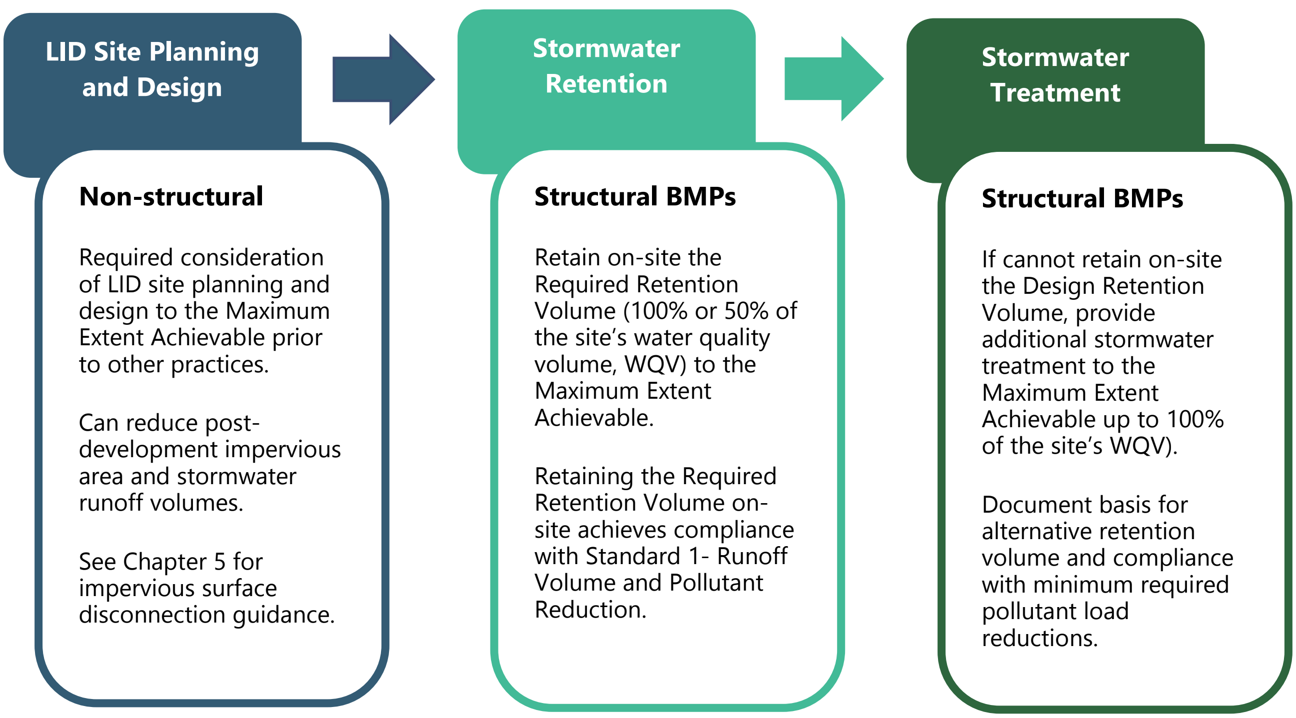
Standard 1 – Runoff Volume and Pollutant Reduction

Standard 1 (Runoff Volume and Pollutant Reduction) is intended to preserve pre-development hydrology (runoff duration, rate, and volume) and pollutant loads to protect water quality and maintain groundwater recharge by retaining and/or treating stormwater runoff from smaller, more frequent storms.

Standard 1 requires consideration of non-structural LID site planning and design techniques to reduce and disconnect post-development impervious areas on a site prior to consideration of structural stormwater BMPs. Once LID site planning and design techniques have been applied, structural stormwater BMPs should be used to retain on-site the required post-development stormwater runoff volume (i.e., retention volume) primarily through stormwater infiltration or reuse. If the retention volume for the site cannot be fully retained on-site, additional stormwater BMPs should be used to treat the volume above that which can be retained. Figure 4-1 illustrates schematically the major elements of and general process for complying with Standard 1.

Figure 4-1. Runoff Volume and Pollutant Reduction (Standard 1) Elements and Process



LID Site Planning and Design (non-structural)

Consider the use of non-structural LID site planning and design strategies, to the **MEA** (see the text box below for the definition) prior to the consideration of other practices, including structural stormwater BMPs, consistent with the CT DEEP stormwater general permits. The objective of this is to ensure that non-structural LID site planning and design techniques are considered at an early stage in the planning process and integrated into the project design.

Refer to Chapter 5 - Low Impact Development Site Planning and Design Strategies for performance criteria and design guidance for impervious area disconnection and other non-structural LID site planning and design strategies that can reduce post-development impervious area and stormwater runoff volumes.

Maximum Extent Achievable (MEA) – LID

For demonstrating "maximum extent achievable" regarding the LID Site Planning and Design requirement, a project proponent should demonstrate the following:

1. All reasonable efforts have been made to incorporate the use of LID site planning and design strategies in accordance with current local, state, and federal regulations,
2. A complete evaluation of all possible LID site planning and design strategies has been performed based on consideration of site characteristic, water quality, and other factors, and
3. The highest practicable use of LID site planning and design strategies is incorporated into the project.

The Stormwater Management Plan (Chapter 12 – Stormwater Management Plan) should include:

- LID Site Planning and Design Opportunities and Constraints Plan
- Completed LID Site Planning and Design Checklist documenting the non-structural LID strategies selected for the project and why other non-structural LID strategies could not be incorporated into the project.

Note: These LID principles are requirements of the CT DEEP Construction General Permit and are highly recommended for other categories of stormwater management.

Stormwater Retention and Treatment (structural)

After application of non-structural LID site planning and design strategies to the MEA, select and design structural stormwater BMPs in accordance with this Manual to manage the remaining post-development stormwater runoff volume from the site through on-site retention and treatment.

Stormwater Retention

Retain on-site the applicable post-development stormwater runoff volume **for the site**, referred to as the "Required Retention Volume," using structural stormwater BMPs. The Required Retention Volume is equal to 100% or 50% of the site's Water Quality Volume (WQV) depending on the type of project or activity (new development, redevelopment, or retrofit) and the existing Directly Connected Impervious Area (DCIA) of the site, consistent with the post-construction stormwater management provisions of the CT DEEP stormwater general permits. Refer to Table 4-2 for determining the appropriate Required Retention Volume for a given land development project or activity.

Table 4-2. Required Retention Volume Determination

Type of Project or Activity	Required Retention Volume (RRV)[1]	Additional Treatment Volume Required[1]	
		If Volume Retained Meets or Exceeds RRV	If Volume Retained Does Not Meet RRV
➢ New development[2] ➢ Redevelopment[3] or retrofit of sites that are currently developed with existing DCIA[4] of less than 40% ➢ Any new stormwater discharges located within 500 feet of tidal wetlands, which are not fresh-tidal wetlands, to avoid dilution of the high marsh salinity and encouragement of the invasion of brackish or upland wetland species	100% of site's WQV	None	(100% of site's WQV) – (Volume Retained)
➢ Redevelopment or retrofit of sites that are currently developed with existing DCIA[4] of 40% or more	50% of site's WQV	None	(100% of site's WQV) – (Volume Retained)

[1] Provide stormwater retention or additional treatment without retention to the Maximum Extent Achievable as defined in the CT DEEP stormwater general permits and described in this section.

[2] "New Development" means any construction or disturbance of a parcel of land that is currently in a natural vegetated state and does not contain alteration by man-made activities.

[3] "Redevelopment" means any construction activity (including, but not limited to, clearing and grubbing, grading, excavation, and dewatering) within existing drainage infrastructure or at an existing site to modify, expand, or add onto existing buildings, structures, grounds, or infrastructure.

[4] For the purpose of determining the Required Retention Volume, existing DCIA should be calculated based on the existing (pre-development) conditions of the overall project site.

- “Retention” means to hold post-development runoff on-site using structural stormwater BMPs or non-structural LID site planning and design strategies. In addition, it means there shall be no subsequent point source discharge to the drainage system or surface waters, including bypass of the stormwater BMP through inlet or outlet controls, **of any portion of** the Required Retention Volume. Retention practices reduce post-development runoff volumes and therefore are also called “runoff reduction” practices.

- Table 8-1. Stormwater Management Suitability in Chapter 8 identifies stormwater BMPs and their suitability for meeting the stormwater retention performance criterion. In general, Infiltration BMPs and Stormwater Reuse BMPs are considered suitable retention practices. Infiltration BMPs are preferred for meeting the stormwater retention performance criteria because they also recharge groundwater. Filtering BMPs (bioretention systems, tree filters, and surface sand filters) can provide retention of stormwater when designed specifically for infiltration. Dry water quality swales and green roofs are also suitable for providing stormwater retention.

- Retention practices should be sized to meet or exceed the applicable Required Retention Volume and should be designed, installed, and maintained consistent with the guidelines contained in this Manual to preserve pre-development hydrology and to achieve minimum average annual pollutant load reductions for sediment, floatables, and nutrients.

- In cases where the Required Retention Volume cannot be fully[44] retained on-site, retain stormwater runoff on-site to the “Maximum Extent Achievable” (see text box for demonstrating this) and provide additional stormwater treatment without retention as summarized in Table 4-2. Required Retention Volume Determination and described in the following section.

The Standard 1 stormwater retention requirements can be met at each individual discharge point along the boundary of the development site or internal to the site (i.e., design point) such as abutting properties, roadways, wetlands and watercourses, and receiving storm drainage systems.[45] I Or the Standard 1 retention requirement may also be demonstrated sitewide or for multiple design points.

[44] Fully means for the site. This can be address through multiple LID strategies, and structural BMPs in series or separately at several discharge points. The element that is important here is the RRV for the entire site.

[45] Per the CTDOT MS4 Permit, linear projects have alternative standards and may take an alternative approach to address constraints that are different than those that affect traditional parcel development projects. These alternative linear project standards can be found in the CTDOT drainage manual, the CTDOT MS4 General Permit, the General Construction Permit and in the supporting materials that CTDOT has developed.

- Appendix C presents calculation methods for designing retention and treatment stormwater BMPs and demonstrating compliance with the Standard 1 retention requirements by demonstrating individual BMPs.

- Pretreatment is necessary for most BMPs and should be provided as necessary (see Table 8-1. Stormwater Management Suitability) guidelines in Chapter 13 – Structural Stormwater BMP Design Guidance.

Maximum Extent Achievable (MEA) – Stormwater Retention*

For the Stormwater Retention requirement, MEA means maximum extent achievable using control measures that are technologically available and economically practicable and achievable considering best industry practice. To demonstrate compliance with the MEA standard for stormwater retention, a project proponent should:

- **Documentation:** Submit documentation for review and approval by the review authority describing site constraints (e.g., brownfields, capped landfills, bedrock, elevated groundwater, etc.) that would prevent on-site retention of the full Design Retention Volume. The documentation should include:
    - An explanation of site limitations
    - A description of the stormwater retention practices implemented
    - An explanation of why this constitutes the Maximum Extent Achievable
    - An alternative retention volume (i.e., the volume that can be retained on-site when the Required Retention Volume cannot be fully retained)
    - A description of the measures used to provide additional stormwater treatment without retention for sediment, floatables, and nutrients above the alternative volume up to the site's WQV
    - Analysis demonstrating that the average annual pollutant load reductions achieved by the proposed stormwater treatment measures meet or exceed minimum required reductions for sediment, floatables, and nutrients. The analysis should use the EPA stormwater BMP performance curves.

AND

- **Offsite Retention Mitigation:** Propose a stormwater retrofit project on another site within the same CT DEEP Subregional Basin or USGS HUC12 watershed (and preferably the same municipality) as the project site, provided the municipality has an offsite mitigation program in place. The proposed retrofit project can be funded directly by the project proponent, or the project proponent can propose a fee to be paid by the project proponent to be deposited into a dedicated account of the municipality for use by the municipality to fund in whole or in part the stormwater retrofit. The fee should be based on an estimate of the cost necessary to implement the retrofit to achieve a similar amount of retention to the amount by which the actual amount of retention fails to achieve the required retention volume for the site. Offsite mitigation is allowed for new development and redevelopment.

***Note:** The term MEA is used, but not specifically defined, in the current MS4 General Permit. The concepts described here are synonymous with the term Maximum Extent Practicable (MEP) of the MS4 General Permit.

- In the case of linear projects that do not involve impervious surfaces (e.g., electrical transmission rights-of-way or natural gas pipelines), stormwater retention is not required if the post-development runoff characteristics do not differ significantly from pre-development conditions.

- In the case of linear redevelopment projects (e.g., roadway reconstruction or widening) for the developed portion of the right of way:

  - For projects that may be unable to retain the Required Retention Volume (50% of the site's WQV), the alternate retention volume and additional treatment measures (see below) may also be applied, OR
  - For projects that will not increase the DCIA within a given CT DEEP Local Basin, the project proponent should implement the additional stormwater treatment measures (see below) but is not required to retain the Required Retention Volume (50% of the site's WQV).
  - For projects that are adding DCIA but unable to meet the retention requirements, the project proponent should prioritize the removal of the pollutant of concern if discharging to an impaired waterbody. If the project is not discharging to an impaired waterbody, the project proponent should prioritize the removal of TSS.

Stormwater Treatment

If the post-development stormwater runoff volume retained on-site does not meet the Required Retention Volume (100% or 50% of the site's WQV) for the site, provide stormwater treatment without retention for the post-development runoff volume above that which can be retained (the "alternate retention volume") up to 100% of the site's WQV (refer to Table 4-2. Required Retention Volume Determination).

Table 8-1. Stormwater Management Suitability identifies stormwater BMPs that can be used to provide stormwater treatment without retention. Treatment practices should be sized for the appropriate WQV or Water Quality Flow (WQF) and should be designed, installed, and maintained consistent with the guidelines contained in this Manual to achieve minimum average annual pollutant load reductions for sediment, floatables, and nutrients.

- Pretreatment is required for most stormwater BMPs and should be provided, as necessary (Table 8-1. Stormwater Management Suitability), in accordance with the design guidelines in Chapter 13 - Structural Stormwater BMP Design Guidance.

- When necessary, meeting Standard 1 through a combination of stormwater retention and treatment may require a treatment train approach – the use of multiple stormwater BMPs in series (e.g., an infiltration BMP sized for a portion of the required retention volume, followed by a treatment BMP to treat the remaining volume **up to** the site's full WQV).

- In cases where the stormwater treatment requirement cannot be fully achieved on-site, provide stormwater treatment to the "Maximum Extent Achievable" (see text box for definition).

Maximum Extent Achievable (MEA) – Stormwater Treatment*

For the Stormwater Treatment requirement, "MEA" means maximum extent achievable using control measures that are technologically available and economically practicable and achievable considering best industry practice. To demonstrate compliance with the MEA standard for stormwater treatment, a project proponent should:

- **Documentation:** Submit documentation for review and approval by the review authority describing site constraints that would prevent on-site treatment of the required treatment volume. The documentation should include:
  - An explanation of site limitations
  - A description of the stormwater treatment practices implemented and an alternative treatment volume (i.e., the volume that can be treated on-site when the required treatment volume cannot be achieved)

AND

- **Offsite Treatment Mitigation:** Propose a stormwater retrofit project on another site within the same CT DEEP Subregional Basin or USGS HUC12 watershed (and preferably the same municipality) as the project site, provided the municipality has an offsite mitigation program in place. The proposed retrofit project can be funded directly by the project proponent, or the project proponent can propose a fee to be paid by the project proponent to be deposited into a dedicated account of the municipality for use by the municipality to fund in whole or in part the stormwater retrofit. The fee should be based on an estimate of the cost necessary to implement the retrofit to achieve a similar amount of treatment to the amount by which the actual amount of treatment fails to achieve the required treatment volume for the site. Offsite mitigation is allowed for new development and redevelopment.

***Note:** The term MEA is used, but not specifically defined, in the current MS4 General Permit. The concepts described here are synonymous with the term Maximum Extent Practicable (MEP) of the MS4 General Permit.

Water Quality Volume

Updated Water Quality Volume

The Water Quality Volume (WQV) concept is based on the "first flush" principle, which assumes that most pollutants in stormwater runoff are conveyed in the initial portion of a storm event. As such, the WQV is the volume of runoff generated by the water quality storm. The water quality storm is defined as the 90th percentile rainfall event (accounting for 90 percent of all 24-hour storms on an average annual basis). The runoff volume associated with the 90th percentile rainfall depth roughly corresponds to the volume of runoff that is infiltrated in a natural condition and thus should be managed on-site to restore and maintain pre-development hydrology for duration, rate, and volume of stormwater flows.[46]

Prior to this update, the water quality storm was defined as the 1-inch storm. This version of the Manual replaces the previous 1-inch water quality storm with an updated 90th percentile rainfall depth of 1.3 inches. Specifically, this represents the average of 90th percentile rainfall depths calculated for several locations throughout Connecticut using daily precipitation observations over an approximately 40-year period of record (1980-2021) and the procedure cited in EPA technical guidance (see Appendix G for further information).

Water Quality Volume Calculation

As described above, the WQV is a key factor in determining the Required Retention Volume and any additional treatment requirements. The WQV is the volume of stormwater runoff from a given storm event that must be retained and/or treated to remove most of the post-development stormwater pollutant load on an average annual basis and to help maintain pre-development site hydrology in terms of duration, rate, and volume of stormwater flows including groundwater recharge. The WQV is calculated using the following equation:

$$WQV = \frac{(P)(R)(A)}{12}$$

where:

WQV = water quality volume (cubic feet)
P = 1.3 inches (90th percentile rainfall event)
R = volumetric runoff coefficient = 0.05+0.009(I)
I = post- development impervious area (percent) after application of non-structural LID site planning and design strategies and before application of structural stormwater BMPs
A = post-development total drainage area of site or design point (square feet)

[46] USEPA. Section 438 Technical Guidance December 2009. Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. EPA 841-B-09-001. December 2009. www.epa.gov/owow/nps/lid/section438.

- For the WQV calculation, impervious area (*I*) should be measured from the post-development site plan and includes all directly connected impervious surfaces (DCIA as defined in this Manual) within boundaries of the site or for the drainage area of the each design point.

- Impervious areas that drain as sheet flow onto and over an adjacent pervious area that, due to its size, slope, vegetation, and underlying soil characteristics, meets the criteria for "simple disconnection criteria for "impervious area (simple) disconnection" can be subtracted from the post development impervious area term in the WQV equation. This provides further incentive to use simple disconnection and other non-structural LID site planning and design strategies to reduce the need for and size of structural stormwater BMPs to meet the retention and treatment performance criterion.

Water Quality Flow

The Water Quality Flow (WQF) is the peak flow rate associated with the water quality storm or WQV, as described above. Although most of the structural stormwater BMPs in this Manual should be sized based on a design volume (Required Retention Volume and any additional treatment volume), some BMPs such as grass channels and proprietary treatment/pretreatment BMPs should be designed based on peak flow rate. In this approach, the stormwater BMP (including inlet structure) must have a flow rate capacity equal to or greater than the design WQF in order to prevent bypass and treat the associated design WQV for the site. Flow diversion structures (also called flow splitters) are typically used to bypass flows in excess of the design WQF for off-line stormwater BMPs.

The design WQF is calculated based on the design WQV for the site using a modified NRCS Runoff Curve Number for small storm events. The procedure is based on the approach described in Claytor and Schueler, 1996.[47] The Inlet and Outlet Controls section of Chapter 13 - Structural Stormwater BMP Design Guidance provides design guidance for flow diversion structures.

Demonstrating Compliance with Standard 1

Stormwater management systems should be designed to achieve the average annual pollutant load reductions from directly connected impervious area for sediment (Total Suspended Solids) and nutrients (Total Phosphorus and Total Nitrogen) shown in Table 4. 3.

Achieving these minimum required load reductions for sediment and nutrients is assumed to provide adequate reductions of other stormwater pollutants including floatable materials. However, it is important to note that if the full retention goal (i.e., Required Retention Volume) is

[47] Claytor, R.A. and T. R. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Silver Spring, Maryland.

met, then it is assumed pollutant reduction is also achieved and individual pollutant calculations are not necessary.

Table 4. 3 Minimum Average Annual Pollutant Load Reductions When Evaluating BMP Selection and Sizing (Only needed when additional stormwater treatment is needed[1])

Water Quality Parameter	New Development	Redevelopment/Retrofits
Total Suspended Solids (TSS)	90%	80%
Total Phosphorus (TP)	60%	50%
Total Nitrogen (TN)	40%	30%

[1] Pollutant load reduction percentages are calculated based on average annual loading and not based on any individual storm event. Load reductions based on post-construction stormwater management standards contained in the EPA Massachusetts MS4 General Permit.

- A proposed stormwater management system meets or exceeds these average annual pollutant load reductions when the Required Retention Volume is retained on-site using suitable stormwater retention practices (refer to Figure 8- 1).[48]
- If the stormwater runoff volume retained on-site does not meet the Required Retention Volume (100% or 50% of the site's WQV), and therefore additional stormwater treatment is required, the project proponent should document that the proposed stormwater management system meets or exceeds the minimum required average annual pollutant load reductions through the use of EPA Region 1 stormwater BMP performance curves (see the following section).

Stormwater BMP Performance Curves

EPA Region 1 developed performance curves to help quantify the pollutant reduction benefits of structural stormwater BMPs. The curves provide estimates of the long-term cumulative pollutant removal performance of a BMP as a function of the BMP size (physical storage capacity). The curves were developed using EPA's Stormwater Management Model and long-term rainfall data from Boston, Massachusetts to simulate rainfall-runoff and pollutant loading and removal during rain events in New England. The models were calibrated and tested with performance data from stormwater controls evaluated by the University of New Hampshire Stormwater Center. The curves relate the depth of runoff treated from the impervious area to average annual pollutant reduction for various types of structural stormwater BMPs and stormwater pollutants. Curves have been developed for TSS, TP, TN, Zinc, fecal indicator bacteria (*E. coli* and Enterococcus), and runoff reduction. Multiple curves have been developed for stormwater

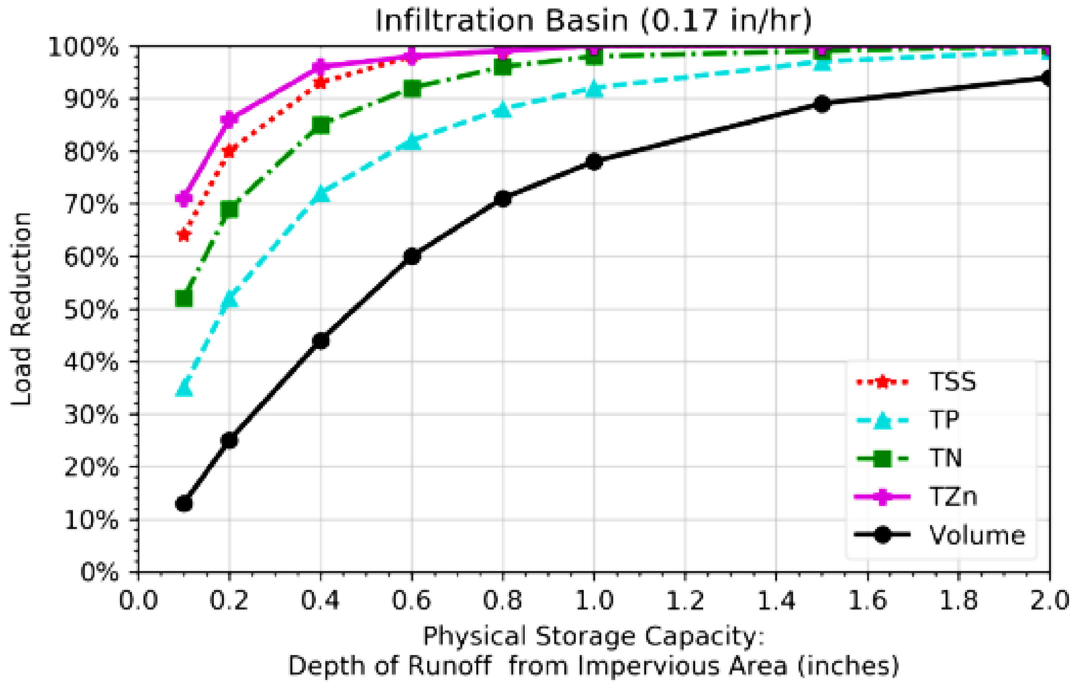
[48] On-site retention of the Required Retention Volume (100% or 50% of the site's WQV) using stormwater BMPs designed in accordance with the guidelines in this Manual is assumed to achieve average annual pollutant load reductions that exceed the minimum required values in Table 4-3 based on EPA Region 1 stormwater BMP performance curves.

infiltration BMPs to represent various soil conditions, land uses and infiltration rates. The curves can be used to size stormwater BMPs and to quantify the pollutant removal benefit (i.e., credit) for a range of sizes and types of BMPs.

Figure 4- 2 shows a typical set of BMP performance curves for an infiltration basin in Type B soils. In this example, an infiltration basin designed with a physical storage volume equivalent to the runoff volume created by the first 1 inch of runoff of precipitation over the contributing impervious area will result in average annual load reductions of approximately 100% for TSS, 92% for TP, and 98% for TN. The curves also demonstrate that:

- Structural stormwater BMPs sized to store less than 1 inch of runoff from the impervious area can still achieve substantial pollutant load reductions, which allows for the use of smaller structural controls for retrofit applications and on sites with limited space and other physical constraints, while still meeting pollutant removal goals.
- Structural stormwater BMPs provide diminishing pollutant reduction benefits above a certain size (the "knee" in the curve), although on-site retention of stormwater volumes **up to** the Required Retention Volume (100% or 50% of the site's WQV) is important to maintain pre-development hydrology (i.e., volume, rate, and temperature of runoff) and groundwater recharge.

Figure 4- 2 Example Stormwater BMP Performance Curves for Infiltration Basin in Type B Soils



Source: University of New Hampshire Stormwater Center

Use of Performance Curves to Demonstrate Compliance with Minimum Required Pollutant Load Reductions for Individual BMPs

When the Required Retention Volume cannot be retained on-site, and therefore additional stormwater treatment is required, the stormwater BMP performance curves should be used to document that the proposed stormwater management system meets or exceeds the minimum required pollutant load reductions listed in Table 4. 3. The following procedure should be used:

1. Calculate the runoff depth from the impervious area BMP can statically store the following equation:

$$Depth\ of\ Runoff\ from\ Impervious\ Area\ (inches) = \frac{V}{DCIA} * 12\frac{inches}{foot}$$

   where:

   V = BMP static storage volume (cubic feet)
   $DCIA$ = post-development Directly Connected Impervious Area (square feet) draining to the BMP after application of non-structural LID site planning and design strategies

   - The static storage volume is the volume of stormwater a structural stormwater BMP can physically hold. It includes the BMP's permanent storage volume (ponding above the surface, voids in subsurface engineered media, and subsurface structures such as chambers or tanks) but does not include the volume associated with peak rate attenuation control (volume above the primary outlet). It also doesn't include the additional treatment volume as a result of the water that infiltrates into the underlying soil while the system is filling or stormwater that bypasses the system through inlet or outlet controls.

   - Appendix C provides the corresponding EPA stormwater BMP performance curves and equations for calculating the static storage volume for each type of structural stormwater BMP presented in this Manual.

2. With the calculated Depth of Runoff from Impervious Area, use the appropriate stormwater BMP performance curves in Appendix C to obtain the average annual pollutant load reduction percentages of the BMP for TSS, TP, and TN.

3. If the pollutant load reduction percentages provided by the BMP meet or exceed the minimum required pollutant load reductions in Table 4. 3 (for all three pollutants), then the proposed stormwater management system meets the pollutant reduction performance criteria.
4. If the pollutant load reduction percentages provided by the BMP are less than the minimum required pollutant load reductions in Table 4. 3 (for any of the three pollutants), then the proposed stormwater management system does not meet the

pollutant reduction performance criteria, and the system should be increased in size to achieve the minimum required pollutant load reduction(s) or another BMP should be selected. In this situation, the curves should be used in "reverse" to determine the required Depth of Runoff from Impervious Area and required static storage volume to achieve the target pollutant load reduction.

5. When multiple stormwater BMPs are used in series to provide treatment or a combination of retention and treatment, the BMP performance curves should be used to calculate the individual average annual pollutant load reduction percentages for each BMP in the treatment train. The overall average annual pollutant load reductions for the entire treatment train should be calculated using one of the following approaches:

   - Use the equation below for two treatment BMPs in series when both BMPs treat the same water as it flows from one BMP to the next:

$$R = (A + B) - \frac{(A \times B)}{100}$$

     where:

     R = total pollutant load reduction (%)
     A = pollutant load reduction of first or upstream BMP (%)
     B = pollutant load reduction of second or downstream BMP (%)

   - For more BMPs in series when all of the BMPs treat the same water as it flows from one BMP to the next, calculate the total pollutant load reduction percentage by successively applying the pollutant load reductions of each individual BMP to the load entering from the upstream BMP. For example:

     - Initial TSS Load Upstream of BMP 1 = 1.0
     - TSS Load Removed by BMP 1 = 1.0 x 60% Removal Rate = 0.6
     - Remaining TSS Load Downstream of BMP 1 = 1.0 – 0.6 = 0.4
     - TSS Load Removed by BMP 2 = 0.4 x 50% Removal Rate = 0.2
     - Final TSS Load Downstream of BMP 2 = 0.4 – 0.2 = 0.2
     - Total TSS Removal Rate = 1.0 – 0.2 = 0.8 or 80%

   - When the upstream BMP bypasses without treatment a portion of the Required Retention Volume to a downstream BMP (i.e., the two BMPs do not treat the same water), obtain the pollutant load reductions for each individual BMP from the performance curves based on their respective static storage volumes. Then calculate the overall pollutant load reduction efficiency of the treatment train as the weighted average of the load reductions of the individual BMPs, weighted by the respective static storage volumes.