4.23-5.66)	5.78 (4.87-6.85)	6.48 (5.35-7.75)	7.19 (5.77-8.74)	7.91 (6.15-9.80)	8.89 (6.69-11.2)	9.65 (7.10-12.3)
24-hr	3.60 (3.16-4.12)	4.16 (3.65-4.76)	5.09 (4.44-5.83)	5.87 (5.10-6.74)	6.95 (5.89-8.18)	7.80 (6.48-9.26)	8.66 (7.00-10.5)	9.54 (7.46-11.7)	10.7 (8.13-13.5)	11.6 (8.63-14.8)
[illegible]	4.24	4.86	5.90	6.78	8.04	9.02	10.0	11.1	12.5	13.6

Runoff Volume



Flow Rate sizes the conveyances to the Stormwater Control Measure, so that required volume to be treated doesn't bypass the system



RUNOFF VOLUME ≠ 1 INCH X DRAINAGE AREA
When 1-inch falls how much runoff volume is generated, that is what needs to be treated

Infiltration, Evaporation, Transpiration, Reuse (Row 1)

Water Quality Treatment Volume and the Corresponding SCM Treatment Type for the 1-year, 24-hour design storm		
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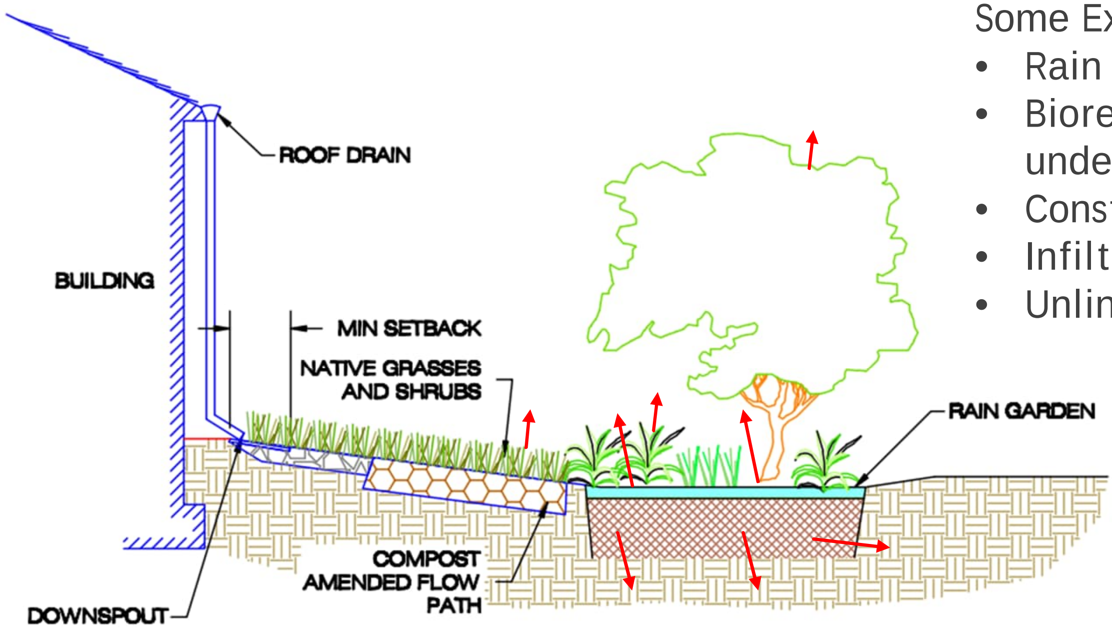


Figure 7: Rooftop Disconnection – Section View: Simple disconnection to downstream bioretention (Source: VADCR, 2011).

Some Examples:

- Rain Gardens
- Bioretention with no underdrain
- Constructed wetlands
- Infiltration trench
- Unlined control measures

Biologically active filtration with an underdrain (Row 2)

biologically active filtration, with an underdrain	runoff generated from the first 1.25 inches of the design storm	To achieve biologically active filtration, SCMs must provide minimum of 12 inches of internal water storage.

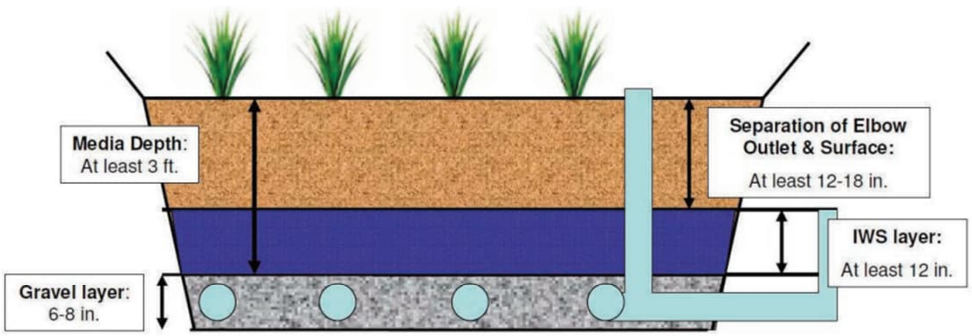
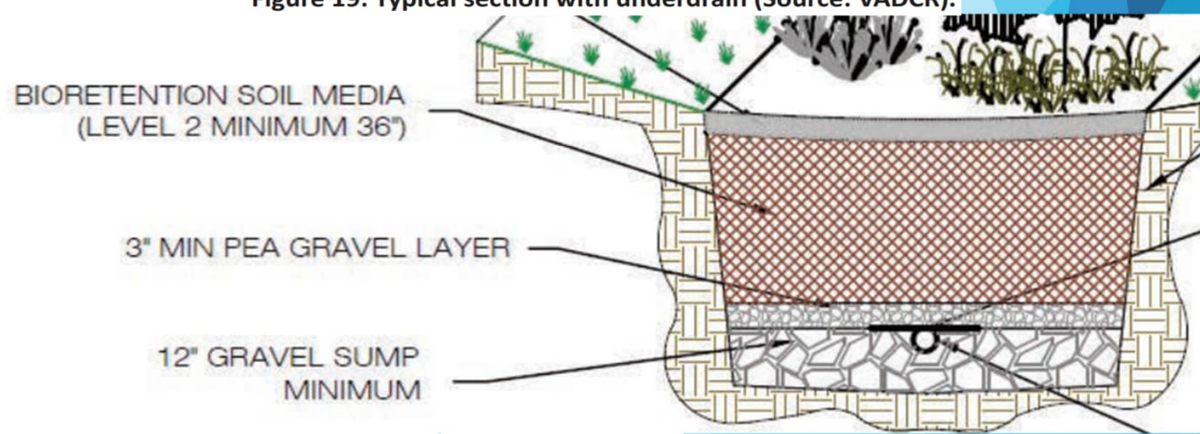


Figure 11: Bioretention cell showing IWS zones (Source: NCDENR).

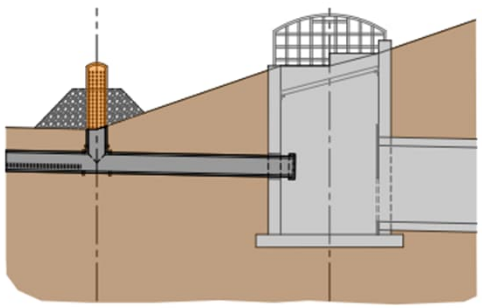
Figure 19: Typical section with underdrain (Source: VADCR).



sand or gravel filtration, settling ponds, extended detention ponds, and wet ponds (Row 3)

sand or gravel filtration, settling ponds, extended detention ponds, and wet ponds	runoff generated from the first 2.5 inches of the design storm or the first 75% of the design storm, whichever is less	Examples include, but are not limited to, sand filters, permeable pavers, and underground gravel detention systems. Ponds must provide forebays comprising a minimum of 10% of the total design volume. Existing regional detention ponds are not subject to the forebay requirement.

Figure 9.10-1-2: Multi-stage outlet example



Iowa Storm Water Management Manual
[iswmm_chapter 09-10.pdf (iowadnr.gov)]

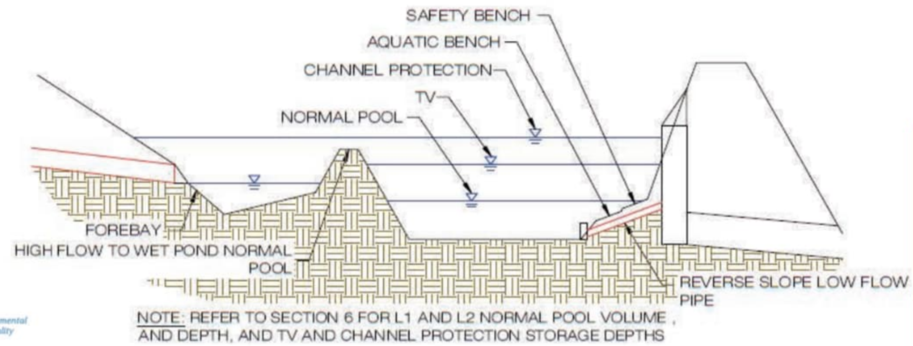
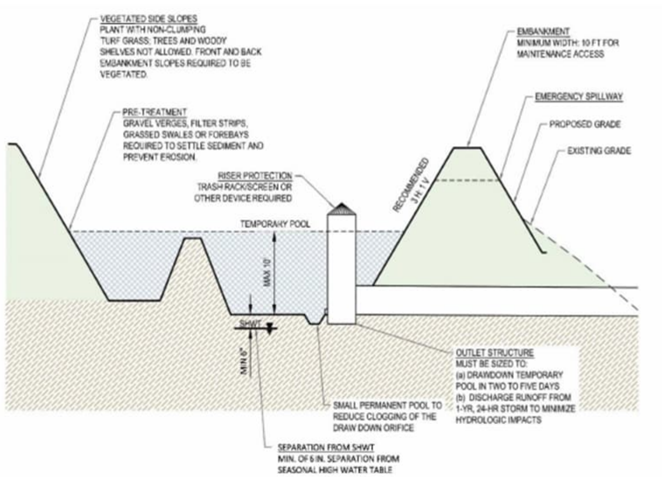


Figure 2: Wet Pond Design Schematics (Source: Virginia).

NCDEQ Stormwater Design Manual

Figure 1: Dry Pond Example: Cross-Section



1.4 Typical Details

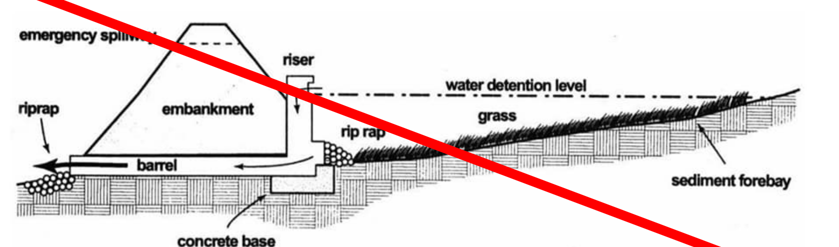
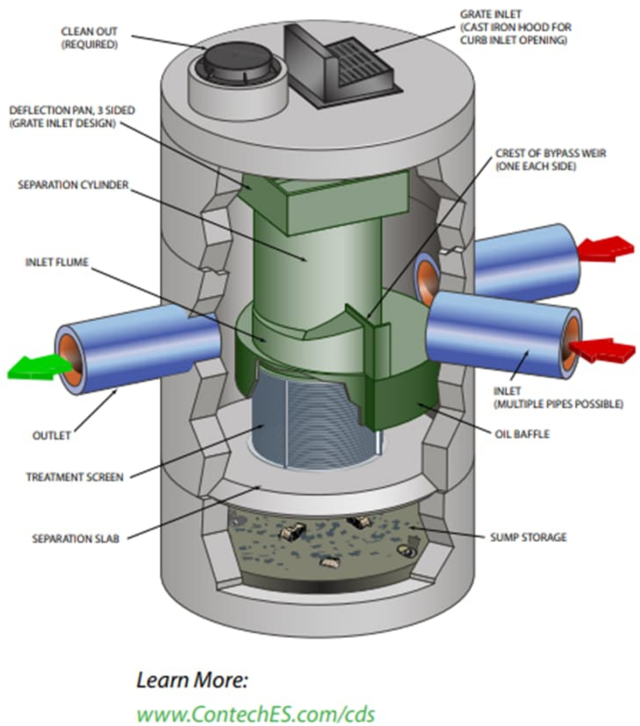


Figure 2: Dry detention pond cross-section (US EPA).

Traditional Dry Detention doesn't fall into this row.

hydrodynamic separation, baffle box settling, other flow-through manufactured treatment devices (MTDs), and treatment trains using MTDs (Row 4)



Contech CDS Hydrodynamic Seperator, cds-bro.pdf (conteches.com)

hydrodynamic separation, baffle box settling, other flow-through manufactured treatment devices (MTDs), and treatment trains using MTDs	maximum runoff generated from the entire design storm	Flow-through MTDs must provide an overall treatment efficiency of at least 80% TSS reduction. Refer to 4.2.5.20

Table 4-1: TSS Removal Rates for BMPs

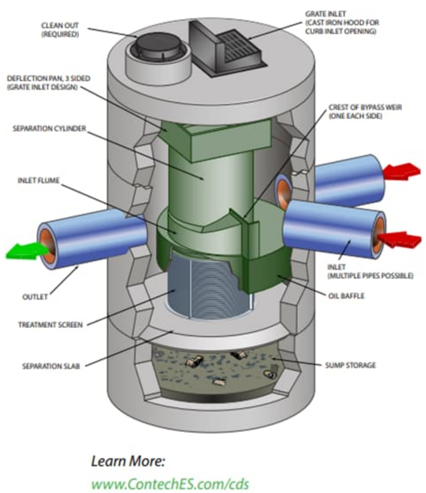
Best Management Practice (BMP)	Adopted TSS Removal Rate (%)
Bioretention System	90
Constructed Stormwater Wetland	90
Dry Well	Volume Reduction Only[1]
Extended Detention Basin	40 to 60[2]
Infiltration Structure	80
Manufactured Treatment Device	See N.J.A.C. 7:8-5.7(d)[3]
Pervious Paving System	Volume Reduction Or 80[4]
Sand Filter	80
Vegetative Filter	60-80
Wet Pond	50-90[5]

[1] See text below.
[2] Final rate based upon detention time. See Chapter 9.
[3] To be determined through testing on a case-by-case basis. See text below.
[4] If system includes a runoff storage bed that functions as an infiltration basin. See Chapter 9.
[5] Final rate based upon pool volume and detention time. See Chapter 9.

NJDEP BMP Manual Chapter 4, NJDEP| Stormwater | NJ Stormwater Best Management Practices Manual NJ Stormwater Best Management Practices Manual

Treatment Trains

- Multiple measures in sequence that are different treatment types. Must equal 80% TSS removal.



HDS at 50% TSS Removal rate (via TAPE/NJDEP)

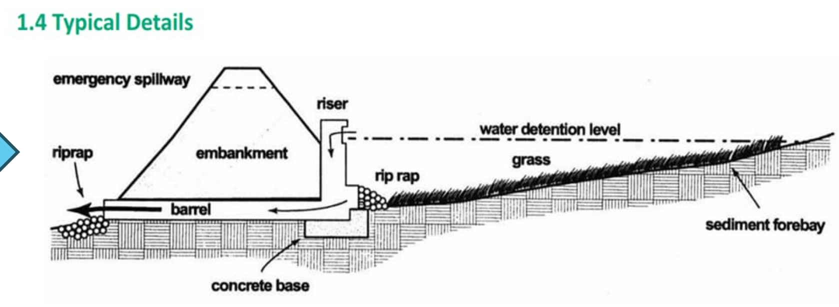


Figure 2: Dry detention pond cross-section (US EPA).

Traditional dry detention basin at 60% TSS Removal rate

= 80% TSS removal

Treatment Train Math: 50+60-(50*60)/100= 80%

Other Parts of the Post-Construction Rule

- Incentives: Volume reduction for redevelopment, vertical density, and others submitted and approved by TDEC.
- Permanent Buffers
  - Exceptional TN Waters (ETW) and waters with unavailable parameters for habitat and siltation require an average buffer of 60 ft.
  - Waters with available parameters for habitat or siltation are required to have an average of 30 ft.
- Inspection and Maintenance:
  - Inspect SCMs every 5 years
  - provide full treatment capacity within 72 hours following the end of the preceding rain event.
  - Legally binding maintenance agreement
  - Documentation of inspections and maintenance
- SCM Inventory and Tracking
  - A system to track public and private SCMs

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TNSA Members Including:

Manufacturers

Consultants

NPDES Municipal Separate Storm Sewer System (MS4) Program (tn.gov)

Helpful Resources

Below you will find a curated selection of resources that have undergone review by the Division of Water Resources staff for their relevance, accuracy, and overall utility. Inclusion in this list signifies that the Division recognizes these resources as valuable references offering guidance in various areas within stormwater management. Users are encouraged to explore these materials and consider how they may inform their understanding and decision-making. Your access to these vetted resources aligns with our commitment to providing reliable information to support informed actions in the realms of environmental stewardship and water quality management.

- Bioretention Design Handbook: Designing Holistic Bioretention for Performance and Longevity | US EPA
- Tools for Treatment: The Science Behind Treatment Strategies for New NPDES Rules Compliance in TN | Contech Engineered Solutions
- Water Quality Treatment Volume (WQTV) Calculation | Civil & Environmental Consultants, Inc.

DESIGNING SCMs FOR WQTV

Proprietary Post-Construction Practices

FEBRUARY / 2024

TENNESSEE STORMWATER ASSOC.

Developed by Members of the TNSA SCM Committee

Jacob Dorman, Committee Chairperson

A guidance document for sizing proprietary SCMs and effectively using the WQTV found in the 2022 NPDES Small MS4 Permit and Tennessee MS4 Rules.

Images for illustrative purposes only. TNSA SCM Committee does not endorse specific proprietary SCMs or assist with selection.

Compliance Toolbox

Proprietary post-construction stormwater control measures (SCMs) improve the quality of runoff through basic separation treatment processes (mechanical separation) or advanced treatment processes (filtration).

In the 2022 NPDES Small MS4 Permit, TDEC defined SCMs by their **dominant treatment process**. Designers should use good engineering practices and consider the latest innovations in stormwater management when selecting the appropriate WQTV design depth

COMPLIANCE BASICS

DESIGN STORM

The design storm is 1-yr, 24-hr storm defined by NOAA Atlas 14.

WQTV

The depth of runoff for the

b9f40d_1eb28d61fc29457dae2e880c1a09feb8.pdf (tnstormwater.org)

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Lesson Learned #1

Appreciating SCM Functionality and Relative Efficiency

Implementing the WQTv Table

Water Quality Treatment Volume and the Corresponding SCM Treatment Type for the 1-year, 24-hour design storm		
SCM Treatment Type	WQTV	Notes
infiltration, evaporation, transpiration, and/or reuse	runoff generated from the first 1 inch of the design storm	Examples include, but are not limited to, bioretention, stormwater wetlands, and infiltration systems.
biologically active filtration, with an underdrain	runoff generated from the first 1.25 inches of the design storm	To achieve biologically active filtration, SCMs must provide minimum of 12 inches of internal water storage.
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- Generally defined by their pollutant removal processes
- Allows for permit flexibility
- Many non-proprietary fit into multiple categories
- Proprietary Practices may fit into more than last category
  - Hydrodynamic separation (HDS) and similar must treat flow associated with full design storm and have performance verified by industry standard protocols
    - TAPE/NJDEP*
    - Max 50% TSS

One Practice, Many Hats Example– Bioretention

Treatment of the first 1.0”of runoff

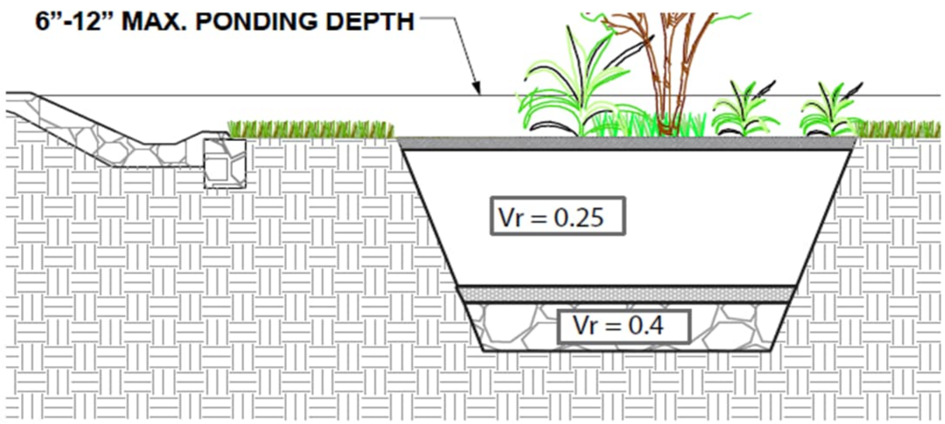

Figure 14: Typical bioretention section with void ratios for volume computations (Source: CHCRPC).

Treatment of the first 1.25” of runoff

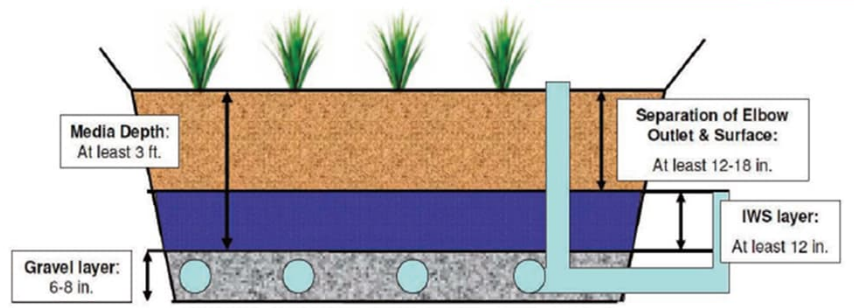

Figure 11: Bioretention cell showing IWS zones (Source: NCDENR).

Treatment of the first 2.5” of runoff (or 75%)

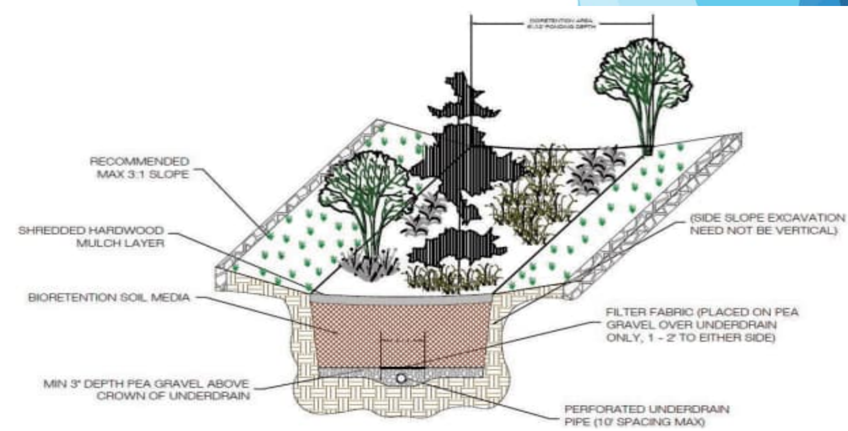

Figure 18: Typical section with underdrain (Source: VADCR).

Differentiation between systems:

First 1.0”= Fully infiltrates WQTv; no underdrain

First 1.25”= Min. 12” Internal Water Storage (IWS)

First 2.5”= Underdrain; no IWS

Example- Proprietary SCMs

Response: To provide equivalency of various treatment processes, the WQTV is graduated…The table classifies all SCMs by the type of treatment process on which they rely, since the vast majority of SCMs can be classified in this way. *TDEC- Rulemaking Hearing; Response to Comments (2/16/22)*

- Water Quality Units (WQU), aka, Hydrodynamic Separators (HDS), historically used for primary treatment
- HDS now only allowed in Row 4 as part of treatment train; not stand-alone
- More advanced high-rate media filters (Row 3) and high-rate biofiltration (Row 2 or 3) allowed

https://publications.tnsosfiles.com/rules_filings/02-16-22.pdf

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Lesson Learned #2

Proper Calculation of the Required Design Storm Volume

Example Water Quality Design Process

3 main components of the design process for water quality:

1. Water quality design storm (1-yr 24-hr, NOAA Atlas 14)
2. Water quality treatment volume (runoff generated from a portion of the design storm for impervious surfaces)
3. SCM selected and designed to achieve treatment efficiency of 80% TSS removal from WQTV

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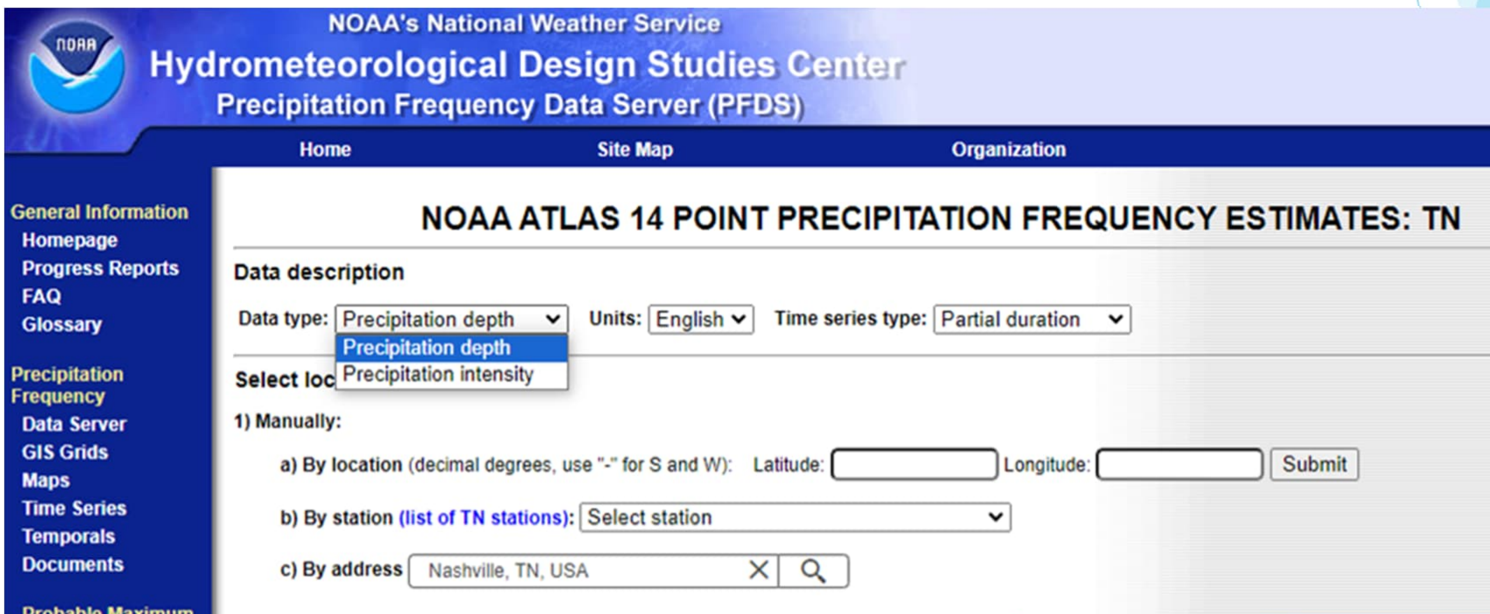
Water Quality Design Storm

Design Storm: 1-year, 24-hour

NOAA Atlas 14

Precipitation depth: Hydrograph Method

Precipitation intensity: Rational Method



Water Quality Design Storm

Precipitation depth:

- Duration = 24-hr
- Recurrence interval = 1-yr

24-hr	2.86 (2.70-3.05)

- Use 2.86” as design storm depth to create hydrograph

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.381 (0.354-0.413)	0.447 (0.415-0.486)	0.515 (0.476-0.559)	0.569 (0.526-0.618)	0.637 (0.585-0.691)	0.688 (0.628-0.746)	0.737 (0.668-0.800)	0.785 (0.706-0.853)	0.843 (0.750-0.920)	0.888 (0.783-0.972)
10-min	0.609 (0.565-0.660)	0.716 (0.664-0.777)	0.825 (0.762-0.896)	0.910 (0.841-0.988)	1.02 (0.932-1.10)	1.10 (1.00-1.19)	1.17 (1.06-1.27)	1.24 (1.12-1.35)	1.33 (1.19-1.46)	1.40 (1.23-1.53)
15-min	0.762 (0.707-0.825)	0.900 (0.834-0.976)	1.04 (0.963-1.13)	1.15 (1.06-1.25)	1.29 (1.18-1.40)	1.39 (1.27-1.50)	1.48 (1.34-1.61)	1.57 (1.41-1.71)	1.68 (1.49-1.83)	1.76 (1.55-1.92)
30-min	1.04 (0.969-1.13)	1.24 (1.15-1.35)	1.48 (1.37-1.61)	1.67 (1.54-1.81)	1.91 (1.75-2.07)	2.09 (1.91-2.26)	2.27 (2.06-2.46)	2.44 (2.20-2.66)	2.67 (2.38-2.91)	2.84 (2.51-3.11)
60-min	1.30 (1.21-1.41)	1.56 (1.45-1.69)	1.90 (1.76-2.06)	2.17 (2.01-2.36)	2.54 (2.33-2.75)	2.83 (2.58-3.07)	3.12 (2.83-3.39)	3.43 (3.08-3.72)	3.83 (3.41-4.18)	4.15 (3.66-4.54)
2-hr	1.54 (1.42-1.66)	1.83 (1.70-1.99)	2.22 (2.06-2.41)	2.54 (2.34-2.75)	2.97 (2.72-3.22)	3.31 (3.02-3.59)	3.66 (3.31-3.98)	4.02 (3.62-4.37)	4.52 (4.00-4.92)	4.90 (4.30-5.36)
3-hr	1.67 (1.55-1.81)	1.99 (1.84-2.16)	2.41 (2.23-2.62)	2.76 (2.54-3.00)	3.23 (2.96-3.50)	3.62 (3.29-3.92)	4.01 (3.62-4.36)	4.42 (3.95-4.80)	4.98 (4.39-5.43)	5.41 (4.73-5.92)
6-hr	2.01 (1.85-2.21)	2.39 (2.20-2.62)	2.90 (2.66-3.18)	3.32 (3.04-3.64)	3.91 (3.56-4.29)	4.40 (3.96-4.82)	4.91 (4.39-5.38)	5.44 (4.82-5.98)	6.19 (5.40-6.82)	6.78 (5.85-7.49)
12-hr	2.39 (2.21-2.61)	2.85 (2.63-3.11)	3.45 (3.18-3.77)	3.96 (3.63-4.31)	4.66 (4.25-5.08)	5.24 (4.74-5.70)	5.85 (5.25-6.36)	6.48 (5.76-7.06)	7.37 (6.45-8.04)	8.07 (6.98-8.86)
24-hr	2.86 (2.70-3.05)	3.42 (3.22-3.65)	4.16 (3.92-4.44)	4.77 (4.48-5.08)	5.61 (5.26-5.97)	6.29 (5.88-6.69)	7.00 (6.51-7.43)	7.73 (7.16-8.21)	8.73 (8.04-9.27)	9.52 (8.72-10.1)
2-day	3.42 (3.22-3.65)	4.09 (3.84-4.36)	5.00 (4.70-5.33)	5.74 (5.39-6.11)	6.80 (6.36-7.23)	7.66 (7.14-8.14)	8.56 (7.94-9.09)	9.51 (8.77-10.1)	10.8 (9.92-11.5)	11.9 (10.8-12.7)
3-day	3.62 (3.41-3.86)	4.32 (4.07-4.60)	5.27 (4.96-5.61)	6.04 (5.67-6.42)	7.11 (6.66-7.55)	7.98 (7.45-8.47)	8.89 (8.26-9.42)	9.82 (9.09-10.4)	11.1 (10.2-11.8)	12.2 (11.1-12.9)
4-day	3.82 (3.60-4.07)	4.55 (4.29-4.85)	5.54 (5.22-5.89)	6.33 (5.96-6.72)	7.42 (6.96-7.87)	8.30 (7.76-8.80)	9.21 (8.57-9.75)	10.1 (9.40-10.7)	11.4 (10.5-12.1)	12.4 (11.3-13.2)
7-day	4.62 (4.35-4.92)	5.51 (5.18-5.87)	6.71 (6.30-7.14)	7.68 (7.20-8.17)	9.05 (8.46-9.62)	10.2 (9.46-10.8)	11.3 (10.5-12.0)	12.5 (11.6-13.3)	14.3 (13.0-15.2)	15.6 (14.1-16.6)
10-day	5.29 (5.00-5.61)	6.30 (5.95-6.68)	7.60 (7.17-8.05)	8.62 (8.12-9.14)	10.0 (9.42-10.6)	11.2 (10.4-11.8)	12.3 (11.5-13.0)	13.4 (12.5-14.2)	15.0 (13.8-15.9)	16.2 (14.9-17.2)
20-day	7.16 (6.80-7.56)	8.48 (8.05-8.95)	10.0 (9.50-10.6)	11.2 (10.6-11.8)	12.7 (12.0-13.4)	13.9 (13.1-14.6)	15.0 (14.2-15.8)	16.1 (15.2-17.0)	17.6 (16.4-18.6)	18.6 (17.4-19.7)
30-day	8.79 (8.36-9.23)	10.4 (9.85-10.9)	12.1 (11.5-12.7)	13.4 (12.7-14.1)	15.2 (14.4-15.9)	16.5 (15.6-17.3)	17.8 (16.8-18.7)	19.1 (17.9-20.1)	20.7 (19.4-21.8)	22.0 (20.5-23.2)
45-day	11.0 (10.5-11.5)	12.9 (12.3-13.5)	14.8 (14.1-15.6)	16.3 (15.5-17.1)	18.2 (17.3-19.1)	19.7 (18.7-20.6)	21.1 (19.9-22.1)	22.4 (21.1-23.5)	24.1 (22.6-25.3)	25.3 (23.7-26.7)
60-day	13.2 (12.6-13.8)	15.5 (14.8-16.2)	17.7 (16.9-18.6)	19.4 (18.5-20.3)	21.5 (20.5-22.5)	23.0 (21.9-24.1)	24.5 (23.2-25.6)	25.8 (24.5-27.1)	27.4 (25.9-28.8)	28.6 (27.0-30.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Water Quality Treatment Volume (WQTV)

- Runoff generated from impervious surfaces (CN=98), based on a portion of the WQTV.
- S = (1000/98) – 10 = 0.2 in
- For Row 3 SCMs (Nashville), first 75% of design storm depth, P = 2.86 in * 0.75 = 2.15"< 2.50 in
- For an example 1-acre site:
  - P (rainfall) = 2.15"
  - Q (runoff) = (2.15 – 0.2S)^2 / (2.15 + 0.8S) = 1.93"
  - WQTV = Area*runoff depth = **7,006 cf**

SCS runoff curve number method

The SCS Runoff Curve Number (CN) method is described in detail in NEH-4 (SCS 1985). The SCS runoff equation is

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S} \qquad \text{[eq. 2-1]}$$

where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

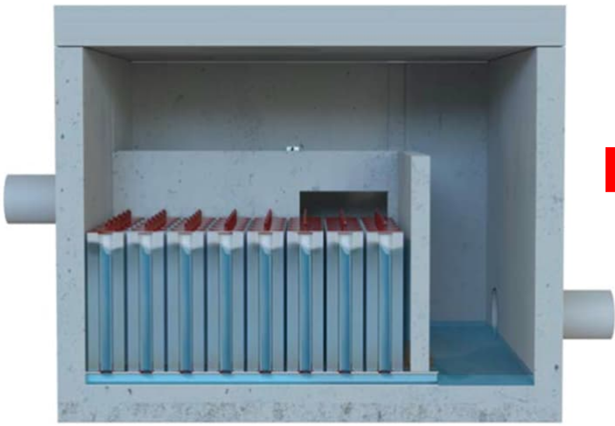
Lesson Learned #3

Conversion of Water Quality Volume to Flow Rate

Example water quality design process

Proprietary membrane filter:

- HC Kraken® Filter
- 80% TSS certified by industry-wide standard (NJDEP)

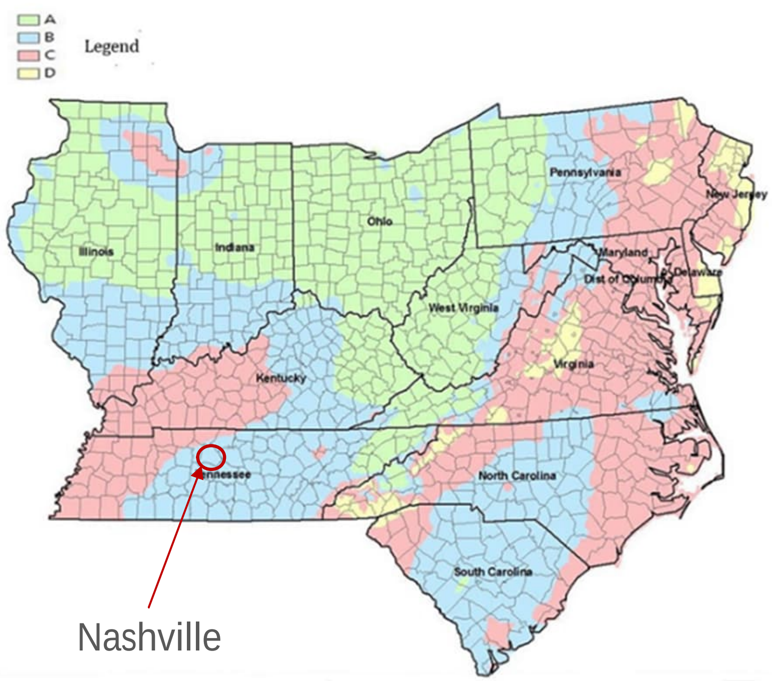


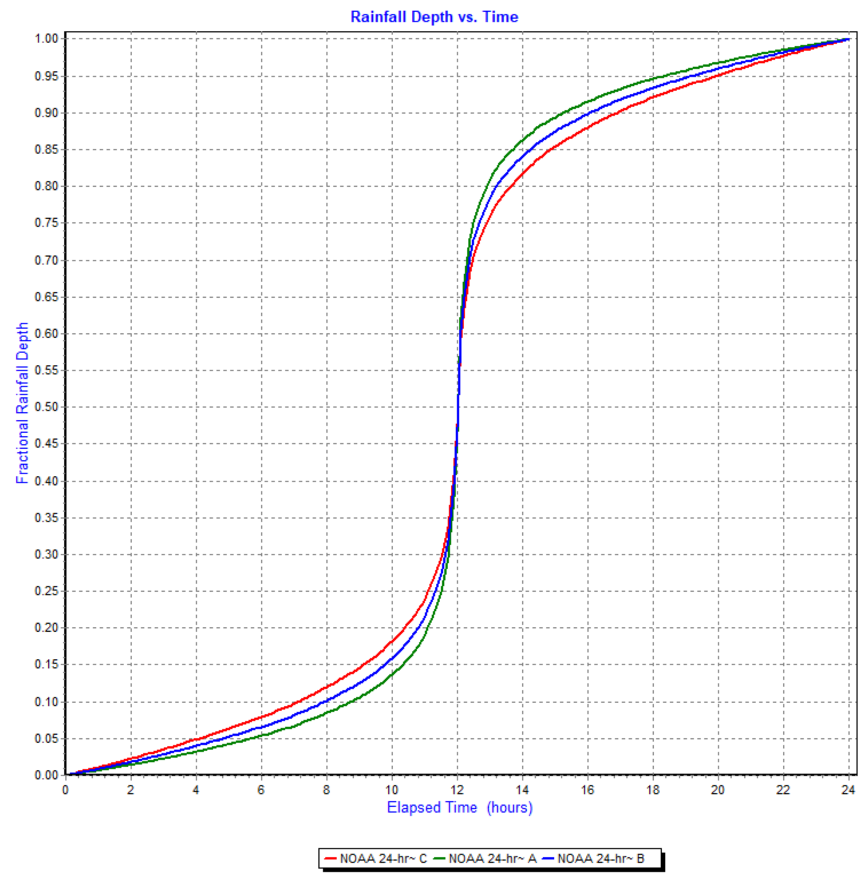
Water Quality Treatment Volume and the Corresponding SCM Treatment Type for the 1-year, 24-hour design storm		
SCM Treatment Type	WQTV	Notes
infiltration, evaporation, transpiration, and/or reuse	runoff generated from the first 1 inch of the design storm	Examples include, but are not limited to, bioretention, stormwater wetlands, and infiltration systems.
biologically active filtration, with an underdrain	runoff generated from the first 1.25 inches of the design storm	To achieve biologically active filtration, SCMs must provide minimum of 12 inches of internal water storage
sand or gravel filtration, settling ponds, extended detention ponds, and wet ponds	runoff generated from the first 2.5 inches of the design storm or the first 75% of the design storm, whichever is less	Examples include, but are not limited to, sand filters, permeable pavers, and underground gravel detention systems. Ponds must provide forebays comprising a minimum of 10% of the total design volume. Existing regional detention ponds are not subject to the forebay requirement.
hydrodynamic separation, baffle box settling, other flow-through manufactured treatment devices (MTDs), and treatment trains using MTDs	maximum runoff generated from the entire design storm	Flow-through MTDs must provide an overall treatment efficiency of at least 80% TSS reduction. Refer to 4.2.5.2d

Converting WQTV to a flow rate

Title 210 – National Engineering Handbook

Figure 4-71: NOAA Atlas 14 Volume 2 Region, Rainfall Distribution Regions





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where

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
I_a = initial abstraction (in)

Initial abstraction (I_a) is all losses before runoff begins. It includes water retained in surface depressions, water intercepted by vegetation, evaporation, and infiltration. I_a is highly variable but generally is correlated with soil and cover parameters. Through studies of many small agricultural watersheds, I_a was found to be approximated by the following empirical equation:

$$I_a = 0.2S \qquad \text{[eq. 2-2]}$$

By removing I_a as an independent parameter, this approximation allows use of a combination of S and P to produce a unique runoff amount. Substituting equation 2-2 into equation 2-1 gives:

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)} \qquad \text{[eq. 2-3]}$$

S is related to the soil and cover conditions of the watershed through the CN. CN has a range of 0 to 100, and S is related to CN by:

$$S = \frac{1000}{CN} - 10 \qquad \text{[eq. 2-4]}$$

Figure 2-1 and table 2-1 solve equations 2-3 and 2-4 for a range of CN's and rainfall.

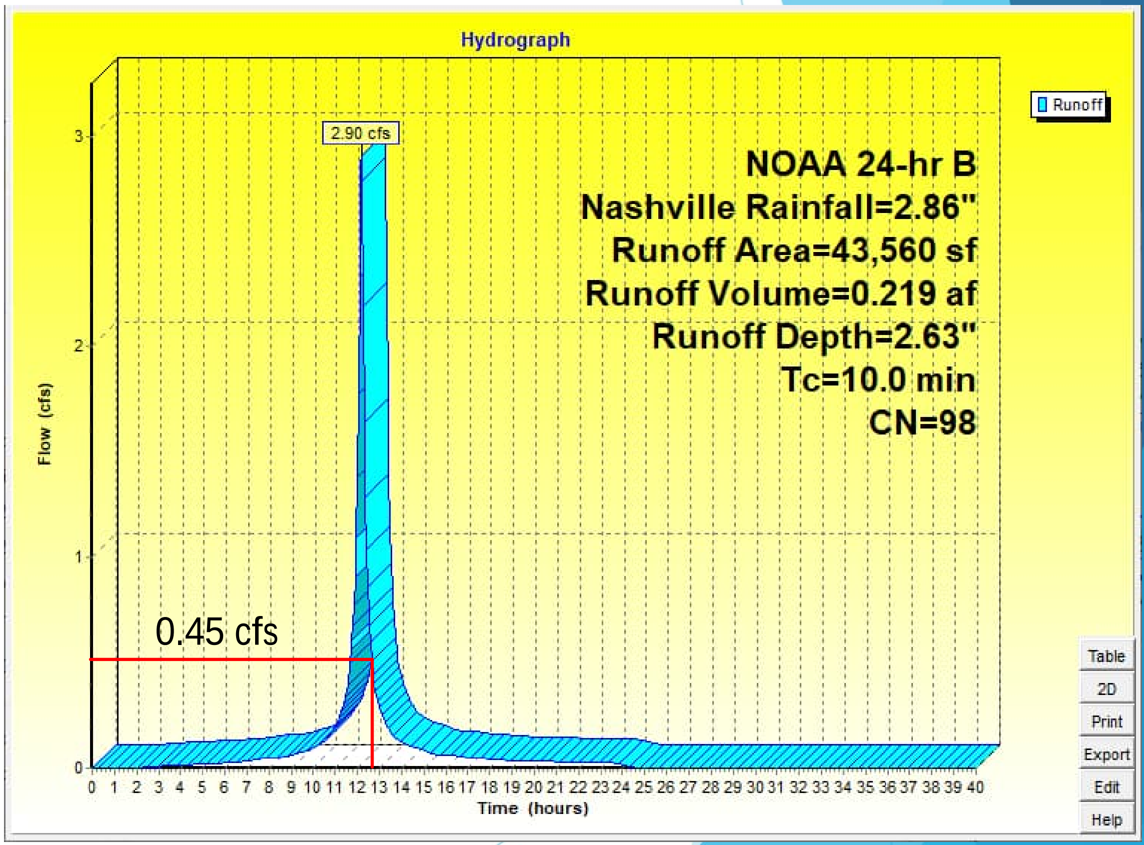
Converting WQTV to a flow rate

Peak Runoff = 2.90 cfs

Target precipitation depth = 2.15”

Hydrograph Results		
Precip (in)	Runoff Depth (in)	Runoff Rate (cfs)
1.00	0.79	0.68
1.25	1.03	1.09
2.15	1.93	~~0.45~~
2.86	2.63	2.90

* Note: the first 75% of the design storm occurs after the peak flow. Therefore, the SCM **must** be designed to treat the max peak flow rate to prevent premature bypassing. Affects SCMs in Rows 3 & 4.



Selecting the SCM size

HC Kraken® Filter:

- Drainage Area = 1 ac
- MTFR = 2.90 cfs
- Cartridge height = 30 in

Cartridge count by MTFR:

- 2.90 cfs / 0.038 cfs/cart = 77 cartridges

Cartridge count by Area:

- 1 ac / 0.032 ac/cart = 32 cartridges

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

The NJDEP certifies the use of the High Capacity Kraken Filter by Bio Clean Environmental Services, Inc. at a TSS removal rate of 80% when designed, operated, and maintained in accordance with the information provided in the Verification Appendix and the following conditions:

Table 1. High Capacity Kraken Filter Cartridge MTFRs and Maximum Allowable Drainage Area

Cartridge Height (in)	Cartridge Maximum Treatment Flow Rate (MTFR) (cfs)	Maximum Allowable Drainage Area (acres)
30	0.038	0.032
20	0.024	0.020
10	0.011	0.009

Lesson Learned #4

Maintenance Matters

Maintenance is necessary!

- Maintenance is important for ALL SCMs and their continued performance
  - Routine maintenance to meet “full treatment capacity within 72 hours” requirement
  - Mechanism for maintenance in perpetuity required
- Recommend setting up maintenance and inspection plans
- Regular inspection plans inform maintenance regimes
- Proprietary SCMs are required to provide maintenance guides
  - Part of NJDEP certification process
  - Also provided on company websites!

Example Maintenance Guide – HC Kraken Filter

Maintenance Indicators

Based upon observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components or cartridges
- Obstructions in the system or its inlet or outlet
- Accumulation of floatables in the pre-treatment chambers in which the length and width of the chamber behind oil/floatables skimmer is fully impacted
- Accumulation of sediment in the primary sedimentation chamber of more than 18" in depth
- Accumulation of sediment in the secondary sedimentation chamber of more than 6" in depth
- Accumulation of sediment in the filter chambers of more than 3" on average
- Substantial build-up of sediments on the filter membrane of the filter cartridges which will have a very dark appearance indicating the membrane may be fully saturated with sediment

Maintenance Equipment

While maintenance can be done fully by hand, it is recommended that a vacuum truck be utilized to minimize time required to maintain the Kraken® Filter:

- Contech Maintenance Form
- Flashlight
- Manhole hook or appropriate tools to access hatches and covers
- Appropriate traffic control signage and procedures
- Measuring pole and/or tape measure
- Protective clothing and eye protection
- Vacuum truck
- Trash can
- Pressure washer

Note: entering a confined space requires appropriate safety and certification. It is generally not required for routine inspections of the system. Entry into the system will be required if it is determined the cartridge filters need washing/cleaning

Maintenance Sequence

1. Remove access hatches set up vacuum truck to clean the pretreatment chamber.

2. Insert vacuum hose in the sedimentation chamber and vacuum out all trash, sediment and standing water.

Questions?

Thank you!

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TN Stormwater Program

CONTECH ENGINEERED SOLUTIONS