Appendix F

Phosphorus Reduction Credits for Selected Non-Structural and Structural Stormwater Control Measures (SCMs)

<u>Table of Contents</u>

List of Tables

List of Figures

List of Examples

PART 1. Methods to Calculate Phosphorus Load Reductions for Non-Structural Stormwater Management Controls (SCMs)

1.1. Introduction

The permittee shall use the following methods to calculate phosphorus load reduction credits for the following enhanced non-structural control practices implemented:

1) Enhanced Street Sweeping Program;
2) Catch Basin Cleaning;
   and
3) Organic Waste and Leaf Litter Collection program

The methods include the use of default Phosphorus reduction factors that EPA has determined are acceptable for calculating phosphorus load reduction credits for these practices.

The methods and annual phosphorus load export rates presented in this attachment are for the purpose of counting load reductions for various SCMs treating stormwater runoff from varying site conditions (i.e., impervious or pervious surfaces) and different land uses (e.g. industrial and commercial) within the watershed. Table 1-1 below provides annual phosphorus load export rates by land use category for impervious and pervious areas. The estimates of annual phosphorus load and load reductions resulting from SCM implementation are intended for use by the permittee to measure compliance with its Phosphorus Reduction Requirement under the permit.

Examples are provided to illustrate use of the methods. In calculating phosphorus export rates, the permittee shall select the land use category that most closely represents the actual use for the area in question. For watersheds with institutional type uses, such as government properties, hospitals, and schools, the permittee shall use the commercial land use category for the purpose of calculating phosphorus loads. Table 1-2 provides a crosswalk table of land use codes between land use groups used in Table 1-1 and the codes used by MassGIS for the 2016 land use/land cover data. For pervious areas, permittees should use the appropriate value for the hydrologic soil group (HSG) if known, otherwise, assume HSG C conditions.

Table 1-1. Average annual distinct P Load export rates for use in estimating P Load reduction credits in the CII GP.

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate, lbs/acre-year
Commercial (Com), Industrial (Ind) and Institutional (Ins)	Directly connected impervious	1.80
	Pervious	See* DevPERV
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.38
	Pervious	See* DevPERV
Medium (MDR) and Low Density Residential (LDR)	Directly connected impervious	1.97
	Pervious	See* DevPERV

Highway (HWY)	Directly connected impervious	1.39
	Pervious	See* DevPERV
Forest (For)	Directly connected impervious	1.50
	Pervious	See* DevPERV
Open Land (Open)	Directly connected impervious	1.50
	Pervious	See* DevPERV
Agriculture (Ag)	Directly connected impervious	1.50
	Pervious	See* DevPERV
*Developed Land Pervious (DevPERV) – HSG A	Pervious	0.03
*Developed Land Pervious (DevPERV) – HSG B	Pervious	0.11
*Developed Land Pervious (DevPERV) – HSG C	Pervious	0.21
*Developed Land Pervious (DevPERV) – HSG D	Pervious	0.37

Notes:

- For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C conditions for the phosphorus load export rate.
- Agriculture includes row crops. Actively managed hay fields and pasture lands. Institutional land uses such as government properties, hospitals and schools are to be included in the commercial and industrial land use grouping for the purpose of calculating phosphorus loading.
- Impervious surfaces within the forest land use category are typically roadways adjacent to forested pervious areas.

Table 1-2. Crosswalk of 2016 Mass GIS land use categories. Institutional land use descriptions also fall into the Commercial/Industrial Land Use Group for calculating Phosphorus Loads.

2016 MassGIS Land Use Code (USEGENCODE)	Description	Land Use Group for Calculating P Load - CII GP
0	Unknown	Open Land
2	Open land	Open Land
3	**Commercial**	**Commercial/ Industrial**
4	**Industrial**	**Commercial/ Industrial**
6	Forest	Forest
7	Agriculture	Agriculture
8	Recreation	Open Land
9	**Tax exempt**	**Commercial/ Industrial**
10	**Mixed use, primarily residential**	**Commercial/ Industrial**
11	Single Family Residential	Medium Density Residential
12	Multi-family Residential	High Density Residential
13	Residential, other	Medium Density Residential
20	**Mixed use, other**	**Commercial/ Industrial**

30	**Mixed use, primarily commercial**	**Commercial/ Industrial**
55	**Right-of-way**	**Commercial/ Industrial**
88	Water	Water

1.1.1. Alternative Methods and/or Phosphorus Reduction Factors

A permittee may propose alternative methods and/or phosphorus reduction factors for calculating phosphorus load reduction credits for these non-structural practices. EPA will consider alternative methods and/or phosphorus reduction factors, provided that the permittee submits adequate supporting documentation to EPA. At a minimum, supporting documentation shall consist of a description of the proposed method, the technical basis of the method, identification of alternative phosphorus reduction factors, supporting calculations, and identification of references and sources of information that support the use of the alternative method and/or factors in the Watershed. If EPA determines that the alternative methods and/or factors are not adequately supported, EPA will so notify the permittee and the permittee may not receive ~~no~~ phosphorus reduction credit for such methods. Those permittees may only receive ~~other than a~~ reduction credits ~~calculated by the permittee~~ following the methods in this attachment for the identified practices.

1.2. Phosphorus Load Reduction Credit Calculations for Non-Structural Stormwater Management Controls (SCMs)

1.2.1. Enhanced Sweeping Program

The permittee may earn a phosphorus reduction credit for conducting an enhanced sweeping program of impervious surfaces.

For the purposes of the CII GP, Permittees shall assume the land use associated with any onsite sweeping area is Commercial/Industrial impervious cover with a 1.80 lbs/ac/yr loading rate.

Table below outlines the default phosphorus removal factors for enhanced sweeping programs. The credit shall be calculated by using the following equation:

$$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} * \text{PLER}_{\text{IC-land use}} * \text{PRF}_{\text{sweeping}}$$

Equation 1-1. Enhanced Sweeping Program

Where:

$\text{Credit}_{\text{sweeping}}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)
IA_{swept} = Area of impervious surface that is swept under the enhanced sweeping program (acres)
$\text{PLER}_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 1-1)
$\text{PRF}_{\text{sweeping}}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 1-3).

If a permittee includes driveways or other linear features in their street sweeping program, the Permittee can use the equation below to convert the area of the linear features swept to acres.

$$Area\ Swept\ [ac] = \frac{Distace\ Swept\ [mi] * Sweeper\ Width\ [8\ ft] * 5280ft * 1\ ac}{43560\ ft^2 * 1\ mi}$$

Table 1-3. Phosphorus reduction efficiency factors ($PRF_{sweeping}$) for sweeping impervious areas

Level	Frequency	Sweeper Technology	$PRF_{sweeping}$
Minimum Effort	2/year (spring and fall)	Mechanical Broom	0.01
		Vacuum Sweeper	0.02
Medium Effort	Every other week in the fall (September 1 to December 15)	Mechanical Broom or Vacuum Sweeper	0.15
High Effort	Monthly sweeping March through August with weekly sweeping in the Fall (September to December)	Vacuum Sweeper	0.25

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Example 1-1. Calculation of enhanced sweeping program credit ($Credit_{sweeping}$)

A permittee proposes to implement an enhanced sweeping program and perform monthly sweeping from March through August and weekly sweeping from September 1 to December 15 at their site, using a vacuum assisted sweeper on 20.3 acres of parking lots and roadways on a commercial site. For this site the needed information is:

IA_{swept} = 20.3 acres
$PLER_{IC\text{-}land\ use}$ = 1.80 lb/acre/yr (from Table 1-1)
$PRF_{sweeping}$ = 0.25 (from Table 1-3)

Substitution into Equation 1-1 yields a $Credit_{sweeping}$ of 9.14 pounds of phosphorus removed per year.

$Credit_{sweeping}$ = $IA_{swept} * PLE_{land\ use} * PRF_{sweeping}$
= 20.3 acres *1.80 lbs/acre/yr * 0.25
= 9.14 lbs/yr

1.2.2. Catch Basin Cleaning

The permittee may earn a phosphorus reduction credit, $Credit_{CB}$, by removing accumulated materials from catch basins (i.e., catch basin cleaning) such that a minimum sump storage capacity of 50% is maintained throughout the year. The credit shall be calculated by using the following equation:

$$\text{Credit}_{CB} = IA_{CB} * PLER_{IC\text{-land use}} * PRF_{CB}$$

Equation 1-2. Catch Basin Cleaning

Where:

Credit_{CB} = Amount of phosphorus load removed by catch basin cleaning (lb/year)
IA_{CB} = Impervious drainage area to catch basins (acres)
$PLER_{IC\text{-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 1-1)
PRF_{CB} = Phosphorus Reduction Factor for catch basin cleaning (see Table 1-4)

Table 1-4. Phosphorus reduction efficiency factor (PRF_{CB}) for semi-annual catch basin cleaning

Frequency	**Practice**	**PRF_{CB}**
Semi-annual	Catch Basin Cleaning	0.02

Example 1-2. Calculation for catch basin cleaning credit (Credit_{CB})

A permittee proposes to clean catch basins on their site (i.e., remove accumulated sediments and contaminants captured in the catch basins) that drain runoff from 15.3 acres of commercial impervious area. For this site the needed information is:

IA_{CB} = 15.3 acre
$PLER_{IC\text{-land use}}$ = 1.80 lbs/acre/yr (from Table 1-1)
PRF_{CB} = 0.02 (from Table 1-4)

Substitution into Equation 1-2 yields a Credit_{CB} of 0.55 pounds of phosphorus removed per year:

Credit_{CB} = $IA_{CB} * PLE_{IC\text{-land use}} * PRF_{CB}$
= 15.3 acre * 1.80 lbs/acre/yr * 0.02
= 0.55 lbs/yr

1.2.3. Enhanced Organic Waste and Leaf Litter Collection Program

The permittee may earn a phosphorus reduction credit by performing regular gathering, removal and disposal of landscaping wastes, organic debris, and leaf litter from impervious surfaces from which runoff discharges to a receiving water. In order to earn this credit ($\text{Credit}_{\text{leaf litter}}$), the permittee must gather and remove all landscaping wastes, organic debris, and leaf litter from impervious roadways and parking lots at least once per week during the period of September 1 to December 15 of each year. Credit can only be earned for those impervious surfaces that are cleared of organic materials in accordance with the description above. The gathering and removal shall occur immediately following any landscaping activities in the Watershed and at additional times when necessary to achieve a weekly cleaning frequency. The permittee must ensure that the disposal of these materials will not contribute pollutants to any surface water discharges. The permittee may use an enhanced sweeping program (e.g., weekly frequency) as part of earning this credit provided that the sweeping is effective at removing leaf litter and organic materials. The $\text{Credit}_{\text{leaf litter}}$ shall be determined by the following equation:

$$\text{Credit}_{\text{leaf litter}} = (\text{Drainage Area}) * (\text{PLER}_{\text{IC-land use}}) * (0.05)$$

Equation 1-3. Enhanced Organic Waste and Leaf Litter Collection Program

Where:

$\text{Credit}_{\text{leaf litter}}$ = Amount of phosphorus load reduction credit for organic waste and leaf litter collection program (lb/year)

Drainage Area = All impervious area (acre) from which runoff discharges to the the receiving water or its tributaries

$\text{PLER}_{\text{IC-land use}}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lbs/acre/yr) (see Table 1-1)

0.05 = 5% phosphorus reduction factor for organic waste and leaf litter collection program

Example 1-3. Calculation for organic waste and leaf litter collection program credit ($\text{Credit}_{\text{leaf litter}}$)

A permittee proposes to implement an organic waste and leaf litter collection program by sweeping the parking lots and access drives at a minimum of once per week using a mechanical broom sweeper for the period of September 1 to December 15 over 12.5 acres of impervious roadways and parking lots on an industrial/commercial site. Also, the permittee will ensure that organic materials are removed from impervious areas immediately following all landscaping activities at the site. For this site the needed information to calculate the $\text{Credit}_{\text{leaf litter}}$ is:

Watershed Area = 12.5 acres; and
$\text{PLER}_{\text{IC-commercial}}$ = 1.80 lbs/acre/yr (from Table 1-1)

Substitution into Equation 1-3 yields a $\text{Credit}_{\text{leaf litter}}$ of 1.13 pounds of phosphorus removed per year:

$$\begin{aligned}\text{Credit}_{\text{leaf litter}} &= (12.5\text{ acres}) * (1.80\text{ lbs/acre/yr}) * (0.05)\\ &= 1.13\text{ lbs/yr}\end{aligned}$$

The permittee also may earn a phosphorus reduction credit for enhanced sweeping of roads and parking lot areas (i.e., Credit $_{\text{sweeping}}$) for the 3.5 months of use. Using Equation 1-1, Credit $_{\text{sweeping}}$ is:

Credit $_{\text{sweeping}}$ = IA $_{\text{swept}}$ * PLE $_{\text{IC-land use}}$ * PRF $_{\text{sweeping}}$
IA $_{\text{swept}}$ = 12.5 acres
PLER $_{\text{IC-commercial}}$= 1.80 lbs/acre/yr (from Table 1-1)
PRF $_{\text{sweeping}}$ = 0.15 (from Table 1-3)

Substitution into Equation 1-1 yields a Credit $_{\text{sweeping}}$ of 3.38 pounds of phosphorus removed per year.

Credit $_{\text{sweeping}}$ = IA $_{\text{swept}}$ * PLER $_{\text{IC-commercial}}$ * PRF $_{\text{sweeping}}$
= 12.5 acres * 1.80 lbs/acre/yr * 0.15
= 3.38 lbs/yr

PART 2. Methods to Calculate Phosphorus Load Reductions for Structural Stormwater Control Measures (SCMs)

2.1. Introduction

This section of Appendix F provides methods to determine design storage volume capacities and to calculate phosphorus load reductions for the following Stormwater Control Measures (SCMs):

1. Infiltration Trench;
2. Surface Infiltration Practices (i.e., basins, rain gardens and bio-retention);
3. Bio-filtration Practice;
4. Gravel Wetland System;
5. Enhanced Bio-filtration with Internal Storage Reservoir (ISR);
6. Sand Filter;
7. Porous Pavement;
8. Wet Pond or wet detention basin;
9. Dry Pond or extended dry detention basin;
10. Dry Water Quality Grass Swale with Detention;
11. Impervious Area Disconnection through Storage (e.g., rain barrels, cisterns, etc.);
12. Impervious Area Disconnection;
13. Conversions of Impervious Area to Permeable Pervious Area; and
14. Soil Amendments to Enhance Permeability of Pervious Areas.

Methods and examples are provided to calculate phosphorus load reductions for SCMs for the four following purposes:

1. To determine the design volume of a SCM to achieve a known phosphorus load reduction target when the contributing drainage area is 100% impervious;
2. To determine the phosphorus load reduction for a SCM with a known design volume capacity when the contributing drainage area is 100% impervious;
3. To determine the design volume of a SCM to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces; and
4. To determine the phosphorus load reduction for a SCM with a known design volume capacity when the contributing drainage area has impervious and pervious surfaces.

Examples are also provided for estimating phosphorus load reductions associated with impervious area disconnections, conversions of impervious area to permeable pervious area, and soil amendments to enhance permeability of pervious area.

Also, this Appendix provides the methodology for calculating the annual stormwater phosphorus load that will be delivered to SCMs for treatment (“SCM Load”) and to be used for quantifying phosphorus load reduction credits. The methods and annual phosphorus export load rates presented in this Appendix are for calculating load reductions for various SCMs treating stormwater runoff from varying site conditions (i.e., impervious surfaces) and different land uses (e.g., commercial and institutional). The estimates of annual phosphorus load and load reductions resulting from SCM implementation are intended for use by the permittee to demonstrate compliance with its Phosphorus Reduction Requirement.

2.2. SCM Performance Credits

For each SCM type identified above (SCMs 1-10), long-term cumulative performance information is provided to calculate phosphorus load reductions or to determine needed design storage volume capacities to achieve a specified reduction target (e.g., 65% phosphorus load reduction). The performance information is expressed as cumulative phosphorus load removed (% removed) depending on the physical storage capacity of the SCM (expressed as inches of runoff from impervious area) and is provided at the end of this Appendix (see Table 2-3 through Table 2-24) and performance curves Figure 2-5 through Figure 2-26). Multiple tables and performance curves are provided for the infiltration practices to represent cumulative phosphorus load reduction performance for seven infiltration rates (“IR”), 0.10, 0.17, 0.27, 0.53, 1.02, 2.41, and 8.27 inches/hour. These infiltration rates represent the saturated hydraulic conductivity of the soils. The permittee may use the performance curves provided in this attachment to interpolate phosphorus load removal reductions for field measured infiltration rates that are different than the infiltration rates used to develop the performance curves. Otherwise, the permittee shall use the performance curve for the IR that is nearest, but less than, the field measured rate.

The Design Storage Volume (“DSV”) or physical storage capacity (as referred to on the x-axis of performance curves) equals the total physical storage volume of the control structure to contain water at any instant in time. Typically, this storage capacity is comprised of the surface ponding storage volume prior to overflow and subsurface storage volumes in storage units and pore spaces of coarse filter media. Table 2-2 provides the formulae to calculate physical storage capacities for the structural control types for using the performance curves.

2.2.1. Impervious area disconnections, conversions of impervious area to permeable pervious area, and soil amendments to enhance permeability of pervious area (SCMs 11-14 above)

For each of these SCMs long-term cumulative performance information is provided to calculate phosphorus load reductions or to determine needed design specifications to achieve a desired reduction target (e.g., 50% phosphorus load reduction). The performance information is expressed as cumulative runoff volume reduction (% removed) depending on the design specifics and actual field conditions. Cumulative percent runoff volume reduction is being used as a surrogate to estimate both the cumulative phosphorus load reduction credits for these SCMs.

To represent a wide range of potential conditions for implementing these types of SCMs, numerous performance tables and curves have been developed to reflect a wide range of potential conditions and designs such as varying storage volumes (expressed in terms of varying ratios of storage volume to impervious area (0.1 to 2.0 inches)); varying ratios of impervious source area to receiving pervious area based on hydrologic soil groups ("HSGs") A, B, C and D (8:1, 6:1, 4:1, 2: 1 and 1:1); and varying discharge time periods for temporary storage (1, 2 or 3 days). The credits are provided at the end of this Attachment (see Table 2-25 through Table 2-32 and performance curves Figure 2-27 through Figure 2-47).

EPA will consider phosphorus load reductions calculated using the methods provided below to be valid for demonstrating compliance with the terms of this permit for SCMs or SCMs that have not been explicitly modeled, if the desired SCM has functionality that is similar to one of the simulated SCM or SCM types. Regarding functionality, only the surface infiltration, the infiltration trench, impervious area disconnections, conversions of impervious area to permeable pervious area, and soil amendments to enhance permeability of pervious area were simulated to direct storm water runoff into the ground (i.e., infiltration). All other simulated SCMs represent practices that are not hydraulically connected to the sub-surface soils (i.e., no infiltration) and have either under-drains or impermeable liners. Following are some simple guidelines for selecting the SCM type and/or determining whether the results of any of the SCM types provided are appropriate for another SCM of interest.

2.2.2. Infiltration Trench

Infiltration Trench is a practice that provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils. Performance results for the infiltration trench can be used for all subsurface infiltration practices including systems that include pipes and/or chambers that provide temporary storage. Also, the results for this SCM type can be used for bio-retention systems that rely on infiltration when the majority of the temporary storage capacity is provided in the void spaces of the soil filter media and porous pavements that allow infiltration to occur. General design specifications for infiltration trench systems are provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2*[1] (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.3. Infiltration Basin

Infiltration basins provide temporary surface storage of runoff (e.g., ponding) for subsequent infiltration into the ground. Appropriate practices for use of the performance estimates include infiltration basins, infiltration swales (not conveyance swales), rain gardens bio-retention systems, and other surface infiltration systems, that rely on infiltration and provide the majority of storage capacity through surface-ponding. If an infiltration system includes both surface storage through ponding and a lessor storage volume within the void spaces of a coarse filter

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[1] As of the date of public notice, the 2008 Massachusetts Stormwater Handbook and Wetlands Protection Act Regulations at 310 CMR 10.00 promulgated in 2014 are currently effective. On December 22, 2023, MassDEP proposed revisions to the Wetlands Regulations and corresponding revisions to 401 water quality certifications, as well as an update to the Stormwater Handbook. See https://www.mass.gov/regulations/310-CMR-1000-wetlands-protection-act-regulations. EPA anticipates that MassDEP may finalize these regulations and the Stormwater Handbook revisions prior to issuance of a Final CII General Permit. If so, EPA will update references in the Permit to reflect the current version of the Stormwater Handbook.

media, then the physical storage volume capacity used to determine the long-term cumulative phosphorus removal efficiency from the infiltration basin performance curves would be equal to the sum of the surface storage volume and the void space storage volume. General design specifications for various surface infiltration systems are provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.4. Bio-filtration

Bio-filtration ~~is a practice that~~ provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity is typically made of void spaces in the filter media and temporary ponding at the surface of the practice. Once the runoff has passed through the filter media~~,~~ it is collected by an under-drainpipe for discharge. The performance curve for this control practice assumes zero infiltration. If a filtration system has subsurface soils that are suitable for infiltration, then user should use the either performance curves for the infiltration trench or the infiltration basin depending on the predominance of storage volume made up by free standing storage or void space storage. Depending on the design of the filter media manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results. Design specifications for bio-filtration systems are provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.5. Gravel Wetland

Gravel Wetland performance ~~results~~ statistics should be used for practices that have been designed in accordance or share similar features with the design specifications for subsurface gravel wetland systems provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf). Also, see report prepared by the University of New Hampshire Stormwater Center entitled *Subsurface Gravel Wetland Design Specifications,* dated January, 2022 (https://scholars.unh.edu/cgi/viewcontent.cgi?article=1073&context=stormwater).

2.2.6. Enhanced Bio-filtration with Internal Storage Reservoir (ISR)

Enhanced bio-filtration with internal storage reservoir (ISR) ~~is a practice that~~ provides temporary storage of runoff for filtering through an engineered soil media, augmented for enhanced phosphorus removal, followed by detention and denitrification in a subsurface internal storage reservoir (ISR) comprised of gravel. Runoff flows are routed through filter media and directed to the underlying ISR via an impermeable membrane for temporary storage. An elevated outlet control at the top of the ISR is designed to provide a retention time of at least 24 hours in the system prior to discharge. The design storage capacity for using the cumulative performance curves is comprised of void spaces in the filter media, temporary ponding at the surface of the practice and the void spaces in the gravel ISR. The cumulative phosphorus load reduction curve for this control is intended to be used for systems in which the filter media has been augmented with materials designed and/or known to be effective at capturing phosphorus. If the filter media is not augmented to enhance phosphorus capture, then the phosphorus performance curve for the Bio-Filter should be used for estimating phosphorus load reductions. The University of New Hampshire Stormwater Center (UNHSC) developed the design of this control practice and a design template can be found at UNHSC's website (https://scholars.unh.edu/cgi/viewcontent.cgi?article=1073&context=stormwater).

2.2.7. Sand Filter

Sand Filter performance ~~results~~ statistics should be used for practices that have been designed in accordance or share similar features with the design specifications for sand filter systems provided in the *Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.8. Porous Pavement

Porous Pavement has ~~performance results represent systems with~~ an impermeable under-liner and an under-drain. *If porous pavement systems do not have an impermeable under-liner so that filtered runoff can infiltrate into sub-soils, then the performance results for an infiltration trench may be used for these systems.* Design specifications for porous pavement systems are provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.9. Extended Dry Detention Pond

Extended Dry Detention Ponds -performance statistics ~~performance results~~ should only be used for practices that have been designed in accordance with the design specifications for extended dry detention ponds provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf).

2.2.10. Water Quality Grass Swale with Detention

Water Quality Grass Swale with Detention performance results should only be used for practices that have been designed in accordance with the design specifications for a dry water quality swale with check dams to temporarily store the target storage volume capture provided in *the Massachusetts Stormwater Handbook, Volume 2/Chapter2* (http://www.mass.gov/eea/docs/dep/water/laws/i-thru-z/v2c2.pdf)

2.2.11. Impervious Area Hydrologic Disconnection using Storage (e.g., rain barrels, cistern, etc.)

Impervious Area Hydrologic Disconnection using Storage performance results are for collecting runoff volumes from impervious areas such as roof tops, providing temporary storage of runoff volume using rain barrels, cisterns, or other storage containers, and discharging stored volume to adjacent vegetated permeable pervious surfaces over an extended period of time. All impervious area disconnection projects must be designed to ensure that the permeable area to receive runoff from adjacent impervious areas are of sufficient size with adequate soils to receive the runoff without causing negative impacts to adjacent down-gradient properties. Careful consideration must be given to the ratio of impervious area to the pervious area that will receive the discharge. Also, devices such as level spreaders to disperse the discharge and provide sheet flow should be employed whenever needed to increase recharge and avoid flow concentration and short circuiting through the pervious area. Soil testing is needed to classify the permeability of the receiving pervious area in terms of HSG.

2.2.12. Impervious Area Hydrologic Disconnection

Impervious Area Hydrologic Disconnection performance results are for diverting runoff volumes from impervious areas such as roadways, parking lots and roof tops, and discharging it to adjacent vegetated permeable surfaces that are of sufficient size with adequate soils to receive the runoff without causing negative impacts to adjacent down-gradient properties. Careful consideration must be given to the ratio of impervious area to the pervious area that will receive the discharge. Also, devices such as level spreaders to disperse the discharge and provide sheet flow should be employed whenever needed to increase recharge and avoid flow concentration and short circuiting through the pervious area. Soil testing is needed to classify the permeability of the receiving pervious area in terms of HSG. Some useful design guidelines and considerations may be found at https://www.mass.gov/files/documents/2016/08/to/practice-of-lid.pdf.

2.2.13. Conversion of Impervious Area to Permeable Pervious Area

Conversion of Impervious Area to Permeable Pervious Area phosphorus load reduction credits are for replacing existing impervious surfaces (such as traditional pavements and buildings with roof tops) with permeable surfaces. To be eligible for credit, it is essential that the area previously covered with impervious surface be restored to provide natural or enhanced hydrologic functioning so that the surface is permeable. Sub-soils beneath pavements are typically highly compacted and will require reworking to loosen the soil and the possible addition of soil amendments to restore permeability. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

2.2.14. Soil Amendments to Increase Permeability of Pervious Areas

Soil Amendments to Increase Permeability of Pervious Area performance results are for the practice of improving the permeability of pervious areas through incorporation of soil amendments, tilling, and establishing dense vegetation. This practice may be used to compliment other practices such as impervious area disconnection to improve overall performance and increase reduction credits earned. Soil testing is needed to classify the permeability (in terms of HSG) of the restored pervious area.

2.3. Method to Calculate Annual Phosphorus Load Delivered to SCMs (SCM Load)

The SCM Load is the annual phosphorus load from the drainage area to each proposed or existing SCM used by permittee to claim credit against its stormwater phosphorus load reduction requirement (i.e., Phosphorus Reduction Requirement). The SCM Load is the starting point from which the permittee calculates the reduction in phosphorus load achieved by each existing and proposed SCM.

Examples are provided to illustrate use of the methods. Table 1-1 provides annual phosphorus load export rates by land use category for impervious areas for phosphorus (PLERs). The permittee shall select the land use categories that most closely represents the actual uses of the drainage areas tributary to SCM. For drainage areas with institutional type uses, such as universities, religious institutions, hospitals, and schools, the permittee shall use the commercial/industrial land use category to calculate phosphorus loads. Table 1-2 provides a crosswalk table of phosphorus load export rate (PLER) land use categories and the corresponding land use category codes used in MassGIS.

2.3.1. Calculating Annual Stormwater Phosphorus Load Directed to SCM

To estimate the annual phosphorus load reduction for a given stormwater SCM, it is first necessary to estimate the amount of annual stormwater phosphorus load that will be directed to the SCM (SCM Load).

For a given SCM:

1. Determine the total drainage area to the SCM;
 Distribute the total drainage area into impervious subareas by land use category as defined by Table 1-2 and Table 1-1;
3. Calculate the phosphorus load for each land use-based impervious subarea by multiplying the subarea by the appropriate phosphorus load export rate (i.e., PLER) provided in Table 1-1; and
4. Determine the total annual phosphorus loads to the SCM by summing the calculated impervious subarea phosphorus loads.

Example 2-1. Determine Phosphorus Loads to a Proposed SCM.

A permittee is proposing a surface stormwater infiltration system that will treat runoff from an industrial site that has a total drainage area of 12.87 acres comprised of 10.13 acres of impervious cover (e.g., roadways, parking areas and rooftops), 1.85 acres of landscaped pervious area and 0.89 acres of wooded area both with HSG C soils. The drainage area information for the proposed SCM is:

SCM Subarea ID	Land Use Category	Cover Type	Area (acres)	PLER (lbs/acre/yr)*
1	Industrial	impervious	10.13	1.80
2	Landscaped (HSG C)	pervious	1.85	0.21
3	Forest (HSG C)	pervious	0.89	0.21

*From Table 1-1

The phosphorus load to the proposed SCM (SCM Load $_P$) is calculated as:

SCM Load $_P$ $= (IA_{Ind} * PLER_{Ind}) + (PA_{Ind} * PLER_{Ind}) + (PA_{FOREST} * PLER_{For})$

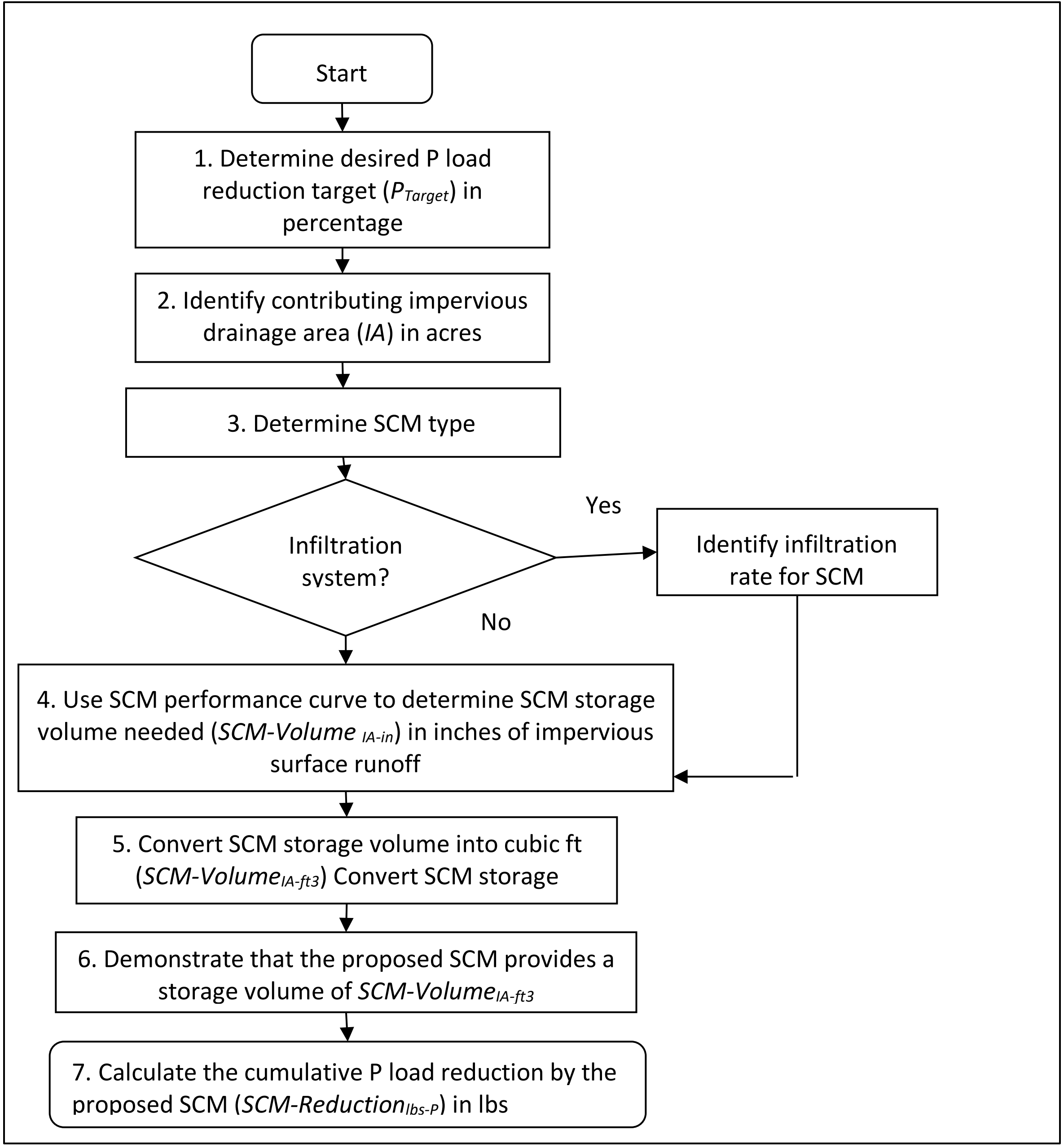
$= (10.13 * 1.80) + (1.85 * 0.21) + (0.89 * 0.21)$

= 18.81 lbs P/year

2.4. Methods to determine the design volume of a SCM or determine a phosphorus (P) load reduction target based on drainage area characteristics.

2.4.1. Method to determine the design volume of a SCM to achieve a known phosphorus (P) load reduction target when the contributing drainage area is 100% impervious:

Figure 2-1. illustrates the steps in the method to determine SCM design volume to achieve a known phosphorus load reduction when contributing drainage area is 100% impervious.



Below are the steps in the method to determine the design volume of a SCM to achieve a known phosphorus (P) load reduction target when the contributing drainage area is 100% impervious:

1) Determine the desired cumulative phosphorus load reduction target (P_{target}) in percentage for the SCM;

2) Determine the contributing impervious drainage area (IA) in acres to the SCM;

3) Determine the SCM type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the SCM;

4) Using the cumulative phosphorus removal performance curves for the selected SCM (Figure 2-5 to Figure 2-26), determine the storage volume for the SCM (SCM-Volume $_{IA\text{-}in}$), in inches of runoff, needed to treat runoff from the contributing IA to achieve the reduction target;

5) Calculate the corresponding SCM storage volume in cubic feet (SCM-Volume $_{IA\text{-}ft3}$) using SCM-Volume $_{IA\text{-}in}$ determined from step 4 and Equation 2-1, below:

$$\boxed{\text{SCM-Volume}_{IA\text{-}ft3} = \text{IA (acre)} * \text{SCM-Volume}_{IA\text{-}in} * 3630\ \text{ft}^3/\text{ac-in}}$$

Equation 2-1. SCM Design Storage Volume Determination in cubic feet

6) Provide supporting calculations using the dimensions and specifications of the proposed SCM showing that the necessary storage volume capacity, SCM-Volume $_{IA\text{-}ft3}$, determined from step 5 will be provided to achieve the P_{Target}; and

7) Calculate the cumulative P load reduction in pounds of P (SCM-Reduction $_{lbs\text{-}P}$) for the SCM using the SCM Load (as demonstrated in **Example 2-1**) and P_{target} by using Equation 2-2:

$$\boxed{\text{SCM-Reduction}_{lbs\text{-}P} = \text{SCM Load} * (P_{target}/100)}$$

Equation 2-2. SCM Reduction

Example 2-2. Determine the design volume of a SCM to achieve a known phosphorus (P) load reduction target when the contributing drainage area is 100% impervious:

A permittee is considering a surface infiltration practice to capture and treat runoff from 2.57 acres of commercial impervious area that will achieve a 70% reduction in average annual phosphorus load. The infiltration practice would be located adjacent to the impervious area. The permittee has measured an infiltration rate (IR) of 0.39 inches per hour (in/hr) in the vicinity of the proposed infiltration practice. Determine the:

A. Design storage volume needed for a surface infiltration practice to achieve a 70% reduction in annual phosphorus load from the contributing drainage area (SCM-Volume $_{\text{IA-ft}^3}$); and

B. Cumulative phosphorus reduction in pounds that would be accomplished by the SCM (SCM-Reduction $_{\text{lbs-P}}$)

Solution:

1. Phosphorus load reduction target (P $_{\text{target}}$) = 70%

2. Contributing impervious drainage area (IA) = 2.57 acres;

3. SCM type is a surface infiltration practice (i.e., basin) with an infiltration rate (IR) of 0.39 in/hr

4. The performance curve for the infiltration basin (i.e., surface infiltration practice), Figure 2-14, IR = 0.27 in/hr is used to determine the design storage volume of the SCM (SCM-Volume $_{\text{IA-in}}$) needed to treat runoff from the contributing IA and achieve a P $_{\text{target}}$ = 70%. The curve for an infiltration rate of 0.27 in/hr is chosen because 0.27 in/hr is the nearest simulated IR that is less than the field measured IR of 0.39 in/hr. From Figure 2-14, the SCM-Volume $_{\text{IA-in}}$ for a P $_{\text{target}}$ = 70% is 0.36 in.

5. The SCM-Volume $_{\text{IA-in}}$ is converted to cubic feet (SCM-Volume $_{\text{IA-ft}^3}$) using Equation 2-1. SCM Design Storage Volume Determination:

$$\text{SCM-Volume}_{\text{IA-ft}^3} = \text{IA (acre)} * \text{SCM-Volume}_{\text{IA-in}} * 3{,}630\ \text{ft}^3/\text{acre-in}$$
$$\text{SCM-Volume}_{\text{IA-ft}^3} = 2.57\ \text{acre} * 0.36\ \text{in} * 3{,}630\ \text{ft}^3/\text{acre-in}$$
$$= \mathbf{3{,}359\ ft^3}$$

6. A narrow trapezoidal infiltration basin with the following characteristics is proposed to achieve the P Target of 70%. As indicated in Table 2-2, the Design Storage Volume (DSV) of a surface infiltration practice is equal to the volume of surface ponding:

$$\text{DSV} = (L * ((W_{\text{bottom}} + W_{\text{top@Dmax}})/2) * D)$$

Length (ft)	Design Depth (ft)	Side Slopes	Bottom area (ft^2)	Pond surface area (ft^2)	Design Storage Volume (ft^3)

355	1.25	3:1	1,387	4,059	3,404

The proposed DSV of 3,404 ft^3 exceeds the SCM-Volume $_{IA\text{-}ft^3}$ needed, 3,359 ft^3 and therefore is sufficient to achieve the P Target of 70%.

7. The cumulative phosphorus load reduction in pounds of phosphorus for the infiltration practice (SCM-Reduction lbs-P) is calculated using Equation 2-2. SCM Reduction. The SCM Load is first determined using the method described above.

SCM Load = IA * impervious cover PLER for commercial use
= 2.57 acres * 1.80 lbs/acre/yr
= 4.63 lbs/yr

SCM-Reduction $_{lbs\text{-}P}$ = SCM Load * (P $_{target}$ /100)
SCM-Reduction $_{lbs\text{-}P}$ = 4.63 lbs/yr * (70/100)
= **3.24 lbs/yr**

Alternate Solution: Alternatively, the permittee could determine the design storage volume needed for an IR = 0.39 in/hr by performing interpolation of the results from the surface infiltration performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr as follows (replacing steps 3 and 4 on the previous page):

Using the performance curves for the infiltration basin (i.e., surface infiltration practice), Figure 2-14, IR = 0.27 in/hr and Figure 2-15, IR = 0.52 in/hr, interpolate between the curves to determine the design storage volume of the SCM (SCM-Volume $_{IA\text{-}in}$) needed to treat runoff from the contributing IA and achieve a P $_{target}$ = 70%.

First calculate the interpolation adjustment factor ("IAF") to interpolate between the infiltration basin performance curves for infiltration rates of 0.27 and 0.52 in/hr:

$$IAF = (0.39 - 0.27)/ (0.52 – 0.27) = 0.48$$

From the two performance curves, develop the following table to estimate the general magnitude of the needed storage volume for an infiltration swale with an IR = 0.39 in/hr and a P $_{target}$ of 70%.

Interpolation Table for determining design storage volume of infiltration basin with IR = 0.39 in/hr and a Phosphorus load reduction target of 70%

SCM Storage Volume	% Phosphorus Load Reduction IR = 0.27 in/hr ($PR_{IR=0.27}$)	% Phosphorus Load Reduction IR = 0.52 in/hr ($PR_{IR=0.52}$)	Interpolated % Phosphorus Load Reduction IR = 0.39 in/hr ($PR_{IR=0.39}$) **$PR_{IR=0.39}$= IAF ($PR_{IR=0.52}$ – $PR_{IR=0.27}$) + $PR_{IR=0.27}$**
0.3	64%	67%	65%

0.4	74%	77%	75%
0.5	79%	82%	80%

As indicated in the table above, the SCM-Volume $_{IA\text{-}in}$ for $PR_{IR=0.39}$ of 70% is between 0.3 and 0.4 inches and can be determined by interpolation:

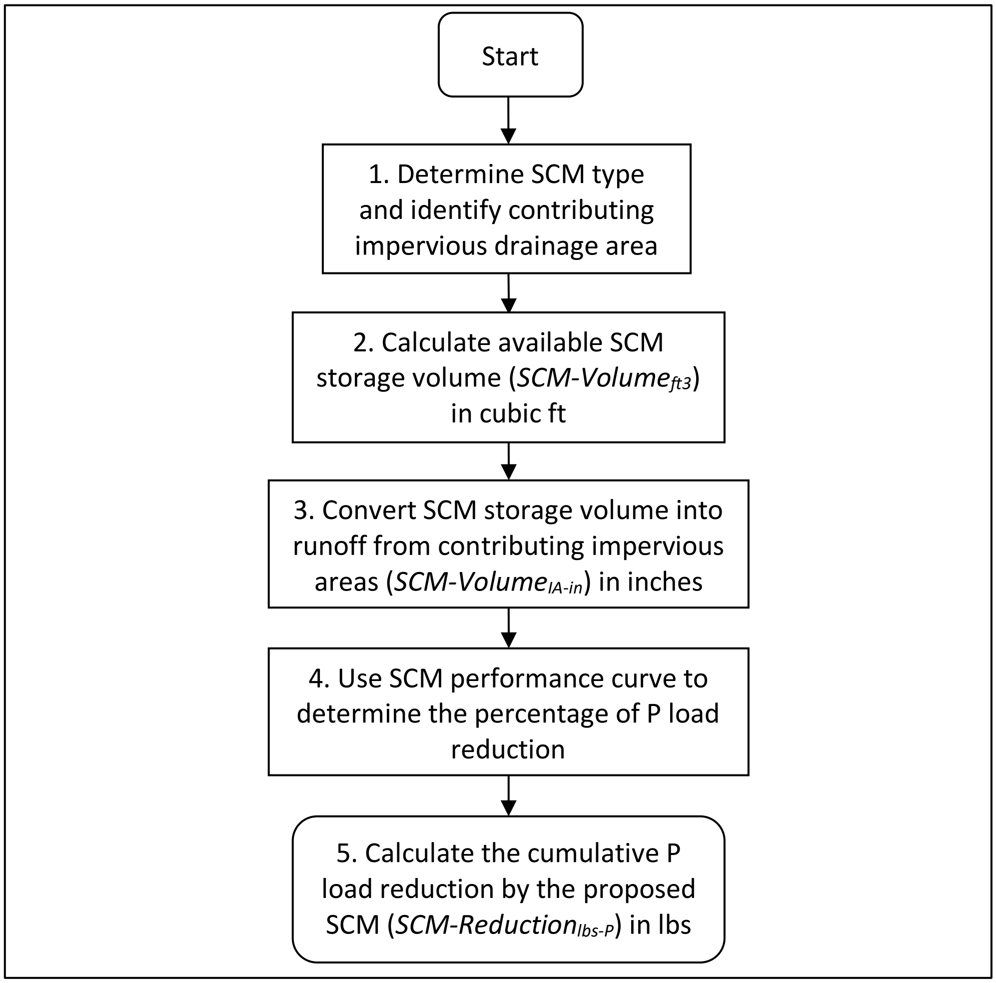
$$\text{SCM-Volume}_{IA\text{-}in} = (70\% - 65\%)/ (75\% - 65\%) \times (0.4 \text{ in} - 0.3 \text{ in}) + 0.3 \text{ in}$$
$$= 0.35 \text{ inches}$$

Convert the resulting SCM-Volume $_{IA\text{-}in}$ to cubic feet (SCM-Volume $_{IA\text{-}ft^3}$) using equation 3-1:

$$\text{SCM-Volume}_{IA\text{-}ft^3} = 2.57 \text{ acre} \times 0.35 \text{ in} \times 3{,}630 \text{ ft}^3\text{/acre-in}$$
$$\mathbf{= 3{,}265\ ft^3}$$

2.4.2. Method to determine the Phosphorus load reduction credit for a SCM with a known design storage volume when the contributing drainage area is 100% impervious.

Figure 2-2. illustrates the steps in the Method to determine the phosphorus load reduction for a SCM with a known design volume when contributing drainage area is 100% impervious**.**



Below are the steps in the method to determine the Phosphorus load reduction credit for a SCM with a known design storage volume when the contributing drainage area is 100% impervious.

1. Identify the SCM type and contributing impervious drainage area (IA);

2. Document the available storage volume (ft^3) of the SCM (SCM-Volume $_{ft^3}$) using the SCM dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

3. Convert SCM-Volume $_{ft^3}$ into inches of runoff from the contributing impervious area (SCM-Volume $_{IA\text{-}in}$) using Equation 2-3:

$$\text{SCM-Volume}_{IA\text{-}in} = \text{SCM-Volume}_{ft^3} / \text{IA (acre)} \times 12 \text{ in/ft} \times 1 \text{ acre}/43560 \text{ ft}^2$$

Equation 2-3, SCM Design Storage Volume Determination in inches

4. Determine the % P load reduction for the SCM (SCM Reduction $_{\%\text{-}P}$) using the appropriate SCM performance curve (Figure 2-5 through Figure 2-26) and the SCM-Volume$_{IA\text{-}in}$ calculated in step 3; and

5. Calculate the cumulative P load reduction in pounds for the SCM (SCM Reduction $_{lbs\text{-}P}$) using the SCM Load as calculated from the procedure described above and the percent P load reduction determined in step 4 by using Equation 2-4:

$$\text{SCM Reduction}_{lbs\text{-}P} = \text{SCM Load} \times (\text{SCM Reduction}_{\%\text{-}P}/100)$$

Equation 2-4. SCM Reduction

Example 2-3. Determine the Phosphorus load reduction credit for a SCM with a known design storage volume when the contributing drainage area is 100% impervious

A permittee is considering an Enhanced Bio-filtration w/ISR system to treat runoff from 1.49 acres of commercial impervious area. Site constraints would limit the enhanced bio-filtration system to have a surface area of 1200 ft^2 and the system would have to be located next to the impervious drainage area to be treated. The design parameters for the enhanced bio-filtration w/ ISR system are presented in the Table below.

Design parameters for bio-filtration system

Components of representation	Parameters	Value
Ponding	Maximum depth	0.5 ft
	Surface area	1200 ft^2
	Vegetative parameter[a]	85-95%
Soil mix	Depth	2.0 ft
	Porosity	0.35
	Hydraulic conductivity	4 inches/hour
Gravel layer	Depth	2.0 ft
	Porosity	0.45
Orifice #1	Diameter	0.08 ft

[a] Refers to the percentage of surface covered with vegetation

Determine the:

A. Percent phosphorus load reduction (SCM Reduction $_{\%\text{-P}}$) for the specified enhanced bio-filtration w/ISR system and contributing impervious Commercial drainage area; and
B. Cumulative Phosphorus reduction in pounds that would be accomplished by the system (SCM-Reduction $_{\text{lbs-P}}$)

Solution:

1. The SCM is an enhanced bio-filtration w/ISR system that will treat runoff from 1.49 acres of Commercial impervious area (IA = 1.49 acre);

2. The available storage volume capacity (ft^3) of the enhanced bio-filtration system (SCM-Volume $_{\text{SCM-ft}^3}$) is determined using the surface area of the system, depth of ponding, and the porosities of the filter media and subsurface gravel ISR:

   SCM-Volume $_{\text{SCM-ft}^3}$ = (surface area * pond maximum depth) + (surface area * ((soil mix depth * soil layer porosity) + (gravel layer depth * gravel layer porosity))

   = (1,200 ft^2 * 0.5 ft) + (1,200 ft^2 * ((2.0 * 0.35) + (2.0 * 0.45))

   = 600 + 1920

= 2,520 ft^3

3. The available storage volume capacity of the enhanced bio-filtration system in inches of runoff from the contributing impervious area (SCM-Volume $_{IA-in}$) is calculated using Equation 2-3:

   SCM-Volume $_{IA-in}$ = (SCM-Volume $_{ft^3}$/ IA (acre) * 12 in/ft * 1 acre/43560 ft^2
   SCM-Volume $_{IA-in}$ = (2520 ft^3/1.49 acre) * 12 in/ft * 1 acre/43560 ft^2 **= 0.47 in**

4. Using the enhanced bio-filtration performance curve shown in Figure 2-21, a **61%** Phosphorus load reduction (SCM Reduction %-P) is determined for the system with a design storage capacity of 0.47 inches for treating runoff from 1.49 acres of impervious area; and

5. Calculate the cumulative Phosphorus load reduction in pounds of for the enhanced bio-filtration w/ISR system (SCM Reduction $_{lbs-P}$) using the SCM Load as calculated from the procedure described above and the SCM Reduction $_{\%-P}$ determined in step 4 by using Equation 2-4. First, the SCM Load is determined as specified above:

SCM Load $_P$ = IA * impervious cover phosphorus export loading rate for Commercial

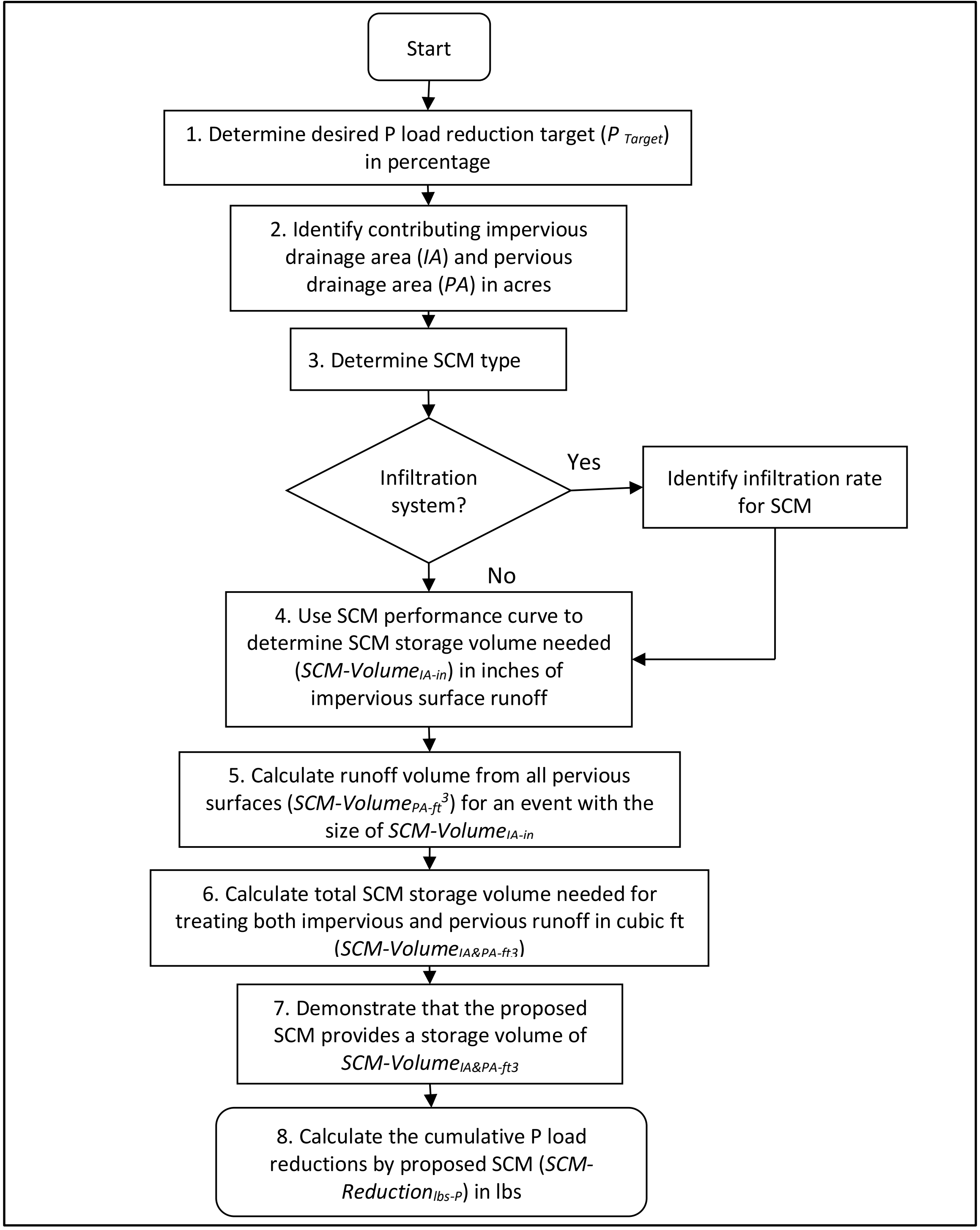
SCM Load $_P$ = 1.49 acres x 1.8 lbs/acre/yr = 2.68 lbs/yr

SCM Reduction $_{lbs-P}$ = SCM Load * (SCM Reduction $_{\%-P}$/100)

SCM Reduction $_{lbs-P}$ = 2.68 lbs/yr * (61/100) = **1.64 lbs/yr**

2.4.3. Method to determine the design storage volume of a SCM to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces:

Figure 2-3. illustrates the steps to determine the design storage volume of a SCM to achieve a known phosphorus load reduction target when the drainage area has impervious and pervious surfaces.



Below are the steps in the method to determine the design storage volume of a SCM to reach a known P load reduction when both impervious and pervious drainage areas are present.

1) Determine the desired cumulative P load reduction target (P_{target}) in percentage for the SCM;

2) Characterize the contributing drainage area to the SCM by identifying the following information for the impervious and pervious surfaces:

Impervious area (IA) - Area (acre) and land use (e.g., commercial)
Pervious area (PA) – Area (acre), land use and hydrologic soil group (HSG)

3) Determine the SCM type (e.g., infiltration trench, gravel wetland). For infiltration systems, determine the appropriate infiltration rate for the location of the SCM in the Watershed;

4) Using the cumulative P removal performance curve for the selected SCM, determine the storage volume capacity of the SCM in inches needed to treat runoff from the contributing impervious area ($\text{SCM-Volume}_{\text{IA-in}}$);

5) Using Equation 2-5 below and the pervious area runoff depth information from Table 2-1, below, determine the total volume of runoff from the contributing pervious drainage area in cubic feet ($\text{SCM Volume}_{\text{PA- ft}^3}$) for a rainfall size equal to the sum of $\text{SCM Volume}_{\text{IA-in}}$, determined in step 4. The runoff volume for each distinct pervious area must be determined;

$$\text{SCM-Volume}_{\text{PA ft}^3} = \sum \left(\text{PA} * (\text{runoff depth}) * 3{,}630\ \text{ft}^3/\text{acre-in}\right)_{(\text{PA1, PAn})}$$

Equation 2-5. SCM Volume, Sum of pervious areas, cubic feet

6) Using Equation 2-6 below, calculate the SCM storage volume in cubic feet ($\text{SCM-Volume}_{\text{IA\&PA-ft}^3}$) needed to treat the runoff depth from the contributing impervious (IA) and pervious areas (PA);

$$\text{SCM-Volume}_{\text{IA\&PA-ft}^3} = \text{SCM Volume}_{\text{PA-ft}^3} + (\text{SCM Volume}_{\text{IA-in}} \times \text{IA (acre)} \times 3{,}630\ \text{ft}^3/\text{acre-in})$$

Equation 2-6. SCM Volume pervious and impervious area, cubic feet

7) Provide supporting calculations using the dimensions and specifications of the proposed SCM showing that the necessary storage volume determined in step 6, $\text{SCM- Volume}_{\text{IA\&PA-ft}^3}$, will be provided to achieve the P_{Target}; and

8) Calculate the cumulative phosphorus load reduction in pounds of phosphorus ($\text{SCM-Reduction}_{\text{lbs-P}}$) for the SCM using the SCM Load (as calculated in example 1) and the P_{target} by using Equation 2-7:

$$\text{SCM-Reduction}_{\text{lbs-P}} = \text{SCM Load} * (P_{\text{target}}/100)$$

Equation 2-7. SCM Reduction

Table 2-1. Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups (HSGs). Soils are assigned to an HSG on the basis of their permeability.

HSG A is the most permeable, and HSG D is the least permeable. HSG categories for pervious areas in the drainage area shall be estimated by consulting local soil surveys prepared by the National Resource Conservation Service (NRCS) or by a storm water professional evaluating soil testing results from the drainage area. If the HSG condition is not known, an HSG C soil condition should be assumed.

Developed Land Pervious Area Runoff Depths based on Precipitation depth and Hydrological Soil Groups

Rainfall Depth, Inches	**Runoff Depth, inches**			
	Pervious HSG A	**Pervious HSG B**	**Pervious HSG C**	**Pervious HSG D**
0.10	**0.00**	**0.00**	**0.00**	**0.00**
0.20	**0.00**	**0.00**	**0.01**	**0.02**
0.40	**0.00**	**0.00**	**0.03**	**0.06**
0.50	**0.00**	**0.01**	**0.05**	**0.09**
0.60	**0.01**	**0.02**	**0.06**	**0.11**
0.80	**0.02**	**0.03**	**0.09**	**0.16**
1.00	**0.03**	**0.04**	**0.12**	**0.21**
1.20	**0.04**	**0.05**	**0.14**	**0.39**
1.50	**0.08**	**0.11**	**0.39**	**0.72**
2.00	**0.14**	**0.22**	**0.69**	**1.08**

Notes: Runoff depths derived from combination of volumetric runoff coefficients from Table 5 of *Small Storm Hydrology and Why it is Important for the Design of Stormwater Control Practices*, (Pitt, 1999), and using the Stormwater Management Model (SWMM) in continuous model mode for hourly precipitation data for Boston, MA, 1998-2002.

Example 2-4. Determine the design storage volume of a SCM to achieve a known phosphorus load reduction target when the contributing drainage area has impervious and pervious surfaces

A permittee is considering a gravel wetland system to treat runoff from an institutional site. The site is 7.5 acres of which 4.0 acres are impervious surfaces and 3.50 acres are pervious surfaces. The pervious area is made up of 2.5 acres of lawns in good condition and 1.0 acre of stable unmanaged woodland. Soils information indicates that all of the woodland and 0.5 acres of the lawn is hydrologic soil group (HSG) B and the other 2.0 acres of lawn are HSG C. The permittee wants to size the gravel wetland system to achieve a cumulative phosphorus load reduction (P_{Target}) of 55% from the entire 7.5 acres.

Determine the:

- **A)** Design storage volume needed for a gravel wetland system to achieve a 55% reduction in annual phosphorus load from the contributing drainage area ($\text{SCM-Volume}_{IA\&PA\text{-}ft^3}$); and
- **B)** Cumulative phosphorus reduction in pounds that would be accomplished by the SCM ($\text{SCM-Reduction}_{lbs\text{-}P}$)

Solution:

1) The SCM type is gravel wetland system.
2) The phosphorus load reduction target (P_{Target}) = 55%.
3) Using the cumulative phosphorus removal performance curve for the gravel wetland system shown in Figure 2-20, the storage volume capacity in inches needed to treat runoff from the contributing impervious area ($\text{SCM Volume}_{IA\text{-}in}$) is 0.71 in;

Using Equation 2-5 and the pervious runoff depth information from Table 2-1, the volume of runoff from the contributing pervious drainage area in cubic feet ($\text{SCM Volume}_{PA-ft^3}$) for a rainfall size equal to 0.71 in is summarized in the table “Runoff contributions from pervious areas for institutional site” below. As indicated from Table 2-1, the runoff depth for a rainfall size equal to 0.71 inches is between 0.6 and 0.8 inches and can be determined by interpolation (example shown for runoff depth of HSG C):

Runoff depth (HSG C) = (0.71 – 0.6)/(0.8 – 0.6) * (0.09 in – 0.06 in) + 0.06 in = <u>0.07 inches</u>

Runoff contributions from pervious areas for institutional site

ID	Type	Pervious Area (acre)	HSG	Runoff (in)	Runoff = (runoff) x PA (acre-in)	Runoff = Runoff (acre-in) x 3630 ft^3/acre-in (ft^3)
PA1	Grass	2.00	C	0.07	0.14	508
PA2	Grass	0.50	B	0.01	0.0	0.0
PA3	Woods	1.00	B	0.01	0.0	0.0
Total	-----	**3.50**	-----	-----	**0.14**	**508**

4) Using Equation 2-6, determine the SCM storage volume in cubic feet ($\text{SCM-Volume}_{IA\&PA\text{-}ft^3}$) needed to treat 0.71 inches of runoff from the contributing impervious area (IA) and the runoff of 0.14 acre-in from the contributing pervious areas, determined in step 5 is:

$$\boxed{\text{SCM Volume}_{\text{IA\&PA-ft}^3} = \text{SCM Volume}_{\text{PA ac-in}} + (\text{SCM Volume}_{\text{IA-in}} * \text{IA (acre)}) * 3{,}630\ \text{ft}^3/\text{acre-in})}$$

Equation 2-8. SCM Volume pervious and impervious area, cubic feet

SCM Volume$_{\text{IA\&PA-ft}}{}^3$ = (508 ft^3+ ((0.71 in * 4.00 acre) * 3,630 ft^3/acre-in) = <u>10,817 ft^3</u>

5) The table "Design details for gravel wetland system" provides design details for of a potential gravel wetland system.

Design details for gravel wetland system:

Gravel Wetland System Components	Design Detail	Depth (ft)	Surface Area (ft^2)	Volume (ft^3)
Sediment Forebay	**10% of Treatment**			
Pond area	**Volume**	1.33	896	1,192
Wetland Cell #1	**----**	--------------	------------------	---------------
Pond area	**45% of Treatment**	2.00	1,914	3,828
Gravel layer	**Volume**	2.00	1,914	1,531
Wetland Cell #2	**----**	--------------	------------------	---------------
Pond area	porosity = 0.4	-	1,914	3,828
Gravel layer	**45% of Treatment**	2.00	1,914	1,531
	Volume	2.00		
	----			
	porosity = 0.4			

The total design storage volume for the proposed gravel wetland system is 11,910 ft^3. This volume is greater than 11,834 ft^3 ((SCM-Volume $_{\text{IA\&PA-ft}^3}$), calculated in step 4) and is therefore sufficient to achieve a P $_{\text{Target}}$ of 55%.

6) The cumulative phosphorus load reduction in pounds of phosphorus (SCM-Reduction $_{\text{lbs-P}}$) for the proposed gravel wetland system is calculated by using equation 3-2 with the SCM Load and the P $_{\text{target}}$ = 55%.

$$\boxed{\text{SCM-Reduction}_{\text{lbs-P}} = \text{SCM Load x } (\text{P}_{\text{target}} / 100)}$$

Equation 2-9. SCM Reduction

The SCM Load is calculated:

SCM Load = (IA * PLER $_{\text{IC Ins}}$) + (PA lawn $_{\text{HSG B}}$ * PLER $_{\text{HSG B}}$) + (PA lawn $_{\text{HSG C}}$ * PLER $_{\text{HSG C}}$) + (PA forest * PA PLER $_{\text{For}}$)

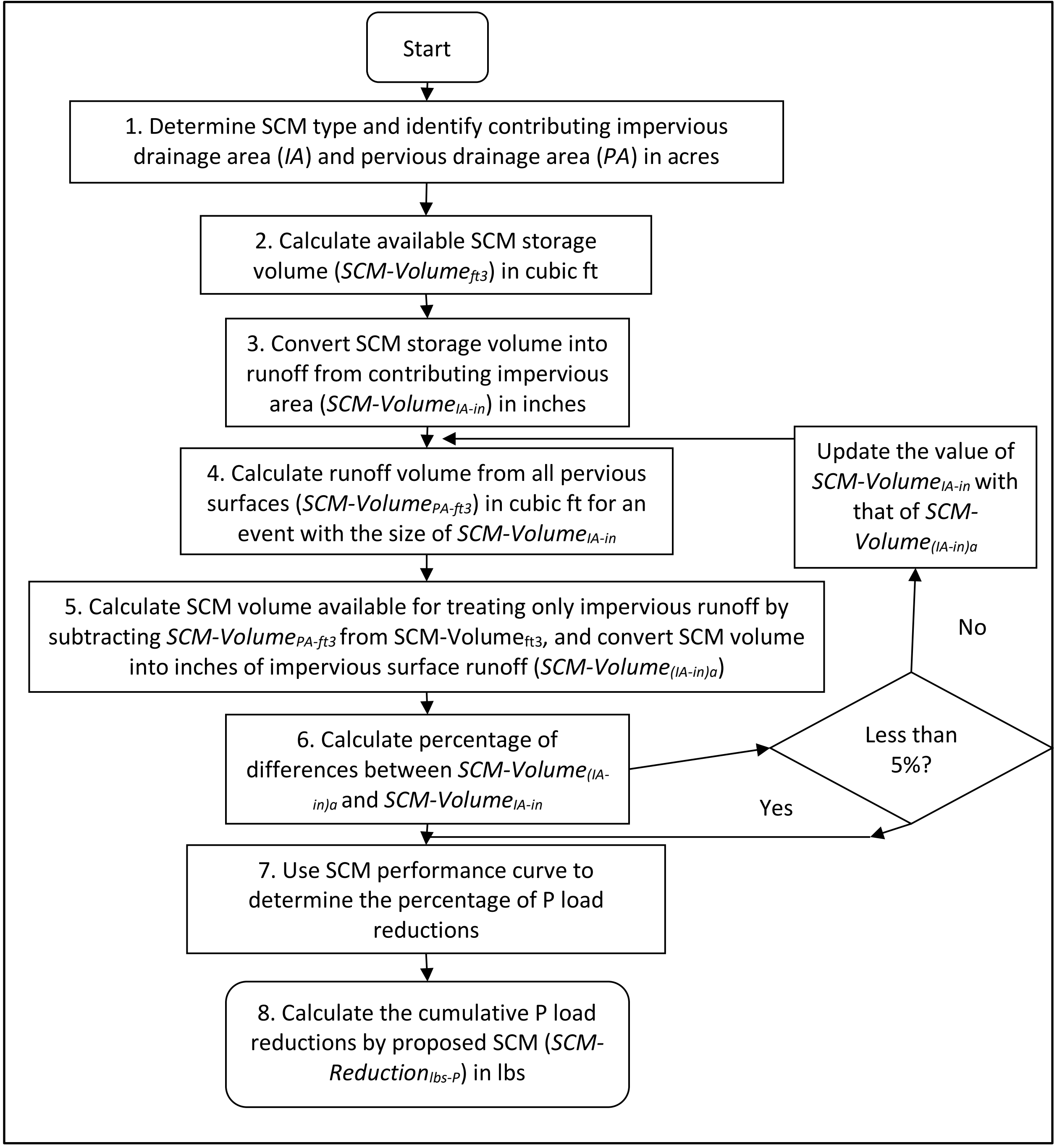
= (4.00 acre * 1.80 lbs/acre/yr) + (0.50 acres * 0.12 lbs/acre/yr) + (2.00 acre * 0.21 lbs/acre/yr) + (1.00 acres * 0.13) = <u>7.81 lbs/yr</u>

SCM-Reduction $_{\text{lbs-P}}$ = SCM Load * (P $_{\text{target}}$ /100)

SCM-Reduction $_{\text{lbs-P}}$ = 7.81 lbs/yr * 55/100 = **4.29 lbs/yr**

2.4.4. Method to determine the phosphorus load reduction for a SCM with a known storage volume when the contributing drainage area has impervious and pervious surfaces:

Figure 2-4. illustrates the steps to determine the phosphorus (P) load reduction for a SCM with a known storage volume when the contributing drainage area has impervious and pervious surfaces.



Below are the steps in the method to determine the phosphorus load reduction for a SCM with a known storage volume when the contributing drainage area has impervious and pervious surfaces:

1) Identify the type of SCM and characterize the contributing drainage area to the SCM by identifying the following information for the impervious and pervious surfaces:

Impervious area (IA) – Area (acre) and land use (e.g., commercial)
Pervious area (PA) – Area (acre), land use, and hydrologic soil group (HSG)

2) Determine the available storage volume (ft^3) of the SCM (SCM-Volume $_{ft^3}$) using the SCM dimensions and design specifications (e.g., maximum storage depth, filter media porosity);

3) To estimate the P load reduction of a SCM with a known storage volume capacity, it is first necessary to determine the portion of available SCM storage capacity (SCM-Volume $_{ft^3}$) that would treat the runoff volume generated from the contributing impervious area (IA) for a rainfall event with a depth of *i* inches (in). This will require knowing the corresponding amount of runoff volume that would be generated from the contributing pervious area (PA) for the same rainfall event (depth of *i* inches). Using

4) below, solve for the SCM capacity that would be available to treat runoff from the contributing imperious area for the unknown rainfall depth of *i* inches (see Equation 2-11):

$$\text{SCM-Volume}_{ft^3} = \text{SCM-Volume}_{(IA\text{-}ft^3)i} + \text{SCM-Volume}_{(PA\text{-}ft^3)i}$$

Equation 2-10. SCM Volume pervious area and impervious area, cubic feet

Where:

SCM-Volume $_{ft^3}$= the available storage volume of the SCM;
SCM-Volume $_{(IA\text{-}ft^3)i}$ = the available storage volume of the SCM that would fully treat runoff generated from the contributing impervious area for a rainfall event of size *i* inches; and
SCM-Volume $_{(PA\text{-}ft^3)i}$ = the available storage volume of the SCM that would fully treat runoff generated from the contributing pervious area for a rainfall event of size *i* inches.

Solving for SCM-Volume $_{(IA\text{-}ft^3)i}$:

$$\text{SCM-Volume}_{(IA\text{-}ft^3)i} = \text{SCM-Volume}_{ft^3} - \text{SCM-Volume}_{(PA\text{-}ft^3)i}$$

Equation 2-11. SCM Volume pervious area and impervious area, rainfall depth, cubic feet

To determine SCM-Volume $_{(IA\text{-}ft^3)i}$, requires performing an iterative process of refining estimates of the rainfall depth used to calculate runoff volumes until the rainfall depth used results in the sum of runoff volumes from the contributing IA and PA equaling the available SCM storage capacity (SCM-Volume $_{ft^3}$). For the purpose of estimating SCM performance, it will be considered adequate when the IA runoff depth (in) is within 5% IA runoff depth used in the previous iteration.

For the first iteration (1), convert the SCM-Volume $_{ft^3}$ determined in step 2 into inches of runoff from the contributing impervious area (SCM Volume $_{(IA\text{-}in)1}$) using Equation 2-12.

$$\text{SCM-Volume}_{(IA\text{-}in)1} = (\text{SCM-Volume}_{ft^3} / \text{IA (acre)}) \times (12 \text{ in/ft} / 43{,}560 \text{ ft}^2\text{/acre})$$

Equation 2-12. SCM Volume pervious area and impervious area, inches

For iterations 2 through n (2…n), convert the SCM Volume $_{(IA\text{-}ft^3)2\ldots n}$, determined in step 6) below, into inches of runoff from the contributing impervious area:
(SCM Volume $_{(IA\text{-}in)2\ldots n}$) using Equation 2-13.

$$\text{SCM-Volume}_{(IA\text{-}in)2\ldots n} = (\text{SCM-Volume}_{(IA\text{-}ft^3)2\ldots n} / \text{IA (acre)}) \times (12 \text{ in/ft} / 43{,}560 \text{ ft}^2\text{/acre})$$

Equation 2-13. Subsequent SCM Volume pervious area and impervious area, inches

5) For 1 to n iterations, use the pervious runoff depth information from Table 2-1 and Equation 2-14 to determine the total volume of runoff (ft^3) from the contributing PA (SCM Volume $_{PA\text{-}ft^3}$) for a rainfall size equal to the sum of SCM-Volume $_{(IA\text{-}in)1}$, determined in step 3. The runoff volume for each distinct pervious area must be determined.

$$\text{SCM Volume}_{(PA\text{-}ft^3)1\ldots n} = \sum ((\text{PA} \times (\text{runoff depth}_{)\ (PA1,\ PA2..PAn)} \times (3{,}630 \text{ ft}^3\text{/acre-in})$$

Equation 2-14. SCM Volume from pervious area, rainfall depth, cubic feet.

6) For iteration 1, estimate the portion of SCM Volume that is available to treat runoff from only the IA by subtracting SCM-Volume $_{PA\text{-}ft^3}$, determined in step 4, from SCM-Volume $_{ft^3}$, determined in step 2, and convert to inches of runoff from IA (see Equation 2-15 and Equation 2-16).

$$\text{SCM-Volume}_{(IA\text{-}ft^3)2} = ((\text{SCM-Volume}_{ft^3} - \text{SCM Volume}_{(PA\text{-}ft^3)1})$$

Equation 2-15. SCM Volume treating IA portion, cubic feet.

$$\text{SCM-Volume}_{(IA\text{-}in)2} = (\text{SCM-Volume}_{(IA\text{-}ft^3)2} / \text{IA (acre)}) \times (12 \text{ in/ft} \times 1 \text{ acre}/43{,}560 \text{ ft}^2)$$

Equation 2-16. SCM Volume treating IA portion, inches.

If additional iterations (i.e., 2 through n) are needed, estimate the portion of SCM volume that is available to treat runoff from only the IA (SCM-Volume $_{(IA\text{-}in)3..n+1}$) by subtracting SCM Volume $_{(PA\text{-}ft^3)2..n}$, determined in step 4, from SCM Volume $_{(IA\text{-}ft^3)3..n+1}$, determined in step 5, and by converting to inches of runoff from IA using Equation 2-16):

7) For iteration a (an iteration between 1 and n+1), compare SCM Volume $_{(IA\text{-}in)a}$ to SCM Volume $_{(IA\text{-}in)a-1}$ determined from the previous iteration (a-1). If the difference in these values is greater than 5% of SCM Volume $_{(IA\text{-}in)a}$ then repeat steps 4 and 5, using SCM Volume $_{(IA\text{-}in)a}$ as the new starting value for the next iteration (a+1). If the difference is less than or equal to 5 % of SCM Volume $_{(IA\text{-}in)a}$ then the permittee may proceed to step 7;

8) Determine the % P load reduction for the SCM (SCM Reduction $_{\%\text{-}P}$) using the appropriate SCM performance curve and the SCM-Volume $_{(IA\text{-}in)n}$ calculated in the final iteration of steps 5 and 6; and

9) Calculate the cumulative P load reduction in pounds for the SCM (SCM Reduction $_{\text{lbs-P}}$) using the SCM Load as calculated Example 3-1 above and the percent P load reduction (SCM Reduction $_{\text{\%-P}}$) determined in step 7 by using Equation 2-17:

$$\text{SCM Reduction}_{\text{lbs-P}} = \text{SCM Load x (SCM Reduction}_{\text{\%-P}}/100)$$

Equation 2-17. SCM Reduction.

Example 2-5. Determine the phosphorus load reduction for a SCM with a known design volume when the contributing drainage area has impervious and pervious surfaces.

A permittee is considering an infiltration basin to capture and treat runoff from a portion of the commercial area (COM). The contributing drainage area is 16.55 acres and has 11.75 acres of impervious area and 4.8 acres of pervious area (PA) made up mostly of lawns and landscaped areas that is 80% HSG D and 20% HSG C. An infiltration basin with the following specifications can be placed at the down-gradient end of the contributing drainage area where soil testing results indicates an infiltration rate (IR) of 0.28 in/hr:

Table Example 3-4-A: Infiltration basin characteristics

Structure	Bottom area (acre)	Top surface area (acre)	Maximum pond depth (ft)	Design storage volume (ft^3)	Infiltration Rate (in/hr)
Infiltration basin	0.65	0.69	1.65	48,155	0.28

Determine the:

A) Percent phosphorus load reduction (SCM Reduction $_{\%\text{-P}}$) for the specified infiltration basin and the contributing impervious and pervious drainage area; and

B) Cumulative phosphorus reduction in pounds that would be accomplished by the SCM (SCM-Reduction $_{\text{lbs-P}}$)

Solution:

1) A surface infiltration basin is being considered. Information for the contributing impervious (IA) and pervious (PA) areas are summarized below.

Impervious area characteristics

ID	Land use	Area (acre)
IA1	COM	11.75

Pervious area characteristics

ID	Area (acre)	Hydrologic Soil Group (HSG)
PA1 PA2	3.84 0.96	D C

2) The available storage volume (ft^3) of the infiltration basin (SCM-Volume $_{ft^3}$) is determined from the design details and basin dimensions; SCM-Volume $_{ft^3}$ = 48,155 ft^3.
3) To determine what the SCM design storage volume is in terms of runoff depth (in) from IA, an iterative process is undertaken:

Solution Iteration 1

For the first iteration (1), the SCM-Volume$_{ft^3}$ is converted into inches of runoff from the contributing impervious area (SCM Volume $_{(IA\text{-}in)1}$) using Equation 2-12.

SCM Volume $_{(IA\text{-}in)1}$ = (48,155 ft^2/ 11.75 acre) * (12 in/ft /43,560 ft^2/acre) = <u>1.13 in</u>

4-1) The total volume of runoff (ft^3) from the contributing PA (SCM Volume $_{PA\text{-}ft^3}$) for a rainfall size equal to the sum of SCM Volume $_{(IA\text{-}in)1}$ determined in step 3 is determined for each distinct pervious area identified in above using the information from Table 2-1 and Equation 2-5. Interpolation was used to determine runoff depths.

SCM Volume $_{(PA\text{-}ft^3)1}$ = ((3.84 acre * (0.33 in) + (0.96 acre * (0.13 in)) * 3,630 ft^3/acre-in = <u>5052 ft^3</u>

5-1) For iteration 1, the portion of SCM Volume that is available to treat runoff from only the IA is estimated by subtracting the SCM Volume $_{(PA\text{-}ft^3)1}$, determined in step 4-1, from SCM Volume$_{ft^3}$, determined in step 2, and converted to inches of runoff from IA:

SCM Volume $_{(IA\text{-}ft^3)\,2}$ = 48,155 ft^3 – 5052 ft^3 = <u>43,103 ft^3</u>

SCM Volume $_{(IA\text{-}in)\,2}$ = (43,103 ft^3/11.75 acre) * (12 in/ft x 1 acre/43,560 ft^2) = <u>1.01 in</u>

6-1) The % difference between SCM Volume $_{(IA\text{-}in)\,2}$, 1.01 in, and SCM Volume $_{(IA\text{-}in)1}$, 1.13 in is determined and found to be significantly greater than 5%:

% Difference = ((1.13 in – 1.01 in)/1.01 in) * 100
= 12%
Therefore, steps 4 through 6 are repeated starting with SCM Volume $_{(IA\text{-}in)\,2}$ = 1.01 in.

Solution Iteration 2
4-2) SCM-Volume $_{(PA\text{-}ft^3)2}$ = ((3.84 acre * 0.21 in) + (0.96 acre * 0.12 in)) * 3,630 ft^3/acre-in
= 3,345 ft^3

5-2) SCM-Volume $_{(IA\text{-}ft^3)\,3}$ = 48,155 ft^3 – 3,345 ft^3
= 44,810 ft^3
SCM-Volume $_{(IA\text{-}in)\,3}$ = (44,810 ft^3/11.75 acre) * (12 in/ft * 1 acre/43,560 ft^2)
= 1.05 in

6-2) % Difference = ((1.05 in – 1.01 in)/1.05 in) x 100
= 4%
The difference of 4% is acceptable.

7) The % phosphorus load reduction for the infiltration basin (SCM Reduction $_{\%\text{-}P}$) is determined by using the infiltration basin performance curve for an infiltration rate of 0.27 in/hr and the treatment volume (SCM-Volume $_{Net\ IA\text{-}in}$ = 1.05 in) calculated in step 5-2 and is **SCM Reduction $_{\%\text{-}P}$ = 93%**.

The performance curve for IR = 0.27 is used rather than interpolating between the performance curves for IR = 0.27 in/hr and 0.52 in/hr to estimate performance for IR = 0.28 in/hr. An evaluation of the performance curves for IR = 0.27 in/hr and IR = 0.52 in/hr for a design storage volume of 1.05 in indicate a small difference in estimated performance (SCM Reduction $_{\%\text{-P}}$ = 93% for IR = 0.27 in/hr and SCM Reduction $_{\%\text{-P}}$ = 95% for IR = 0.52 in/hr).

8) The cumulative phosphorus load reduction in pounds of phosphorus (SCM-Reduction $_{\text{lbs-P}}$) for the proposed infiltration basin is calculated by using Equation 2-18. SCM Reduction with the SCM Load and the P $_{\text{target}}$ of 93%.

$$\text{SCM-Reduction}_{\text{lbs-P}} = \text{SCM Load} \times (\text{P}_{\text{target}}/100)$$

Equation 2-18. SCM Reduction

Using Table 1-1, the SCM load is calculated:
SCM Load = (IA x impervious cover phosphorus export loading rate for Commercial)
+ (PA $_{\text{HSG D}}$ x pervious cover phosphorus export loading rate for HSG D)
+ (PA $_{\text{HSG C}}$ x pervious cover phosphorus export loading rate for HSG C)

SCM Load = (11.75 acres x 1.8 lbs/acre/yr) + (3.84 acres x 0.37 lbs/acre/yr)
+ (0.96 acres x 0.21 lbs/acre/yr)
= 22.77 lbs/yr

SCM-Reduction $_{\text{lbs-P}}$ = 22.77 lbs/yr x 93/100 = **21.18 lbs/yr**

Example 2-6. Determine the phosphorus reductions for disconnecting impervious area using storage with delayed release.

A commercial operation has an opportunity to divert runoff from 0.75 acres of impervious roof top to a 5000 gallon (668.4 ft^3) storage tank for temporary storage and subsequent release to 0.09 acres of pervious area (PA) with HSG C soils.
Determine the:

A) Percent phosphorus load reduction rates (SCM Reduction $_{\%\text{-}P}$) for the specified impervious area (IA) disconnection and storage system assuming release times of 1, 2 and 3 days for the stored volumes to discharge to the pervious area; and

B) Cumulative phosphorus load reductions in pounds that would be accomplished by the system (SCM-Reduction $_{lbs\text{-}P}$) for the three storage release times, 1, 2 and 3 days.

Solution:

1) Determine the storage volume in units of inches of runoff depth from contributing impervious area:

Storage Volume $_{IA\text{-}in}$ = (668.4 ft^3/(0.75 acre * 43.560 ft^2/acre)) x 12 inch/ft
= 0.25 inches

2) Determine the ratio of the contributing impervious area to the receiving pervious area:
IA:PA = 0.75 acres/0.09 acres
= 8.3

3) Using Table 2-25 or Figure 2-29 for a IA:PA ratio of 8:1, determine the phosphorus load reduction rates for a storage volume of 0.25 inches that discharges to HSG C with release rates of 1, 2 and 3 days: Using interpolation the reduction rates are shown in Table 3-5-A:

Table Example 3-5-A: P Reduction Rates

Percent Phosphorus load reduction for IA disconnection with storage to PA HSG C			
Storage Volume $_{IA\text{-}in}$	**Storage release rate, days**		
	1	**2**	**3**
0.25	**39%**	**42%**	**43%**

4) The cumulative phosphorus load reductions in pounds of phosphorus for the IA disconnection with storage (SCM-Reduction $_{lbs\text{-}P}$) is calculated using Equation 2-2.

Phosphorus:

SCM Load $_P$ = IA (acre) * PLER $_{IC\text{-}Com}$ (see Table 3-1)
= 0.75 acres * 1.80 lbs/acre/yr
= 1.35 lbs/yr

SCM Reduction $_{lbs\text{-}P}$ = SCM Load * (SCM Reduction $_{\%\text{-}P}$/100)
SCM Reduction $_{lbs\text{-}P}$ = 1.35 lbs/yr * (39/100)
= **0.53 lbs/yr**

The table below presents the SCM Reduction $_{lbs\text{-}P}$ for each of the release rates:

P Reduction Loads

Phosphorus load reduction for IA disconnection with storage to PA HSG C, lbs			
Storage Volume $_{\text{IA-in}}$	**Storage release rate, days**		
	1	**2**	**3**
0.25	**0.53**	**0.56**	**0.58**

Example 2-7. Determine the phosphorus load reduction for disconnecting impervious area with and without soil augmentation in the receiving pervious area.

The same commercial property as in the above example wants to evaluate disconnecting drainage from the 0.75 acres impervious roof top and discharging it directly to 0.09 acres of pervious area (PA) with HSG C. Also, the property has the opportunity to purchase a small adjoining area (0.06 acres), also HSG C, to increase the size of the receiving PA from 0.09 to 0.15 acres and to allow the property owner to avoid having to install a drainage structure to capture overflow runoff from the PA. The property owner has been informed that the existing PA soil can be tilled and augmented with soil amendments to support denser vegetative growth and improve hydrologic function to approximate HSG B.
Determine the:

- **A)** Percent phosphorus load reduction rates (SCM Reduction $_{\%\text{-P}}$) for the specified impervious area (IA) disconnection to both the 0.09 and 0.15 acres receiving PAs with and without soil augmentation; and
- **B)** Cumulative phosphorus reductions in pounds that would be accomplished by the IA disconnection for the various scenarios (SCM-Reduction $_{\text{lbs-P}}$).

Solution:

1. Determine the ratio of the contributing impervious area to the receiving pervious area:
   IA:PA = 0.75 acres/0.09 acres
   = 8.3
   IA:PA = 0.75 acres/0.15 acres
   = 5.0
2. Using Table 2-30Table 2-25 and Figure 2-47 for a IA:PA ratios of 8:1 and 5:1, respectively, determine the phosphorus load reduction rates for IA disconnections to HSG C and HSG B:

Reduction Rates

Percent Phosphorus load reduction rates for IA disconnection		
Receiving PA	**IA:PA**	
	8:1	5:1
HSG C	7%	14%
HSG B (soil augmentation)	14%	22%

3. The cumulative phosphorus load reduction in pounds of phosphorus for the IA disconnection with storage (SCM-Reduction $_{\text{lbs-P}}$) is calculated using Equation 2-2. The SCM Load was calculated in the previous example and is 1.34 lbs/yr.
4.

SCM Reduction $_{\text{lbs-P}}$ = SCM Load * (SCM Reduction $_{\%\text{-P}}$/100)
For PA of 0.09 acres HSG C the SCM Reduction $_{\text{lbs-P}}$ is calculated as follows:
SCM Reduction $_{\text{lbs-P(0.09ac- HSG C)}}$ = 1.34 lbs/yr * (7/100)
= **0.09 lbs/yr**

The table below presents the SCM Reduction $_{\text{lbs-P}}$ for each of the scenarios:

Pounds Phosphorus load reduction for IA disconnection, lbs/yr		
Receiving PA	**Area of Receiving PA, acres**	
	0.09	**0.15**
HSG C	0.09	0.19
HSG B (soil augmentation)	0.19	0.29

Example 2-8. Determine the phosphorus load reduction for converting impervious area to permeable/pervious area.

A property owner is planning upcoming road reconstruction work in an industrial (IND) area, and has identified an opportunity to convert impervious surfaces to permeable/pervious surfaces by narrowing the road width of 3.7 miles (mi) of roadway from 32 feet (ft) to 28 ft and eliminating 3.2 miles of 4 ft wide paved sidewalk (currently there are sidewalks on both sides of the roadways targeted for restoration). The newly created permeable/pervious area will be tilled and treated with soil amendments to support vegetated growth in order to restore hydrologic function to at least HSG B.

Determine the:

A) Percent phosphorus load reduction rate (SCM Reduction $_{\%\text{-}P}$) for the conversion of impervious area (IA) to permeable/pervious area (PA); and

B) Cumulative phosphorus reduction in pounds that would be accomplished by the project (SCM-Reduction $_{lbs\text{-}P}$).

Solution:

1) Determine the area of IA to be converted to PA:

New PA = (((3.7 mi * 4 ft) + (3.2 mi * 4 ft)) x 5280 ft/mi)/43,560 ft^2/acre
= 3.35 acres

2) Using Table 2-31, the phosphorus load reduction rate for converting IA to HSG B is 94.1%

3) The SCM Load is first determined using the method described above.

SCM Load = IA * phosphorus export loading rate for IND IA (see Table 1-1)
= 3.35 acres x 1.8 lbs/acre/yr
= 6.03 lbs/yr

4) The cumulative phosphorus load reduction in pounds of phosphorus for the IA conversion (SCM-Reduction $_{lbs\text{-}P}$) is calculated using Equation 2-2.

SCM Reduction $_{lbs\text{-}P}$ = SCM Load * (SCM Reduction $_{\%\text{-}P}$/100)
SCM Reduction $_{lbs\text{-}P}$ = 6.03 lbs/yr * (94.1/100)
= 5.67 lbs/yr

Table 2-2. Method for determining stormwater control design volume (DSV) (i.e., capacity) using long-term cumulative performance curves.

Stormwater Control Type	Description	Applicable Stormwater Control Measure Performance Curve	Equation for calculating Design Storage Capacity for Estimating Cumulative Reductions using Performances Curves
Infiltration Trench	Provides temporary storage of runoff using the void spaces within the soil/sand/gravel mixture that is used to backfill the trench for subsequent infiltration into the surrounding sub-soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = void space volumes of gravel and sand layers DSV = $(L \times W \times D_{stone} \times n_{stone}) + (L \times W \times D_{sand} \times n_{sand})$
Subsurface Infiltration	Provides temporary storage of runoff using the combination of storage structures (e.g., galleys, chambers, pipes, etc.) and void spaces within the soil/sand/gravel mixture that is used to backfill the system for subsequent infiltration into the surrounding sub-soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Water storage volume of storage units and void space volumes of backfill materials. Example for subsurface galleys backfilled with washed stone: DSV = $(L \times W \times D)_{galley} + (L \times W \times D_{stone} \times n_{stone})$
Surface Infiltration	Provides temporary storage of runoff through surface ponding storage structures (e.g., basin or swale) for subsequent infiltration into the underlying soils.	Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Water volume of storage structure before bypass. Example for linear trapezoidal vegetated swale DSV = $(L \times ((W_{bottom}+W_{top@Dmax})/2) \times D)$
Rain Garden/Bio-retention (no underdrains)	Provides temporary storage of runoff through surface ponding and possibly void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils.	Infiltration Basin (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Ponding water storage volume and void space volumes of soil filter media. Example for raingarden: DSV = $(A_{pond} \times D_{pond}) + (A_{soil} \times D_{soil} \times n_{soil\ mix})$
Tree Filter (no underdrain)	Provides temporary storage of runoff through surface ponding and void spaces within the soil/sand/gravel mixture that is used to filter runoff prior to infiltration into underlying soils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = Ponding water storage volume and void space volumes of soil filter media. DSV = $(L \times W \times D_{ponding}) + (L \times W \times D_{soil} \times n_{soil\ mix})$

Bio-Filtration (w/underdrain)	Provides temporary storage of runoff for filtering through an engineered soil media. The storage capacity includes void spaces in the filter media and temporary ponding at the surface. After runoff has passed through the filter media it is collected by an under-drain pipe for discharge. Manufactured or packaged bio-filter systems such as tree box filters may be suitable for using the bio-filtration performance results.	Bio-filtration	DSV = Ponding water storage volume and void space volume of soil filter media. Example of a linear biofilter: DSV = (L x W x $D_{ponding}$)+ (L x W x D_{soil} x n_{soil})
Enhanced Bio-filtration w/ Internal Storage Reservoir (ISR) (no infiltration)	Based on design by the UMA Stormwater Center (UMASC). Provides temporary storage of runoff for filtering through an engineered soil media, augmented for enhanced phosphorus removal, followed by detention and denitrification in a subsurface internal storage reservoir (ISR) comprised of gravel. An elevated outlet control at the top of the ISR is designed to provide a retention time of at least 24 hours in the system to allow for sufficient time for denitrification and nitrogen reduction to occur prior to discharge. The design storage capacity for using the cumulative performance curves is comprised of void spaces in the filter media, temporary ponding at the surface of the practice and the void spaces in the gravel ISR.	Enhanced Bio-filtration w/ISR	DSV = Ponding water storage volume and void space volume of soil filter media and gravel ISR. DSV =(A_{bed} x $D_{ponding}$)+(A_{bed} x D_{soil} x n_{soil})+(A_{ISR} x D_{gravel} x n_{gravel})
Gravel Wetland	Provides temporary surface ponding storage of runoff in a vegetated wetland cell that is eventually routed to an underlying saturated gravel internal storage reservoir (ISR) for nitrogen treatment. Outflow is controlled by an elevated orifice that has its invert elevation equal to the top of the ISR layer and provides a retention time of at least 24 hours.	Gravel Wetland	DSV = pretreatment volume + ponding volume + void space volume of gravel ISR. DSV = ($A_{pretreatment}$ x $D_{preTreatment}$)+ ($A_{wetland}$ x $D_{ponding}$)+(A_{ISR} x D_{gravel} x n_{gravel})
Porous Pavement with subsurface infiltration	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces of a subsurface gravel reservoir prior to infiltration into subsoils.	Infiltration Trench (6 infiltration rates: 0.17, 0.27, 0.52, 1.02, 2.41 and 8.27 inches per hour)	DSV = void space volumes of gravel layer DSV = (L x W x D_{stone} x n_{stone})

Porous pavement w/ impermeable underliner w/underdrain	Provides filtering of runoff through a filter course and temporary storage of runoff within the void spaces prior to discharge by way of an underdrain.	Porous Pavement	Depth of Filter Course = D_{FC}
Sand Filter w/underdrain	Provides filtering of runoff through a sand filter course and temporary storage of runoff through surface ponding and within void spaces of the sand and washed stone layers prior to discharge by way of an underdrain.	Sand Filter	DSV = pretreatment volume + ponding volume + void space volume of sand and washed stone layers. $DSV = (A_{pretreatment} \times D_{preTreatment}) + (A_{bed} \times D_{ponding}) + (A_{bed} \times D_{sand} \times n_{sand}) + (A_{bed} \times D_{stone} \times n_{stone})$
Wet Pond	Provides treatment of runoff through routing through permanent pool.	Wet Pond	DSV= Permanent pool volume prior to high flow bypass $DSV=A_{pond} \times D_{pond}$ (does not include pretreatment volume)
Extended Dry Detention Basin	Provides temporary detention storage for the design storage volume to drain in 24 hours through multiple out let controls.	Dry Pond	DSV= Ponding volume prior to high flow bypass $DSV=A_{pond} \times D_{pond}$ (does not include pretreatment volume)
Dry Water Quality Swale/Grass Swale	Based on MA design standards. Provides temporary surface ponding storage of runoff in an open vegetated channel through permeable check dams. Treatment is provided by filtering of runoff by vegetation and check dams and infiltration into subsurface soils.	Water Quality Grass Swale	DSV = Volume of swale at full design depth $DSV=L_{swale} \times W_{swale} \times D_{ponding\ swale}$
Definitions: DSV = Design Storage Volume = physical storage capacity to hold water; **VSV** = Void Space Volume; **L** = length, **W** = width, **D** = depth at design capacity before bypass, **n** = porosity fill material, **A** = average surface area for calculating volume; **Infiltration rate** = saturated soil hydraulic conductivity			

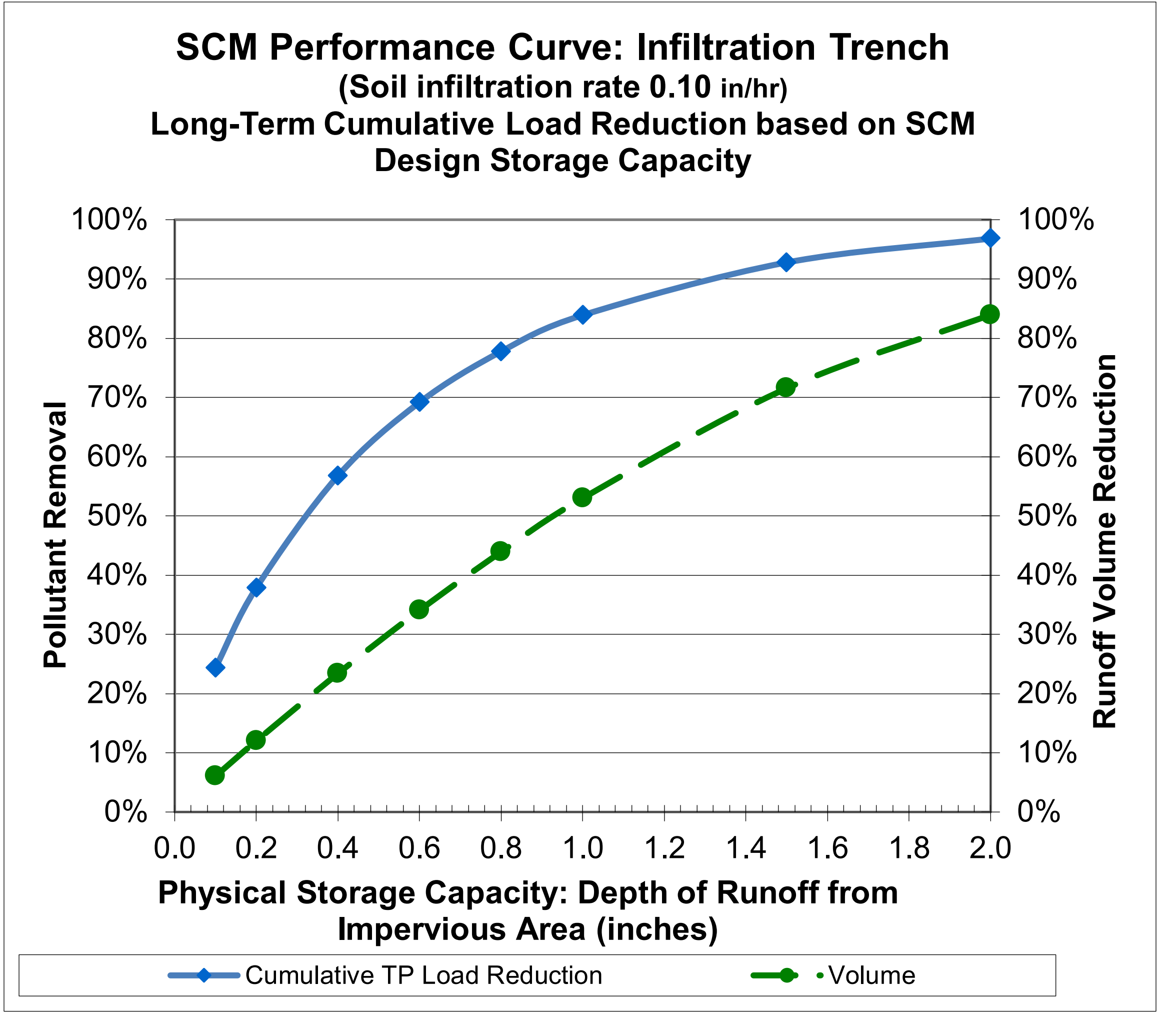
2.5. Phosphorus Load Reduction Credit Calculations for Structural Stormwater Control Measures (SCMs)

2.5.1. Infiltration Trench (IR = 0.10 in/hr) SCM Performance Table and Curve

Table 2-3. Infiltration Trench (IR = 0.10 in/hr) SCM Performance Table

Infiltration Trench (0.10 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	6%	12%	23%	34%	44%	53%	72%	84%
Cumulative Phosphorus Load Reduction	24%	38%	57%	69%	78%	84%	93%	97%

Figure 2-5. Infiltration Trench (infiltration rate = 0.10 in/hr) SCM Performance Curve

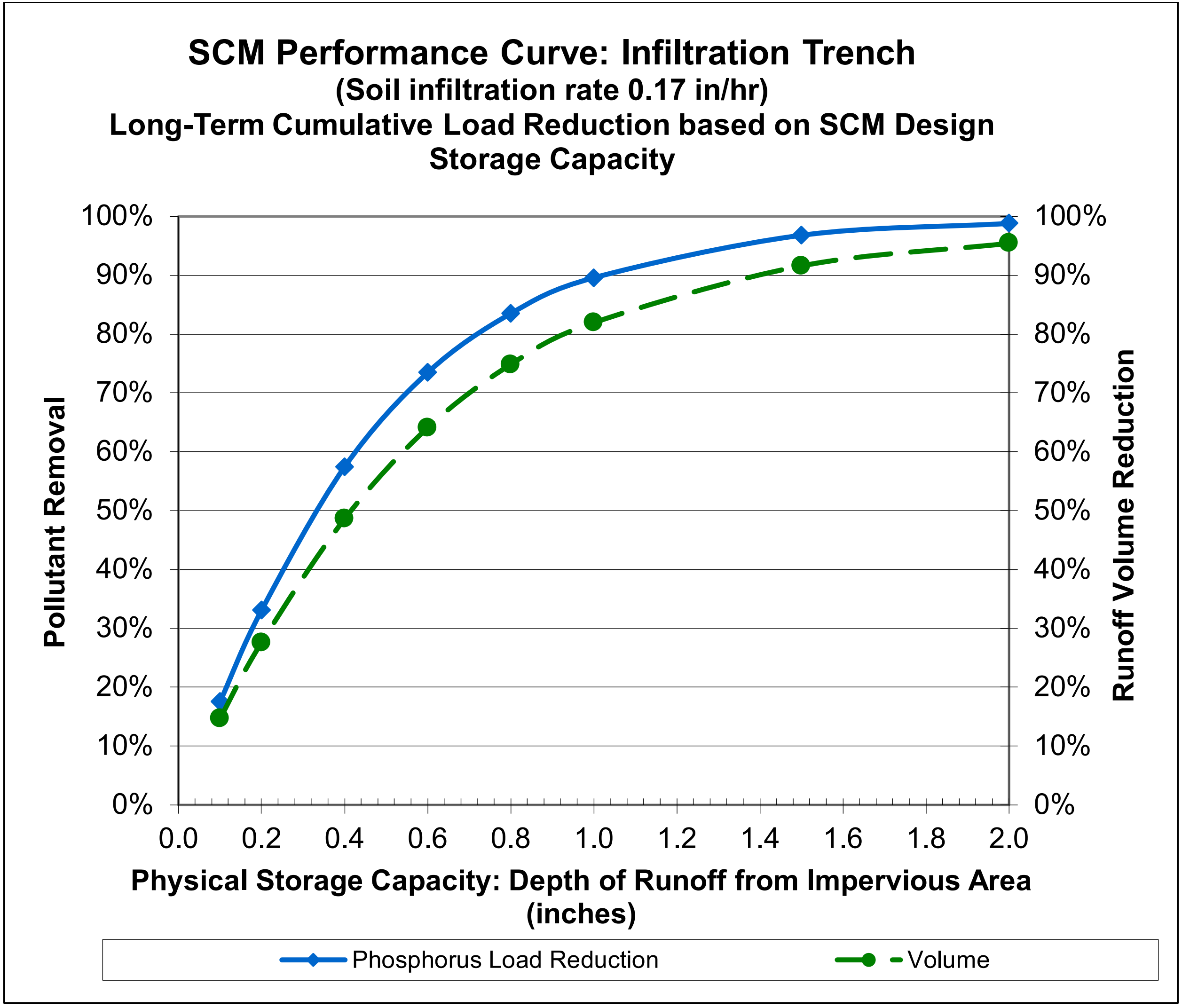


2.5.2. Infiltration Trench (IR = 0.17 in/hr) SCM Performance Table and Curve

Table 2-4. Infiltration Trench (IR = 0.17 in/hr) SCM Performance Table

Infiltration Trench (IR = 0.17 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	15%	28%	49%	64%	75%	82%	92%	95%
Cumulative Phosphorus Load Reduction	18%	33%	57%	73%	83%	90%	97%	99%

Figure 2-6. Infiltration Trench (infiltration rate = 0.17 in/hr) SCM Performance Curve

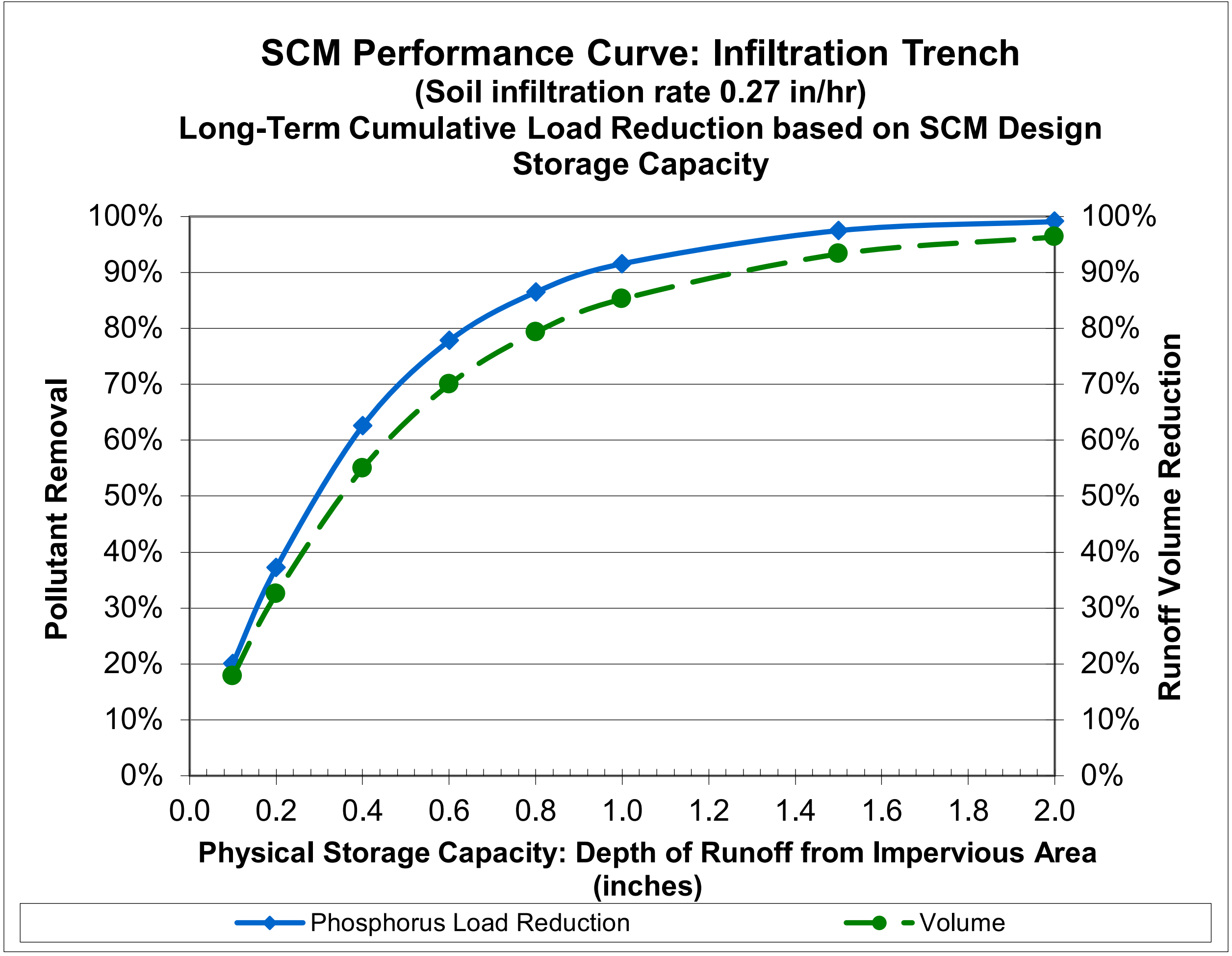


2.5.3. Infiltration Trench (IR = 0.27 in/hr) SCM Performance Table and Curve

Table 2-5. Infiltration Trench (IR = 0.27 in/hr) SCM Performance Table

Infiltration Trench (IR = 0.27 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	17.8%	32.5%	55.0%	70.0%	79.3%	85.2%	93.3%	96.3%
Cumulative Phosphorus Load Reduction	20%	37%	63%	78%	86%	92%	97%	99%

Figure 2-7.Infiltration Trench (infiltration rate = 0.27 in/hr) SCM Performance Curve

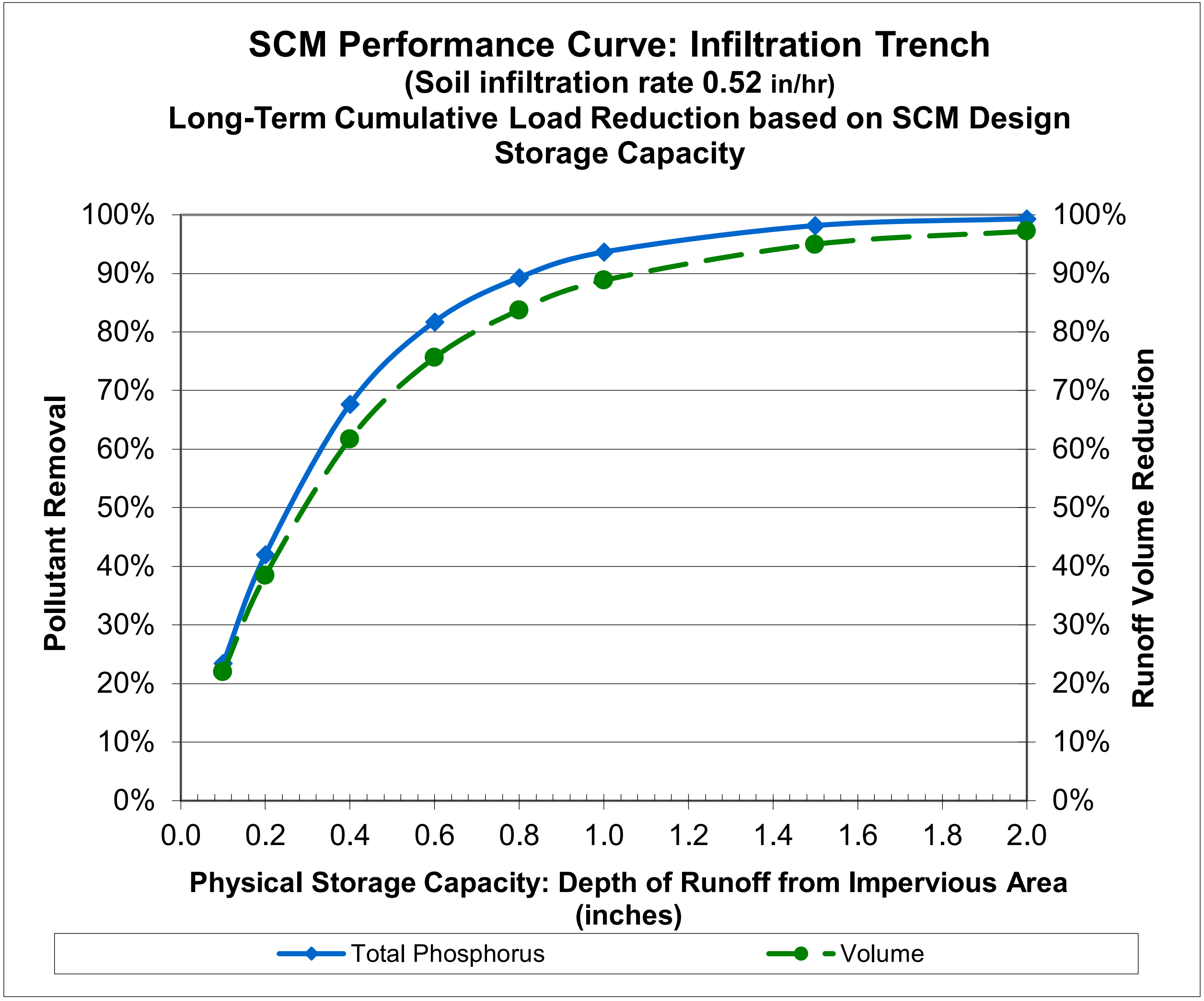


2.5.4. Infiltration Trench (IR = 0.52 in/hr) SCM Performance Table and Curve

Table 2-6. Infiltration Trench (IR = 0.52 in/hr) SCM Performance Table

Infiltration Trench (IR = 0.52 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	22.0%	38.5%	61.8%	75.7%	83.7%	88.8%	95.0%	97.2%
Cumulative Phosphorus Load Reduction	23%	42%	68%	82%	89%	94%	98%	99%

Figure 2-8.Infiltration Trench (infiltration rate = 0.52 in/hr) SCM Performance Curve

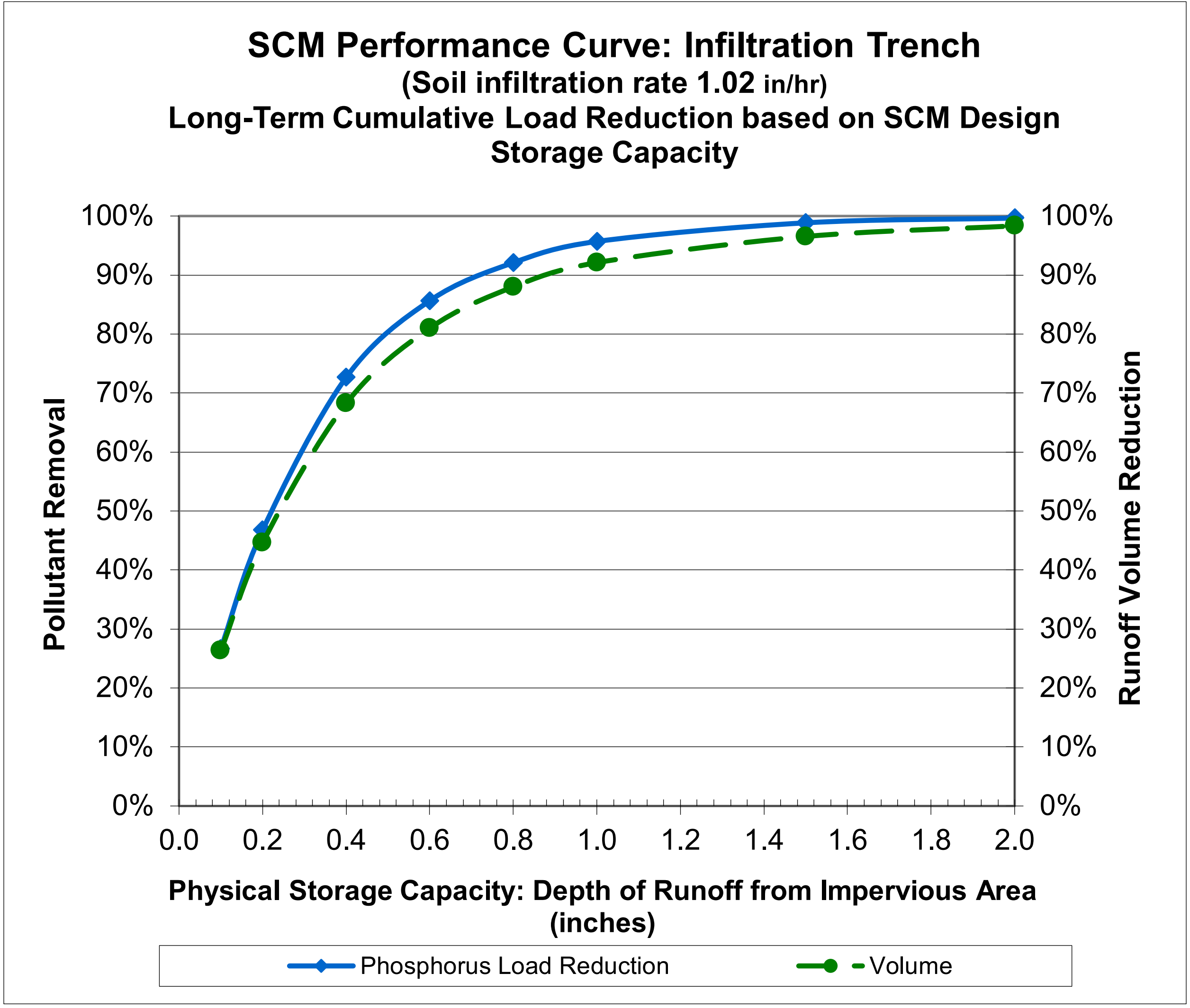


2.5.5. Infiltration Trench (IR = 1.02 in/hr) SCM Performance Table and Curve

Table 2-7. Infiltration Trench (IR = 1.02 in/hr) SCM Performance Table

Infiltration Trench (IR = 1.02 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	26.3%	44.6%	68.2%	81.0%	88.0%	92.1%	96.5%	98.3%
Cumulative Phosphorus Load Reduction	27%	47%	73%	86%	92%	96%	99%	100%

Figure 2-9. Infiltration Trench (infiltration rate = 1.02 in/hr) SCM Performance Curve

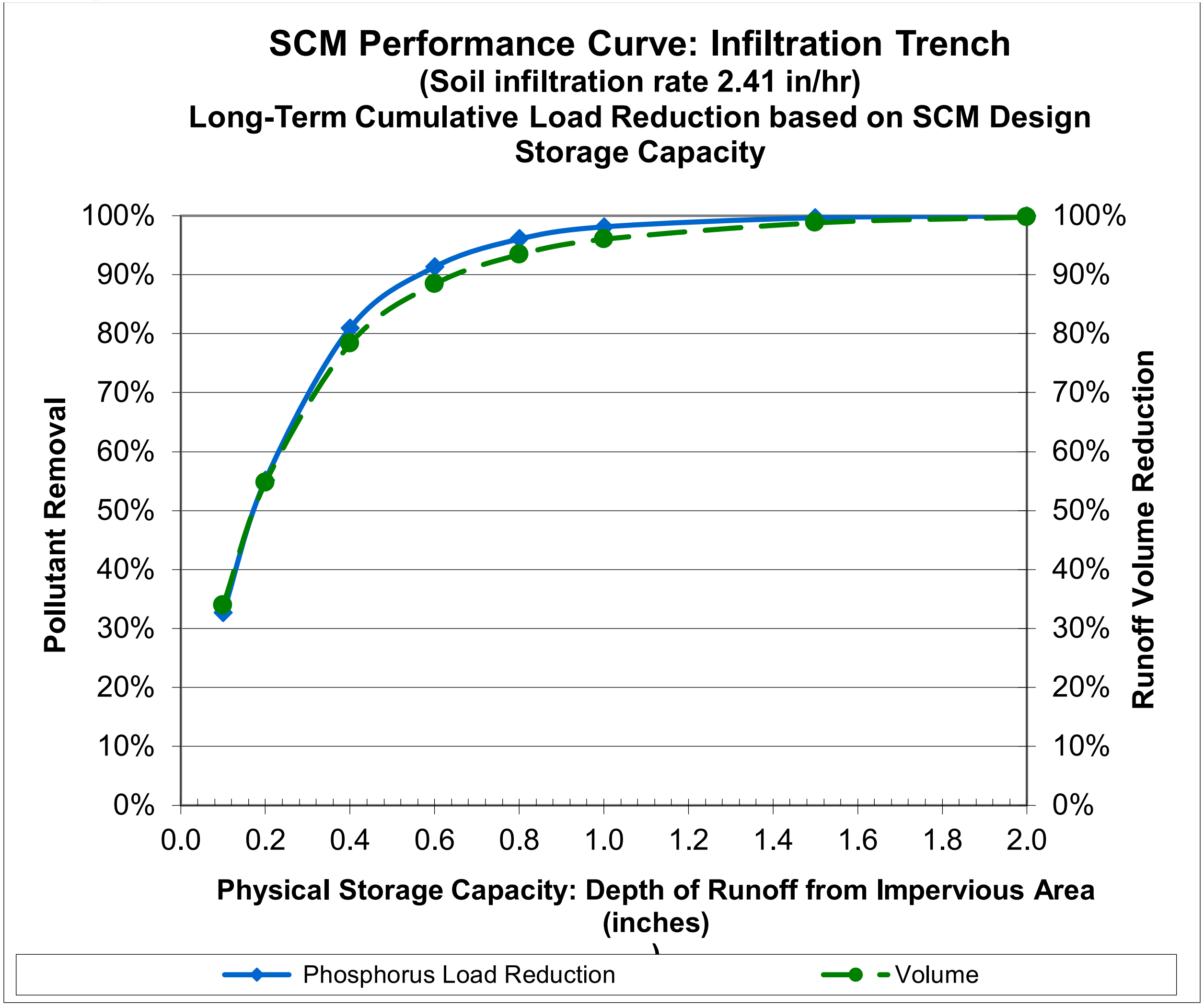


2.5.6. Infiltration Trench (IR = 2.41 in/hr) SCM Performance Table and Curve

Table 2-8. Infiltration Trench (IR = 2.41 in/hr) SCM Performance Table

Infiltration Trench (IR = 2.41 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff Treated from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	34%	55%	78%	88%	93%	96%	99%	100%
Cumulative Phosphorus Load Reduction	33%	55%	81%	91%	96%	98%	100%	100%

Figure 2-10. Infiltration Trench (infiltration rate = 2.41 in/hr) SCM Performance Curve

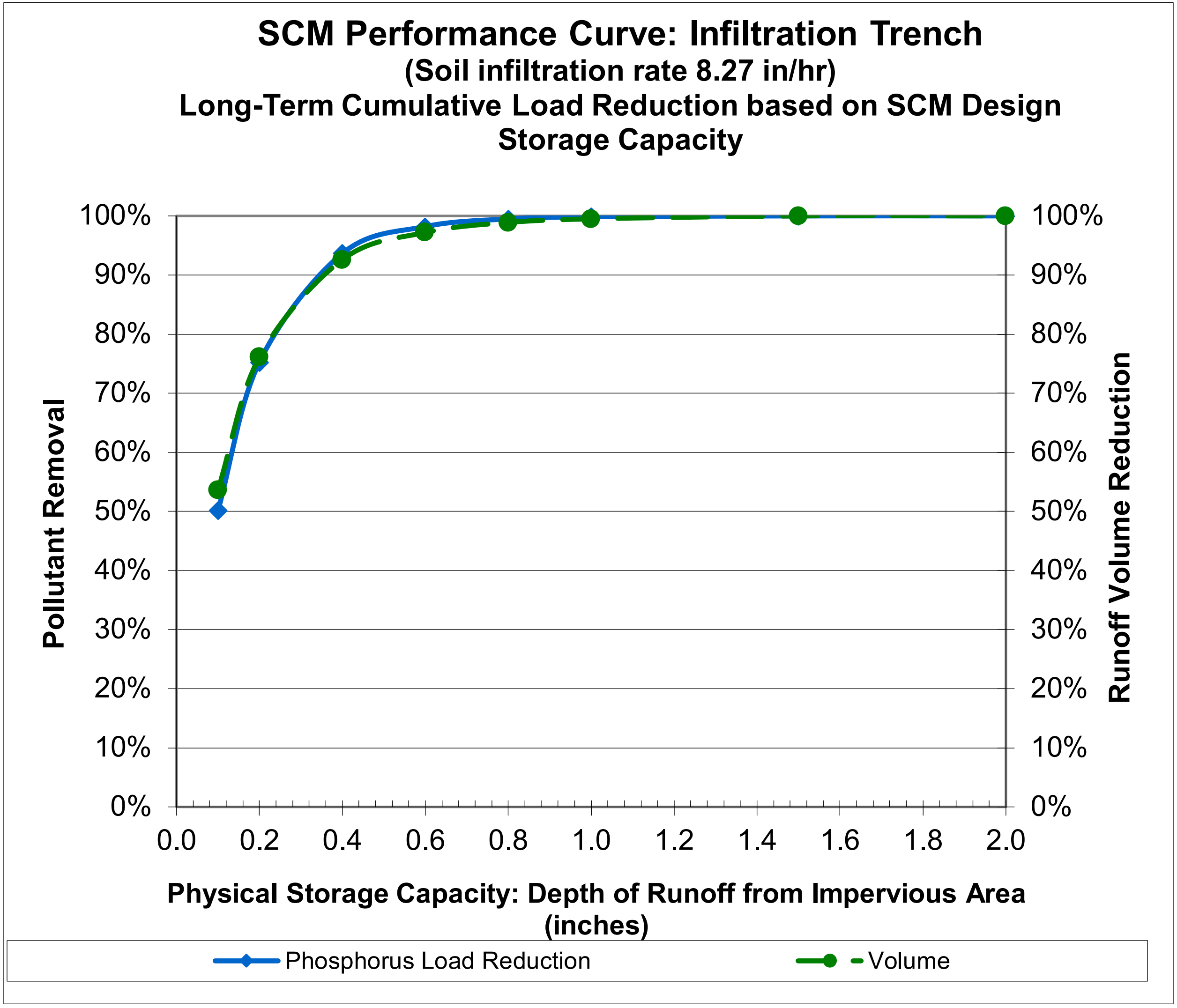


2.5.7. Infiltration Trench (IR = 8.27 in/hr) SCM Performance Table and Curve

Table 2-9. Infiltration Trench (IR = 8.27 in/hr) SCM Performance Table

Infiltration Trench (8.27 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	53.6%	76.1%	92.6%	97.2%	98.9%	99.5%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	50%	75%	94%	98%	99%	100%	100%	100%

Figure 2-11. Infiltration Trench (infiltration rate = 8.27 in/hr) SCM Performance Curve

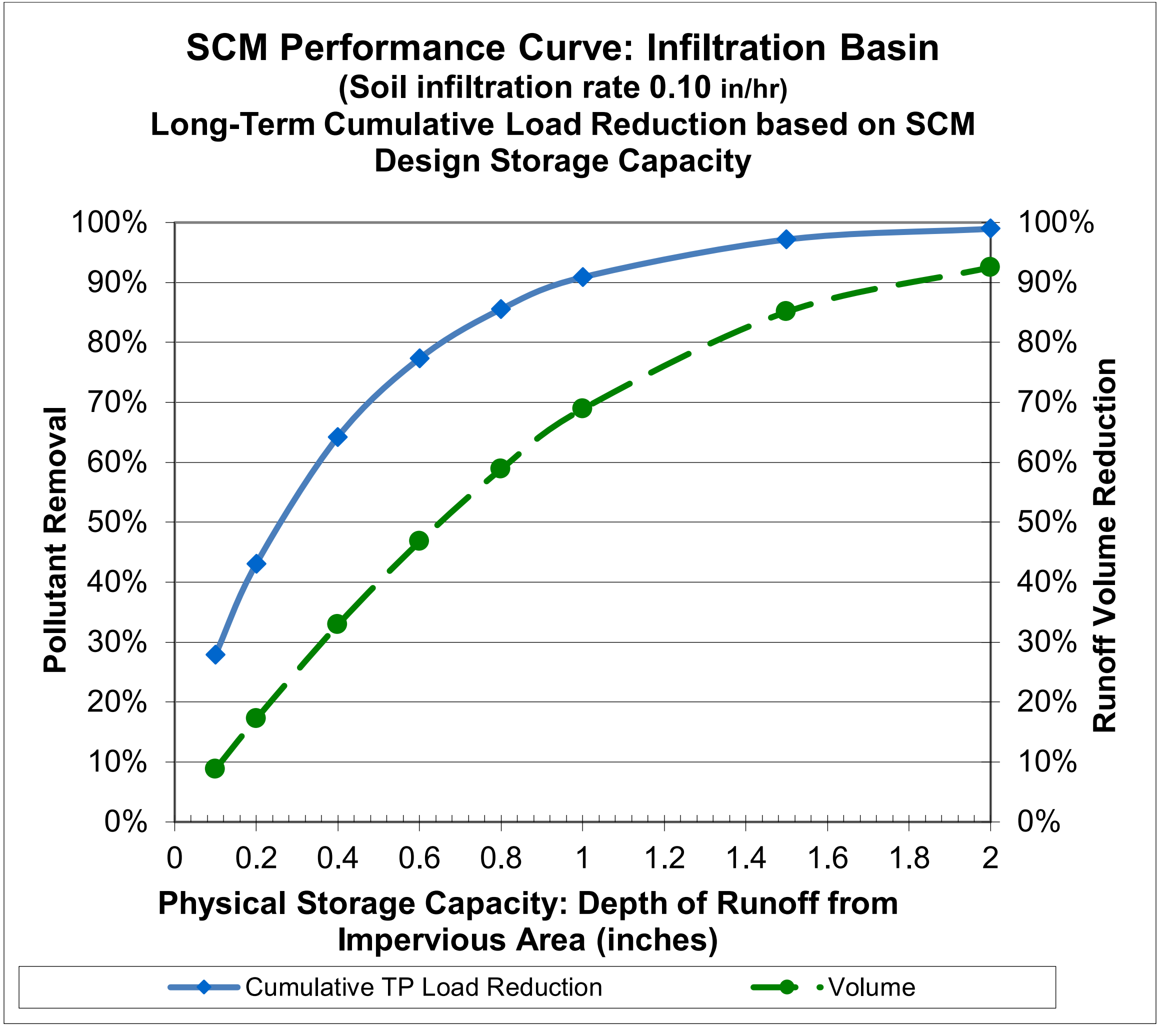


2.5.8. Infiltration Basin (IR = 0.10 in/hr) SCM Performance Curve and Table

Table 2-10. Infiltration Basin (IR = 0.10 in/hr) SCM Performance Table

Surface Infiltration (0.10 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1	1.5	2
Runoff Volume Reduction	9%	17%	33%	47%	59%	69%	85%	93%
Cumulative Phosphorus Load Reduction	28%	43%	64%	77%	86%	91%	97%	99%

Figure 2-12. Infiltration Basin (infiltration rate = 0.10 in/hr) SCM Performance Curve

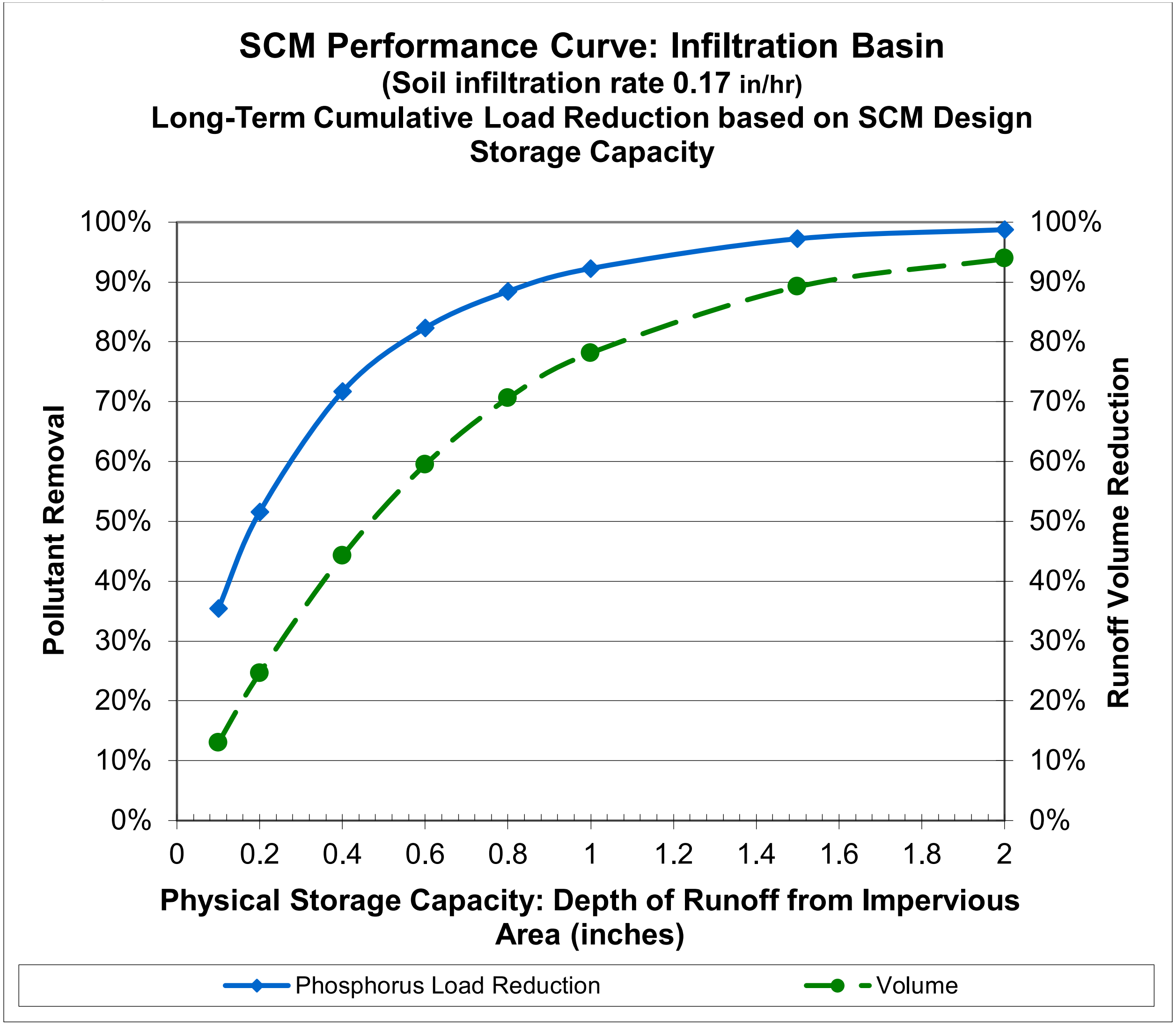


2.5.9. Infiltration Basin (IR = 0.17 in/hr) SCM Performance Curve and Table

Table 2-11. Infiltration Basin (IR = 0.17 in/hr) SCM Performance Table

Infiltration Basin (0.17 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	13%	25%	44%	59%	71%	78%	89%	94%
Cumulative Phosphorus Load Reduction	35%	52%	72%	82%	88%	92%	97%	99%

Figure 2-13. Infiltration Basin (infiltration rate = 0.17 in/hr) SCM Performance Curve

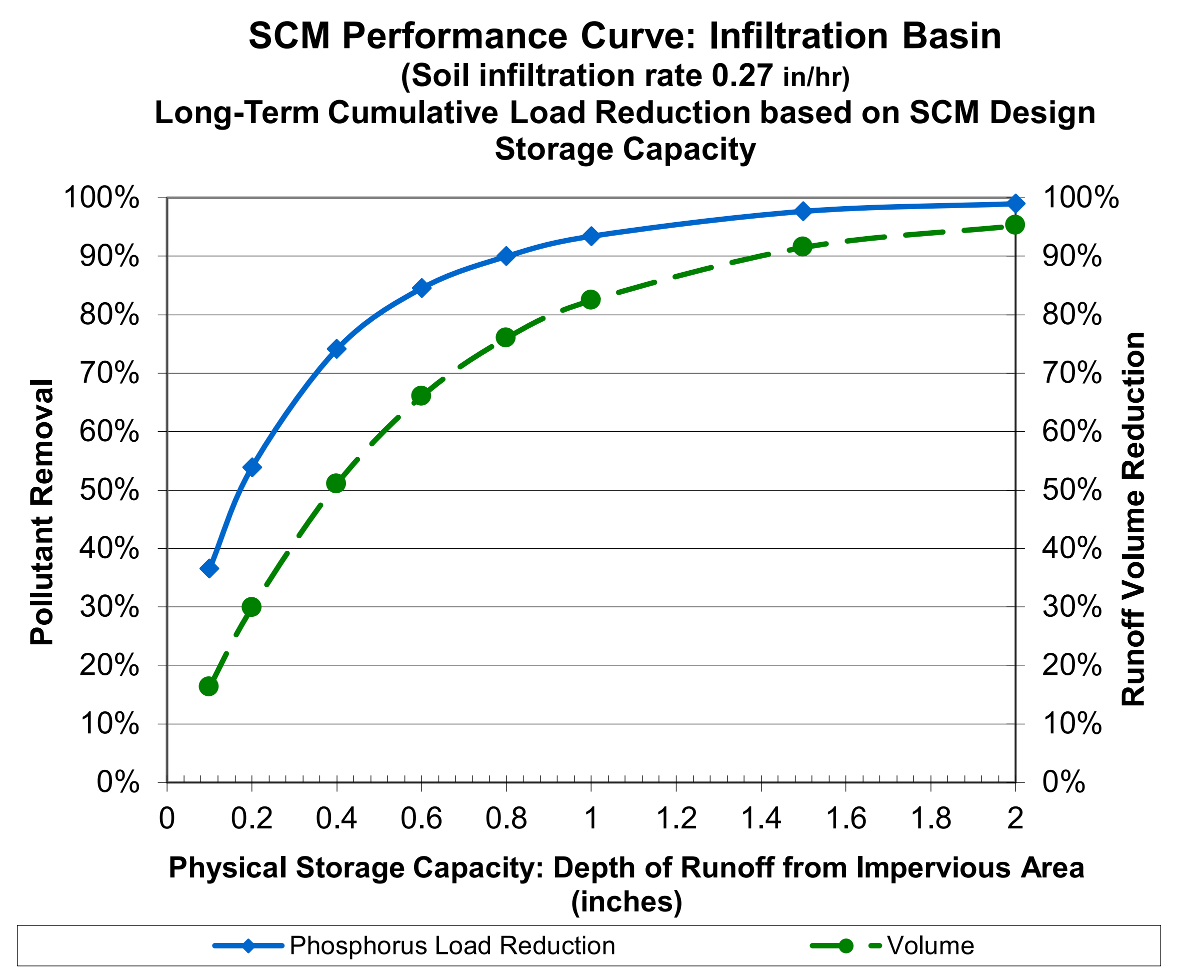


2.5.10. Infiltration Basin (IR = 0.27 in/hr) SCM Performance Table and Curve

Table 2-12. Infiltration Basin (IR = 0.27 in/hr) SCM Performance Table

Infiltration Basin (0.27 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	16%	30%	51%	66%	76%	82%	91%	95%
Cumulative Phosphorus Load Reduction	37%	54%	74%	85%	90%	93%	98%	99%

Figure 2-14. Infiltration Basin (infiltration rate = 0.27 in/hr) SCM Performance Curve

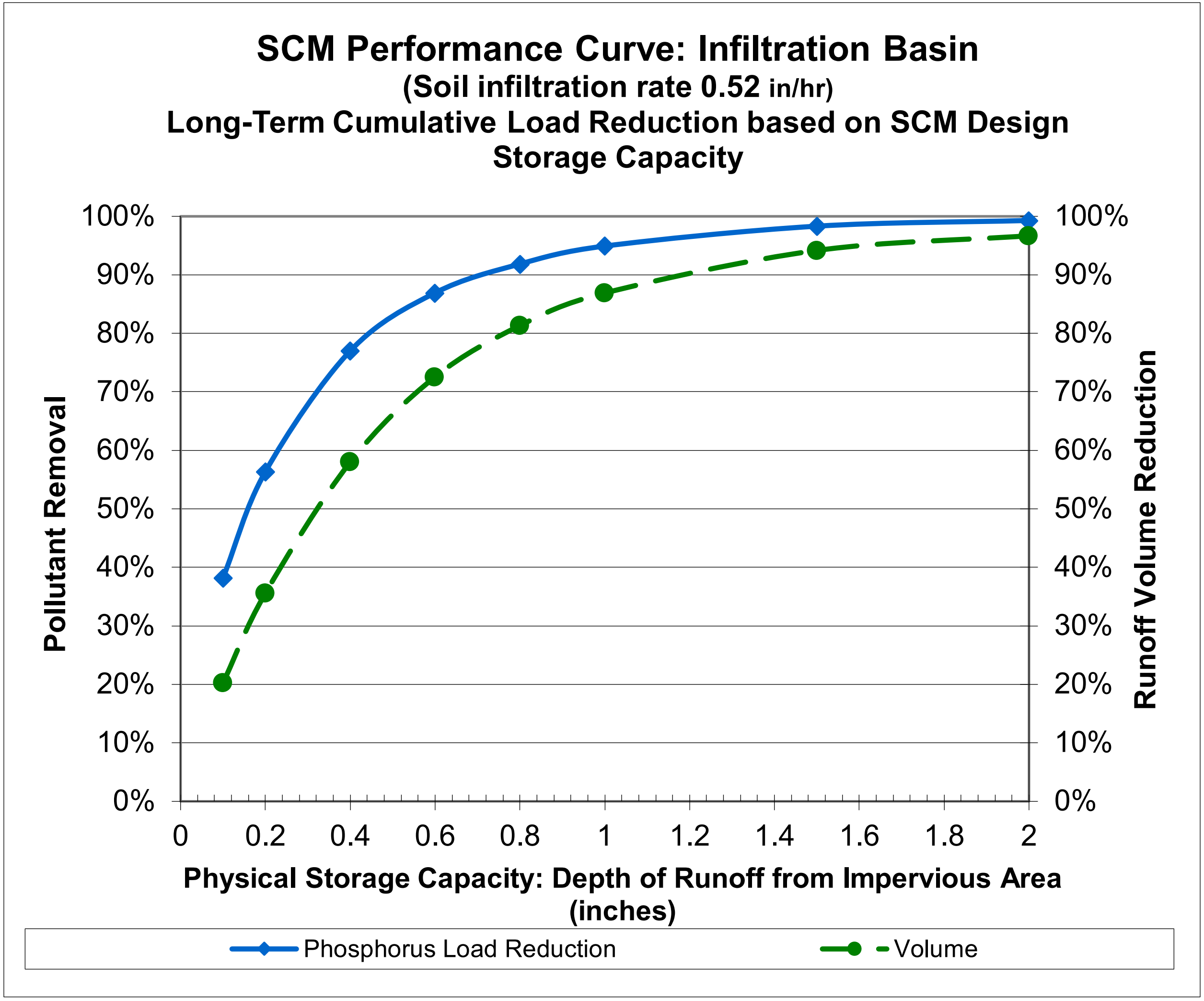


2.5.11. Infiltration Basin (IR = 0.52 in/hr) SCM Performance Table and Curve

Table 2-13. Infiltration Basin (IR = 0.52 in/hr) SCM Performance Table

Infiltration Basin (0.52 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	20%	36%	58%	73%	81%	87%	94%	97%
Cumulative Phosphorus Load Reduction	38%	56%	77%	87%	92%	95%	98%	99%

Figure 2-15. Infiltration Basin (infiltration rate = 0.52 in/hr) SCM Performance Curve

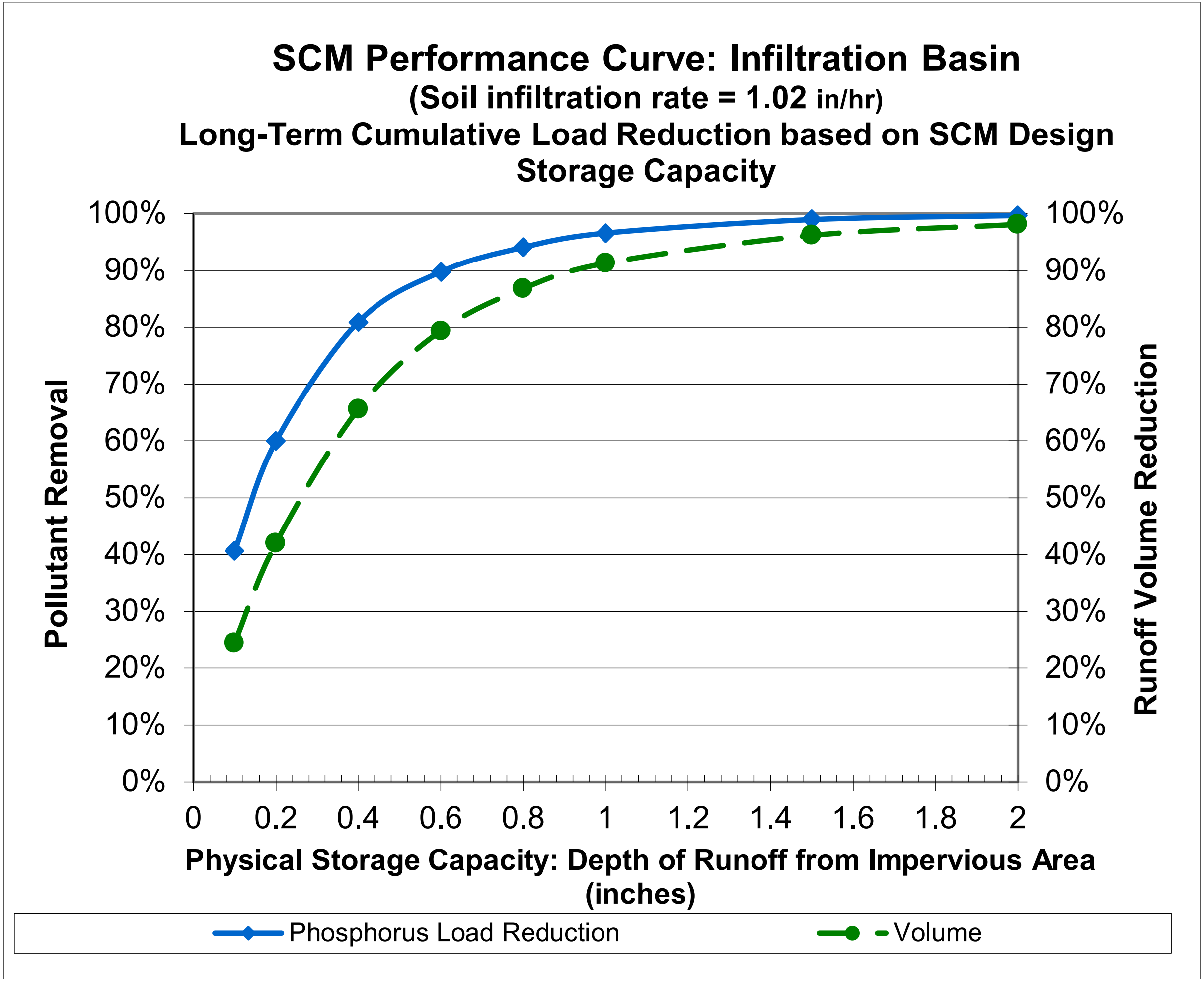


2.5.12. Infiltration Basin (IR = 1.02 in/hr) SCM Performance Table and Curve

Table 2-14. Infiltration Basin (IR = 1.02 in/hr) SCM Performance Table

Infiltration Basin (1.02 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	24.5%	42.0%	65.6%	79.4%	86.8%	91.3%	96.2%	98.1%
Cumulative Phosphorus Load Reduction	41%	60%	81%	90%	94%	97%	99%	100%

Figure 2-16. Infiltration Basin (infiltration rate = 1.02 in/hr) SCM Performance Curve

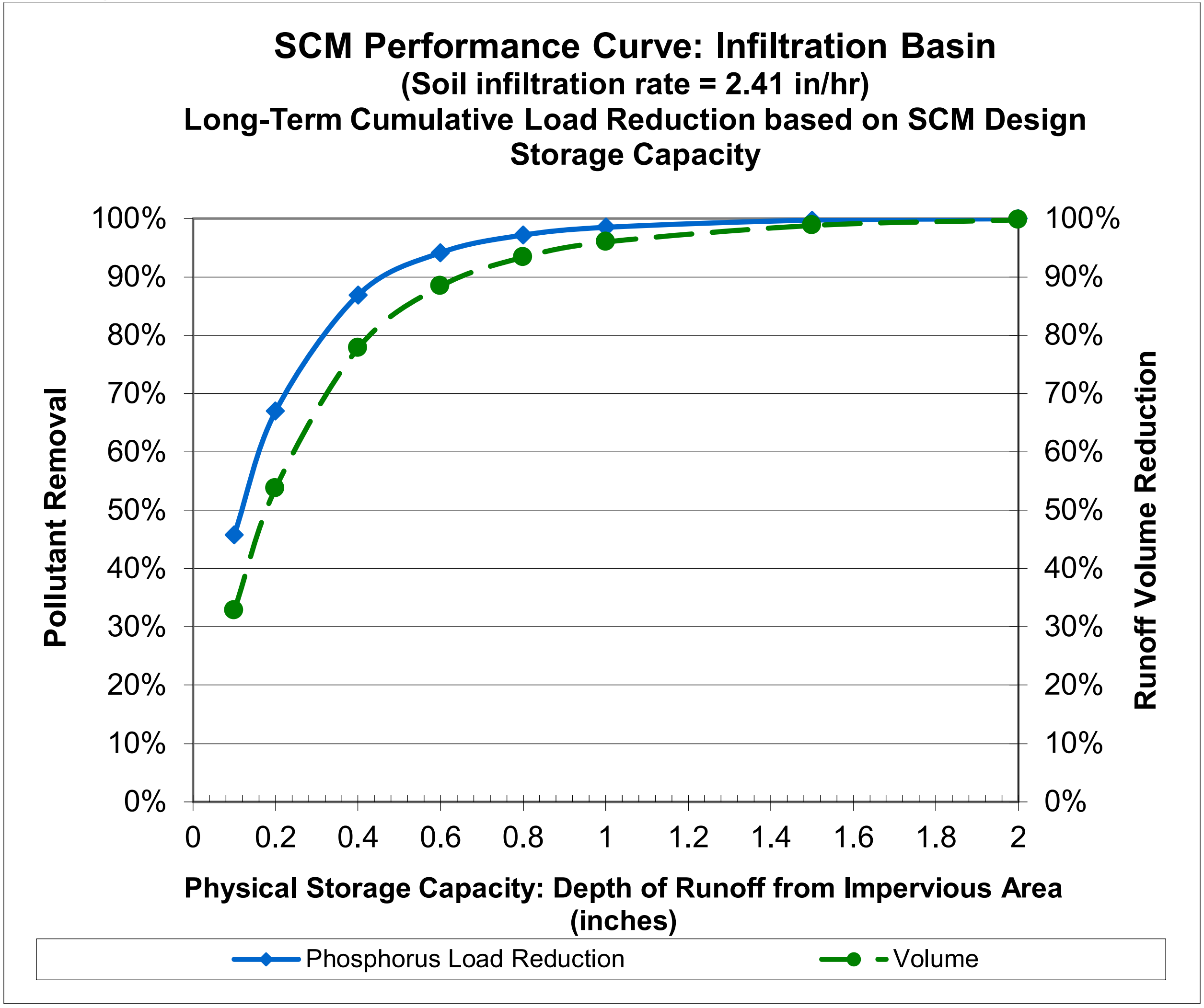


2.5.13. Infiltration Basin (IR = 2.41 in/hr) SCM Performance Table and Curve

Table 2-15. Infiltration Basin (IR = 2.41 in/hr) SCM Performance Table.

Infiltration Basin (2.41 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	32.8%	53.8%	77.8%	88.4%	93.4%	96.0%	98.8%	99.8%
Cumulative Phosphorus Load Reduction	46%	67%	87%	94%	97%	98%	100%	100%

Figure 2-17. Infiltration Basin (infiltration rate = 2.41 in/hr) SCM Performance Curve

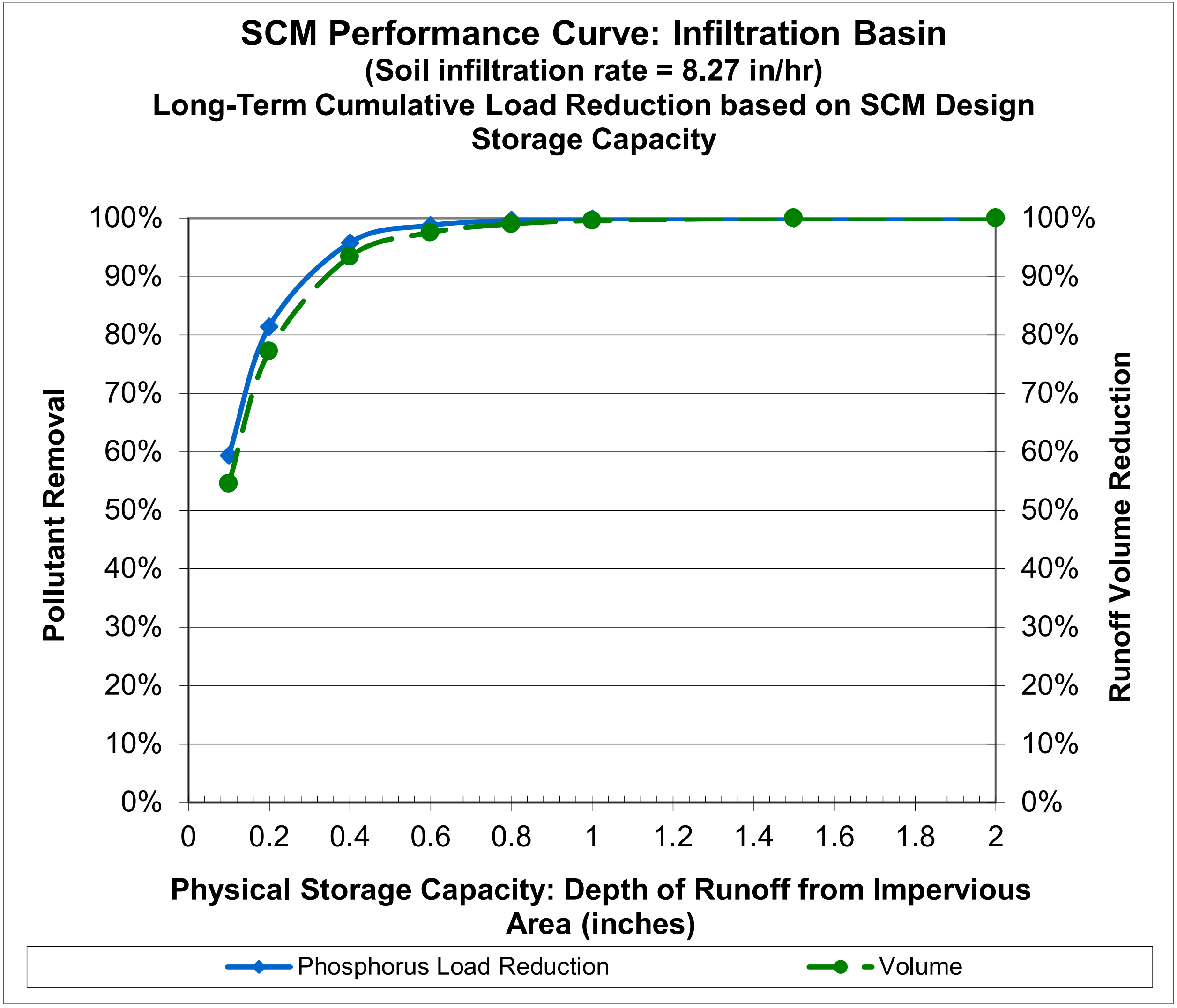


2.5.14. Infiltration Basin (IR = 8.27 in/hr) SCM Performance Table and Curve

Table 2-16. Infiltration Basin (IR = 8.27 in/hr) SCM Performance Table

Infiltration Basin (8.27 in/hr) SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	54.6%	77.2%	93.4%	97.5%	99.0%	99.6%	100.0%	100.0%
Cumulative Phosphorus Load Reduction	59%	81%	96%	99%	100%	100%	100%	100%

Figure 2-18. Infiltration Basin (infiltration rate = 8.27 in/hr) SCM Performance Curve

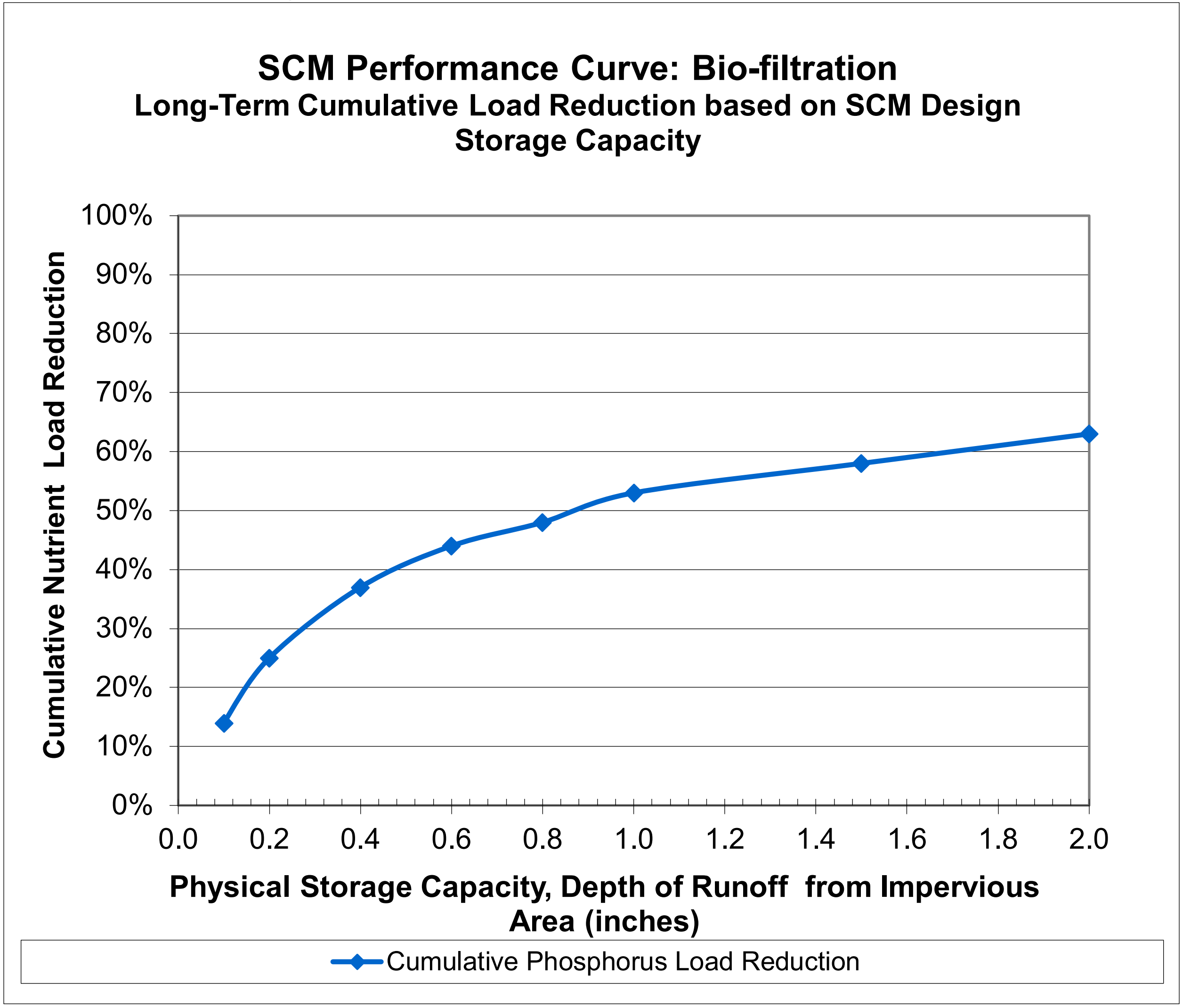


2.5.15. Bio-filtration SCM Performance Table and Curve

Table 2-17. Bio-filtration SCM Performance Table

Bio-filtration SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%

Figure 2-19. Bio-filtration SCM Performance Curve

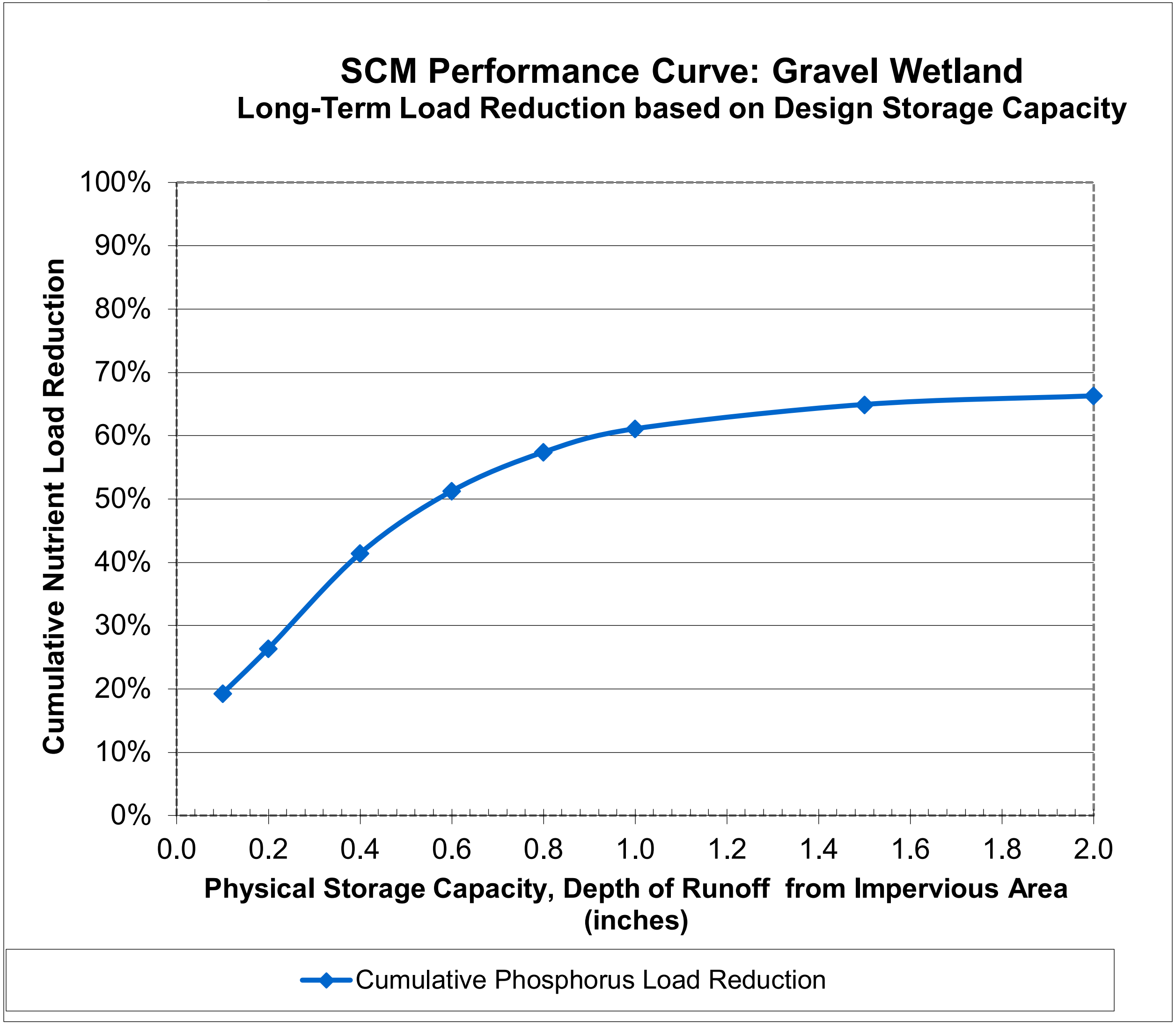


2.5.16. Gravel Wetland SCM Performance Table and Curve

Table 2-18. Gravel Wetland SCM Performance Table

Gravel Wetland SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	19%	26%	41%	51%	57%	61%	65%	66%

Figure 2-20. SCM Performance Curve: Gravel Wetland



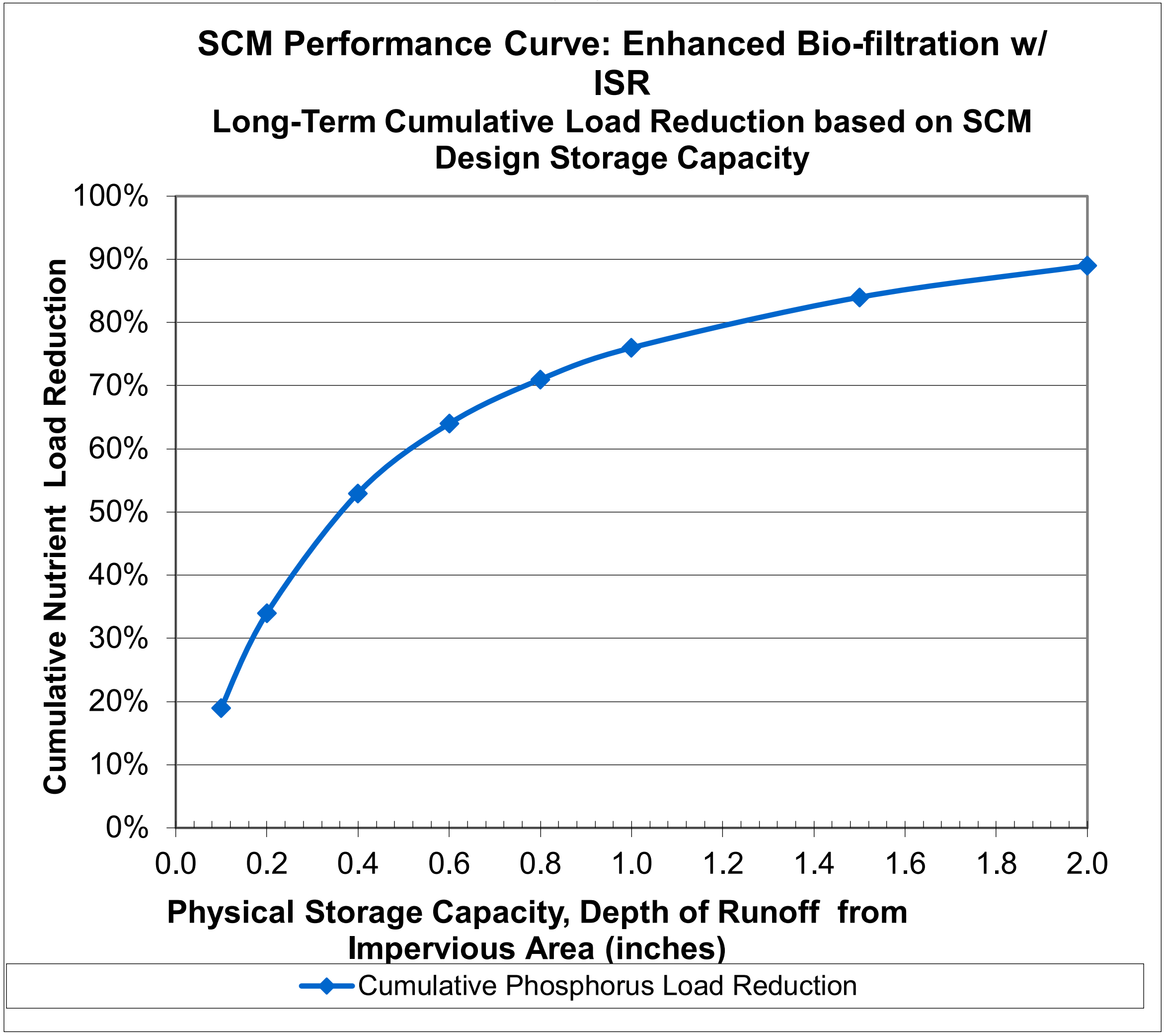
2.5.17. Enhanced Bio-filtration* with Internal Storage Reservoir (ISR) SCM Performance Table and Curve

Table 2-19. Enhanced Bio-filtration* with Internal Storage Reservoir (ISR) SCM Performance Table

Enhanced Bio-filtration* w/ ISR SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	19%	34%	53%	64%	71%	76%	84%	89%

*Filter media augmented with phosphorus sorbing materials to enhance phosphorus removal.

Figure 2-21. SCM Performance Curve: Enhanced Bio-filtration with Internal Storage Reservoir (ISR)

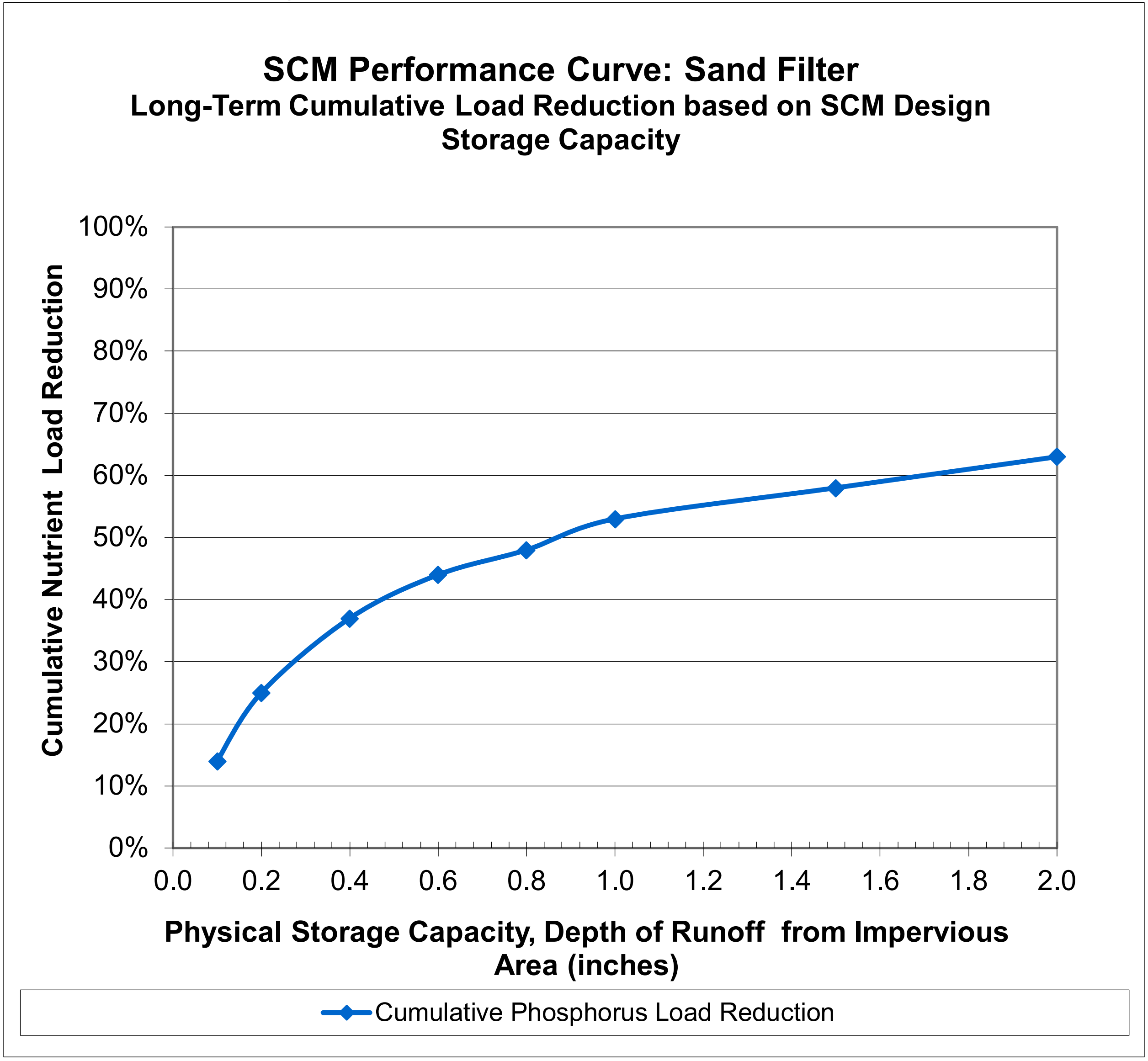


2.5.18. Sand Filter SCM Performance Table and Curve

Table 2-20. Sand Filter SCM Performance Table

Sand Filter SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%

Figure 2-22. SCM Performance Curve: Sand Filter

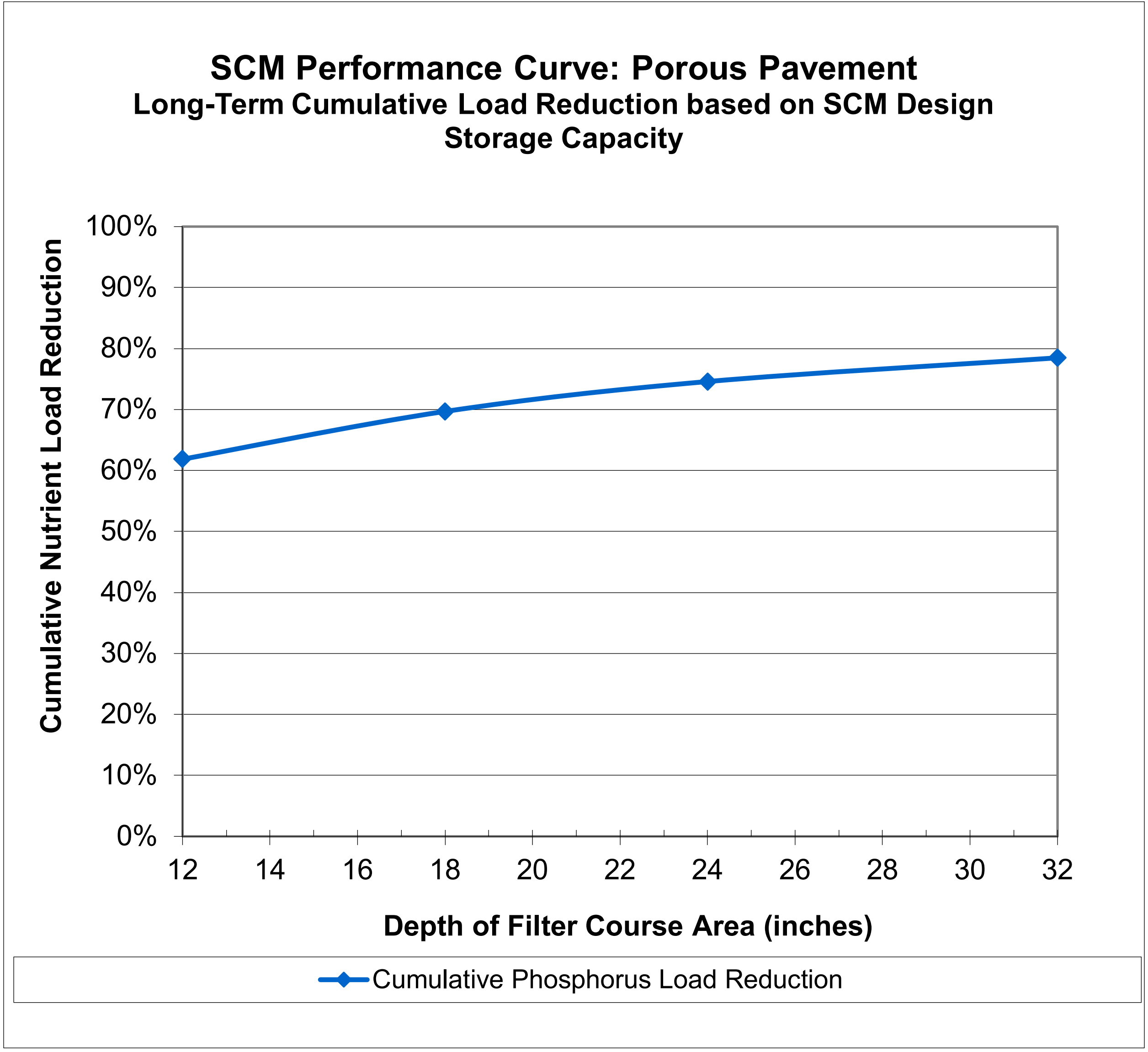


2.5.19. Porous Pavement SCM Performance Table and Curve

Table 2-21. Porous Pavement SCM Performance Table

Porous Pavement SCM Performance Table: Long-Term Phosphorus Load Reduction				
SCM Capacity: Depth of Filter Course Area (inches)	12.0	18.0	24.0	32.0
Cumulative Phosphorus Load Reduction	62%	70%	75%	78%

Figure 2-23.SCM Performance Curve: Porous Pavement

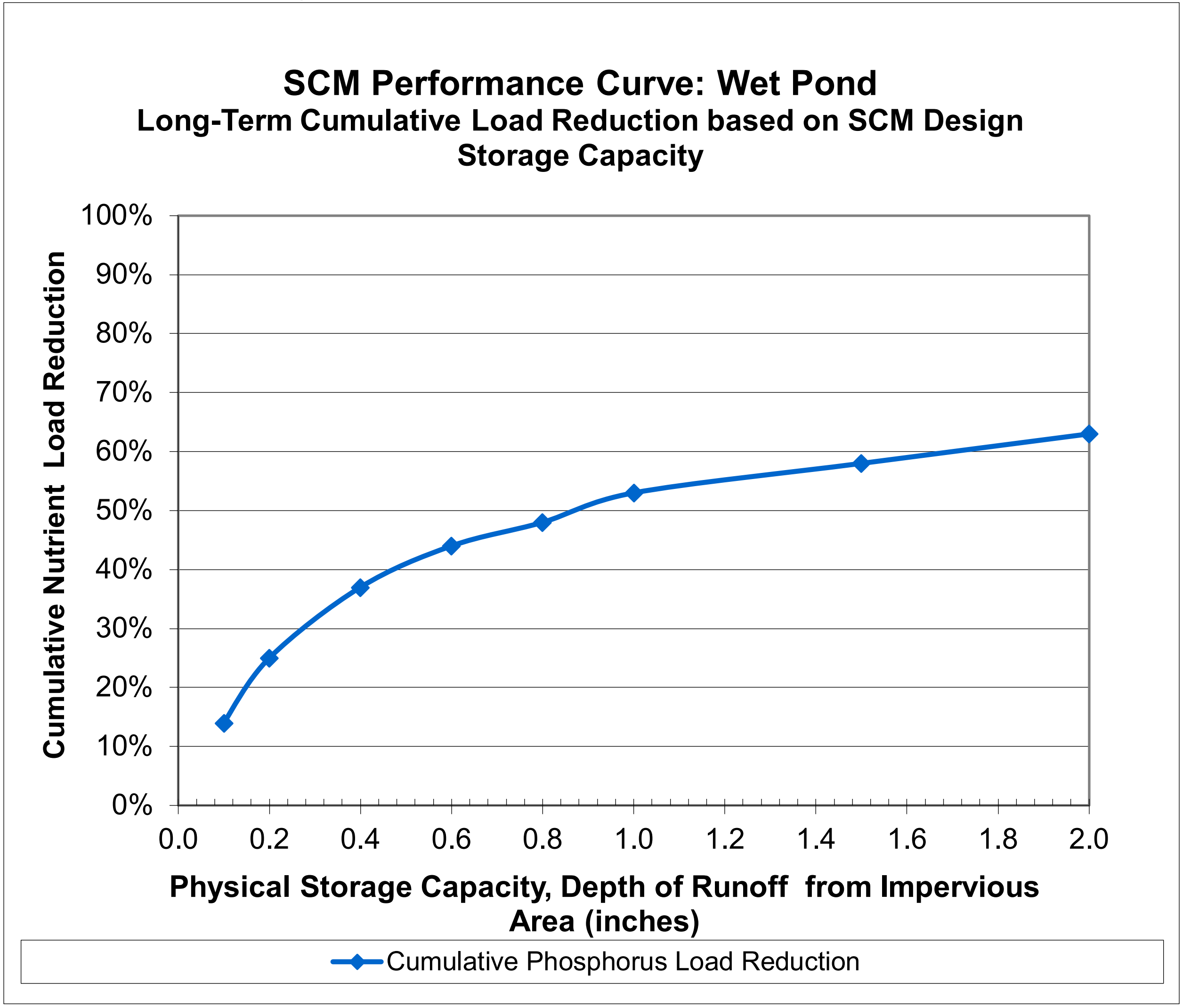


2.5.20. Wet Pond SCM Performance Table and Curve

Table 2-22. Wet Pond SCM Performance Table

Wet Pond SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	14%	25%	37%	44%	48%	53%	58%	63%

Figure 2-24. SCM Performance Curve: Wet Pond

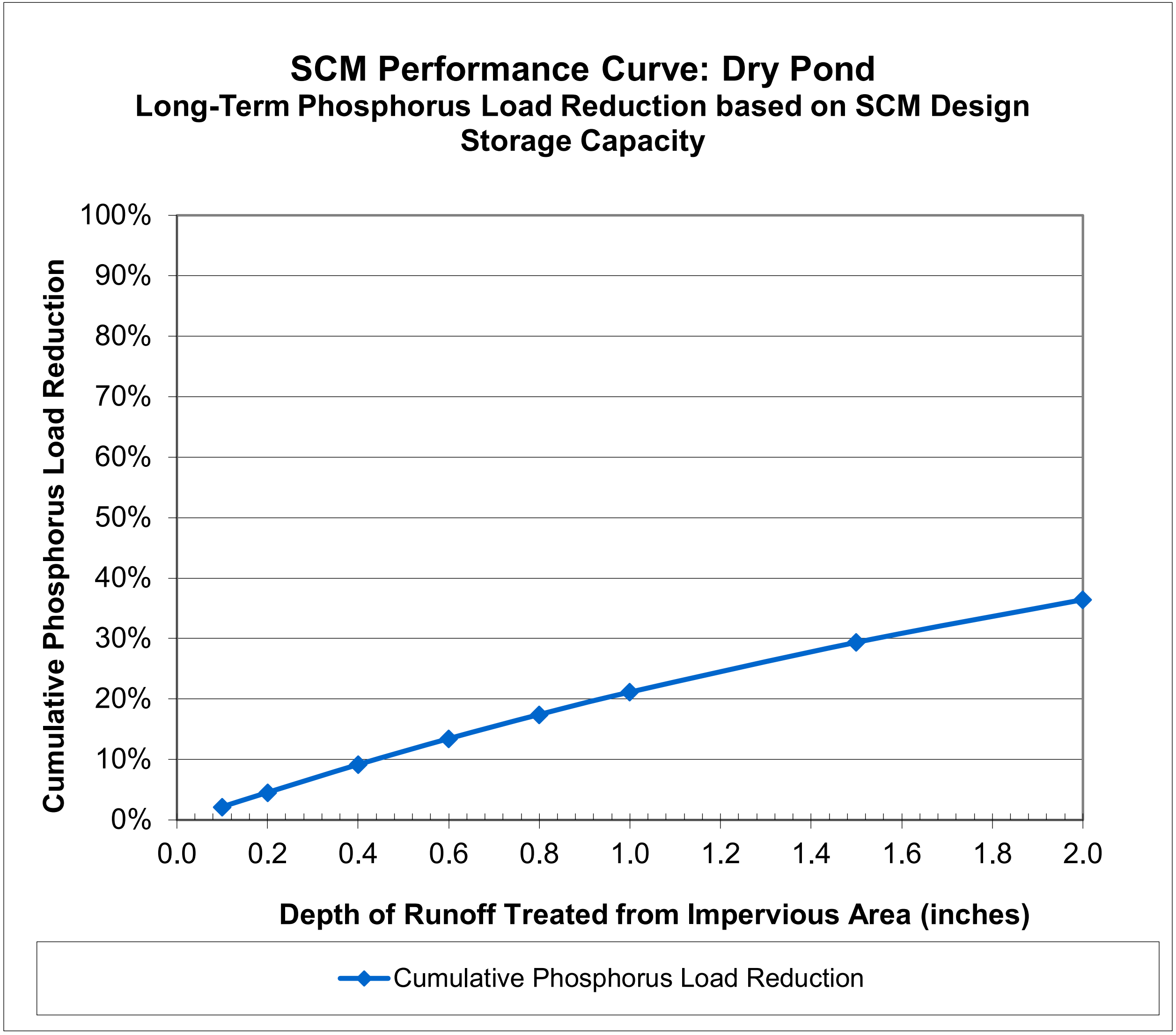


2.5.21. Dry Pond SCM Performance Table and Curve

Table 2-23. Dry Pond SCM Performance Table

Extended Dry Pond SCM Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Cumulative Phosphorus Load Reduction	2%	5%	9%	13%	17%	21%	29%	36%

Figure 2-25. SCM Performance Curve: Dry Pond

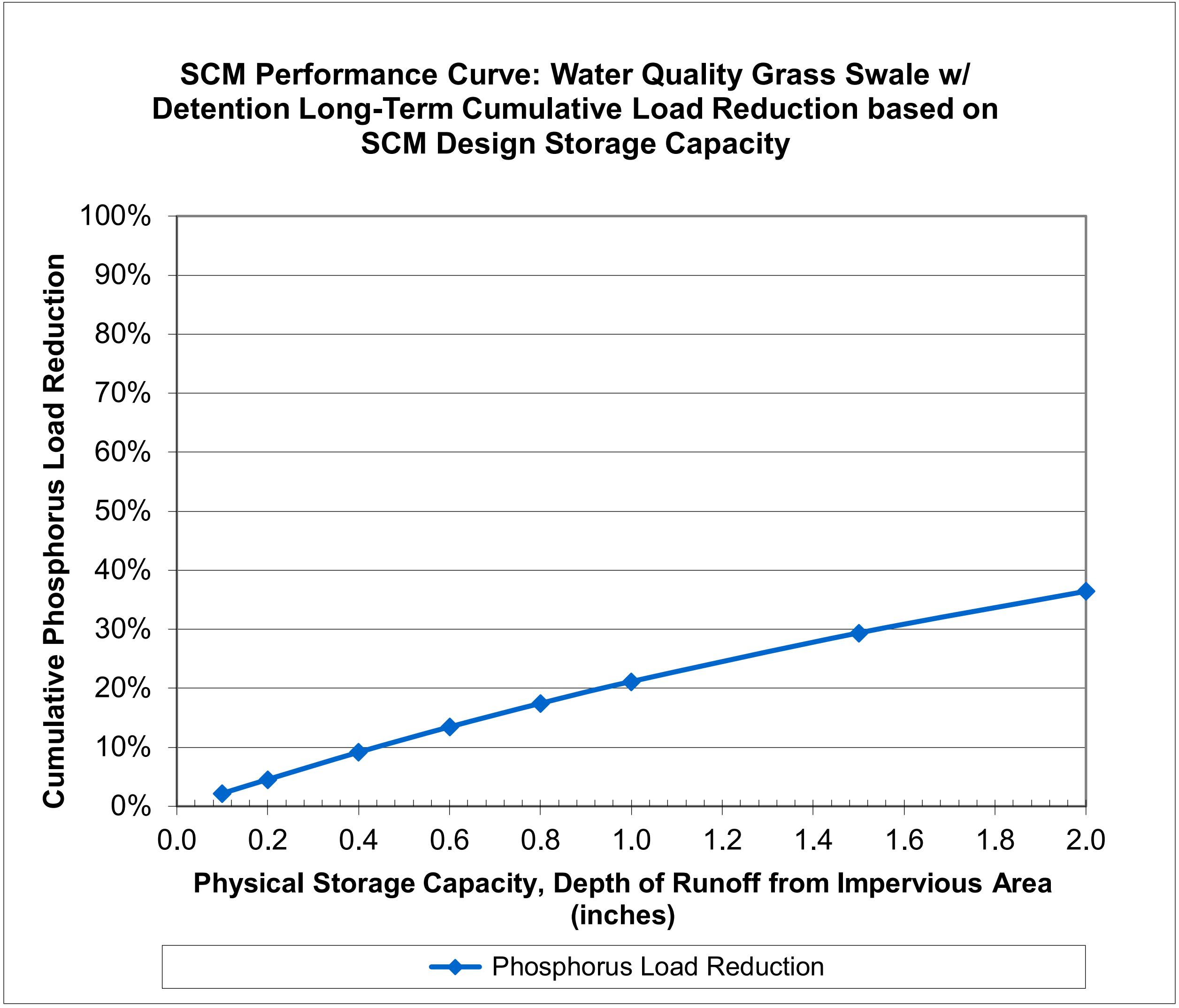


2.5.22. Water Quality Grass Swale with Detention SCM Performance Table and Curve

Table 2-24. Water Quality Grass Swale with Detention SCM Performance Table

Water Quality Grass Swale with Detention Performance Table: Long-Term Phosphorus Load Reduction								
SCM Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Phosphorus Load Reduction	2%	5%	9%	13%	17%	21%	29%	36%

Figure 2-26. SCM Performance Curve: Water Quality Grass Swale with Detention



2.5.23. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 Table and Curves

Table 2-25. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1.

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1												
Storage volume to impervious area ratio	Total Runoff Volume (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	22%	22%	21%
0.2 in	40%	38%	37%	40%	38%	37%	37%	38%	37%	24%	26%	27%
0.3 in	52%	50%	49%	52%	50%	49%	40%	46%	49%	24%	26%	27%
0.4 in	61%	59%	58%	59%	59%	58%	40%	48%	54%	24%	26%	27%
0.5 in	67%	66%	64%	62%	66%	64%	40%	48%	56%	24%	26%	27%
0.6 in	70%	71%	70%	62%	70%	70%	40%	48%	56%	24%	26%	27%
0.8 in	71%	78%	77%	62%	73%	77%	40%	48%	56%	24%	26%	27%
1.0 in	71%	80%	80%	62%	73%	79%	40%	48%	56%	24%	26%	27%
1.5 in	71%	81%	87%	62%	73%	81%	40%	48%	56%	24%	26%	27%
2.0 in	71%	81%	88%	62%	73%	81%	40%	48%	56%	24%	26%	27%

Figure 2-27. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG A Soils

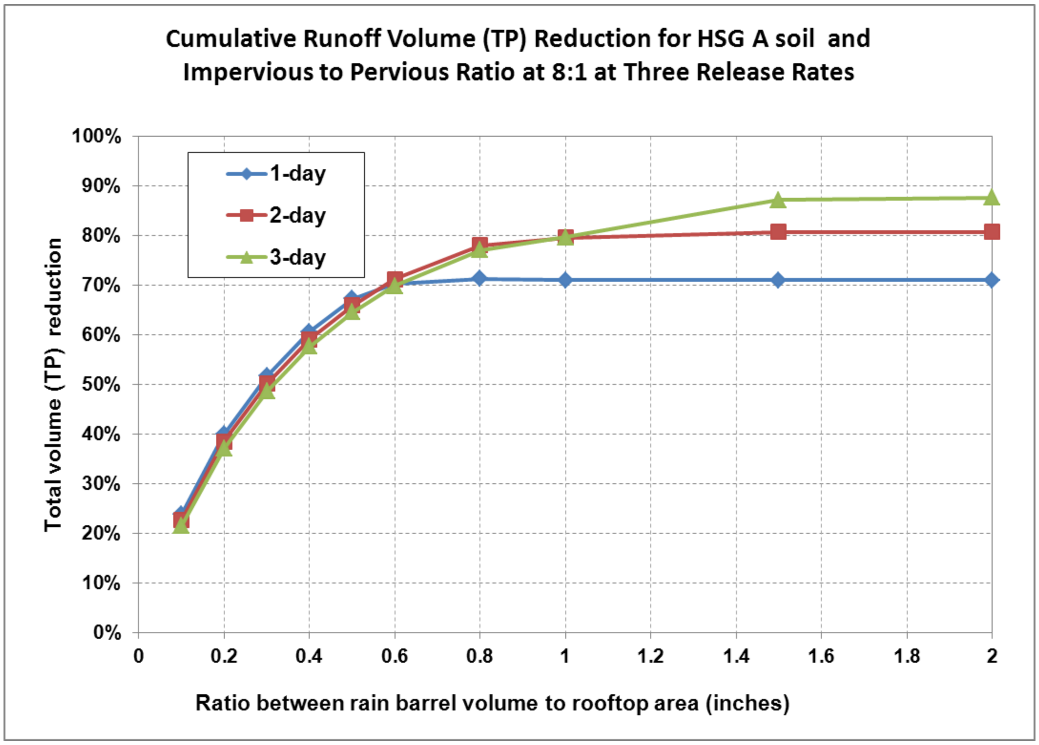


Figure 2-28. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG B Soils

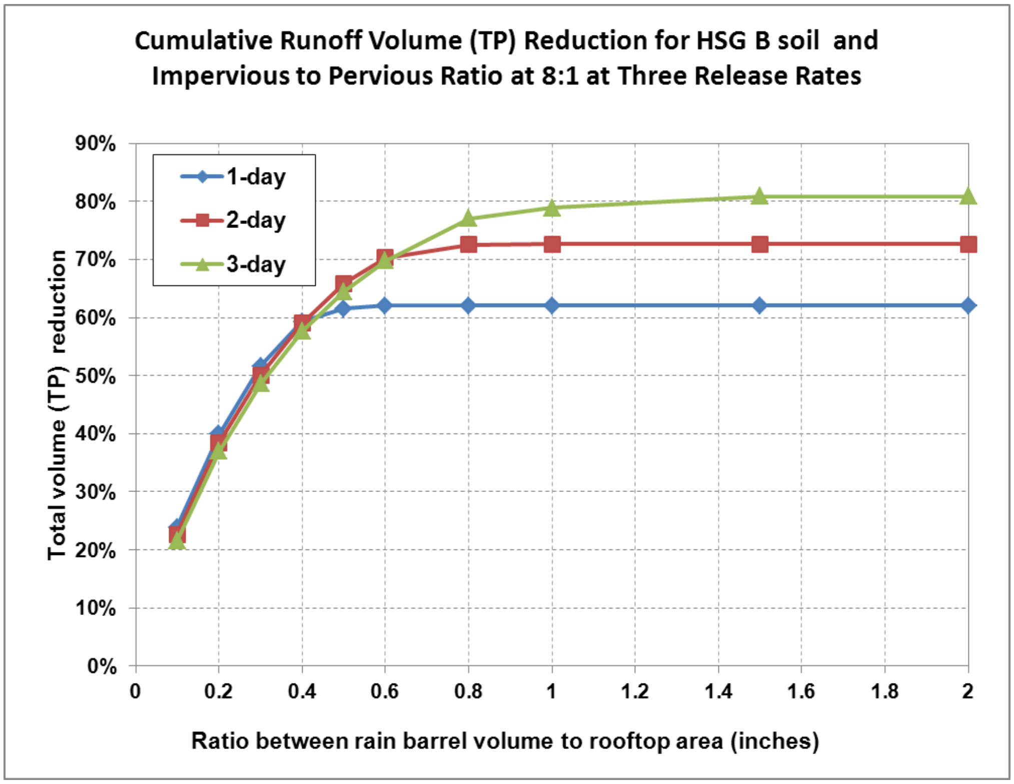


Figure 2-29. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG C Soils

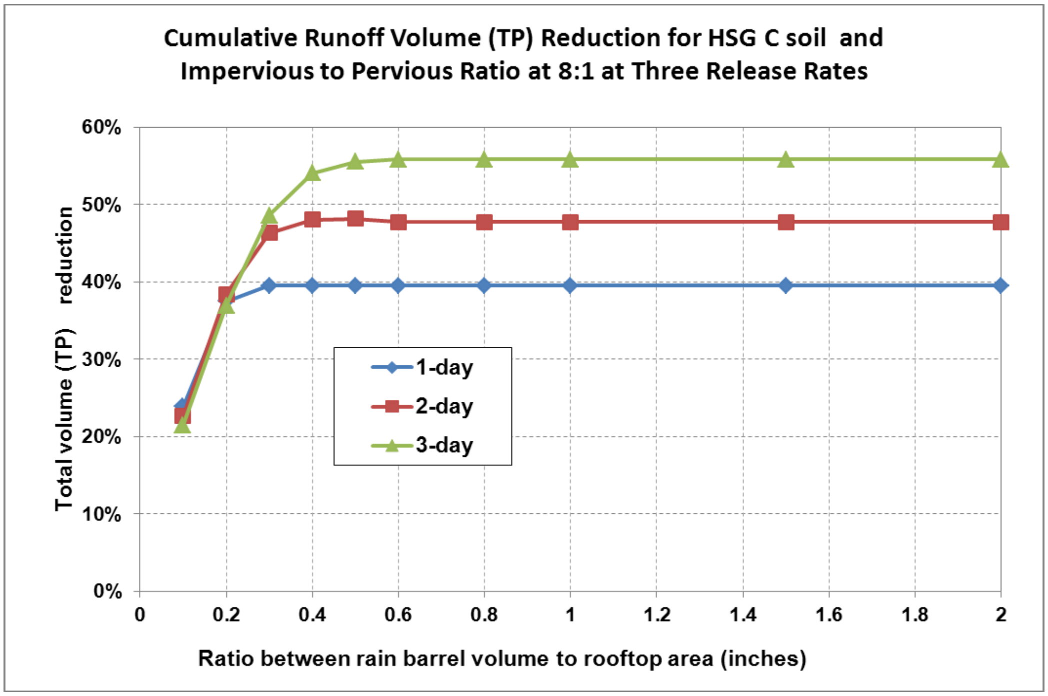
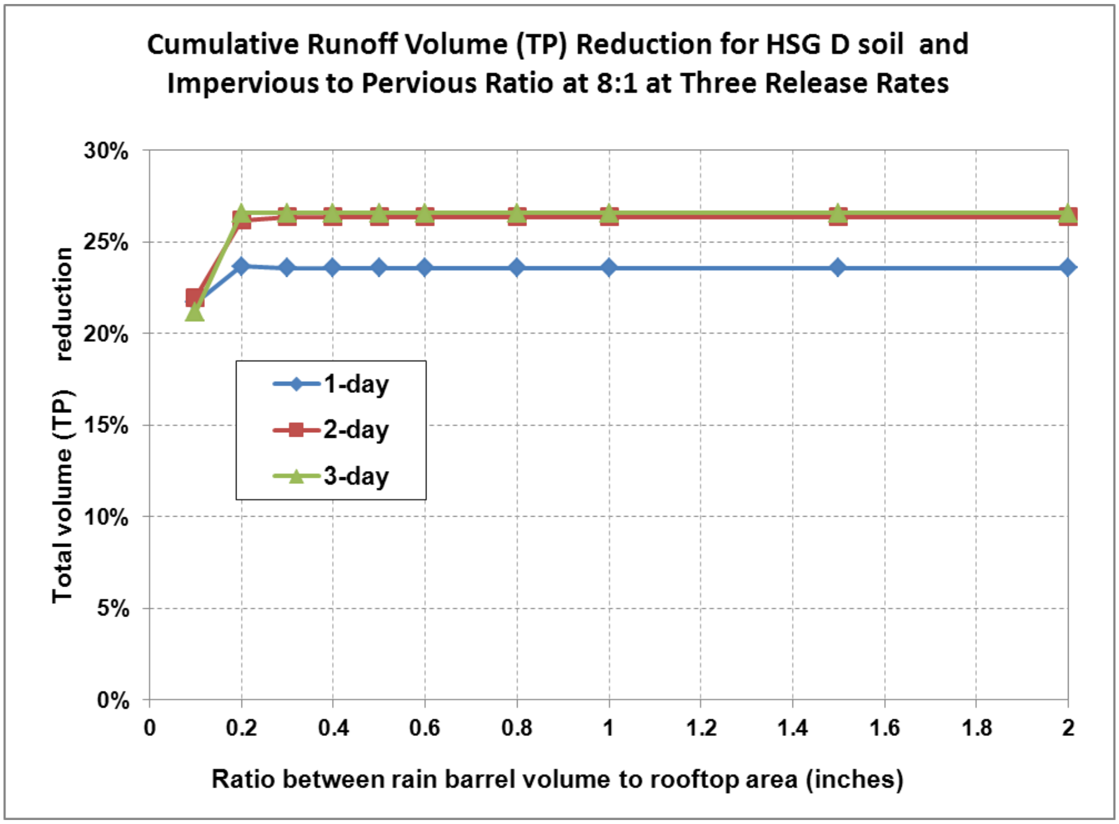


Figure 2-30. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 8:1 for HSG D Soils



2.5.24. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 Table and Curves

Table 2-26. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1												
Rain barrel volume to impervious area ratio	**Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages**											
	HSG A			**HSG B**			**HSG C**			**HSG D**		
	1-day	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	23%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	28%	30%	33%
0.3 in	52%	50%	49%	52%	50%	49%	47%	50%	49%	29%	31%	34%
0.4 in	61%	59%	58%	61%	59%	58%	48%	55%	58%	29%	31%	34%
0.5 in	67%	66%	64%	67%	66%	64%	48%	57%	63%	29%	31%	34%
0.6 in	73%	71%	70%	70%	71%	70%	48%	57%	65%	29%	31%	34%
0.8 in	78%	78%	77%	71%	78%	77%	48%	57%	66%	29%	31%	34%
1.0 in	79%	81%	80%	71%	79%	80%	48%	57%	66%	29%	31%	34%
1.5 in	79%	87%	88%	71%	80%	87%	48%	57%	66%	29%	31%	34%
2.0 in	79%	87%	91%	71%	80%	87%	48%	57%	66%	29%	31%	34%

Figure 2-31. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG A Soils

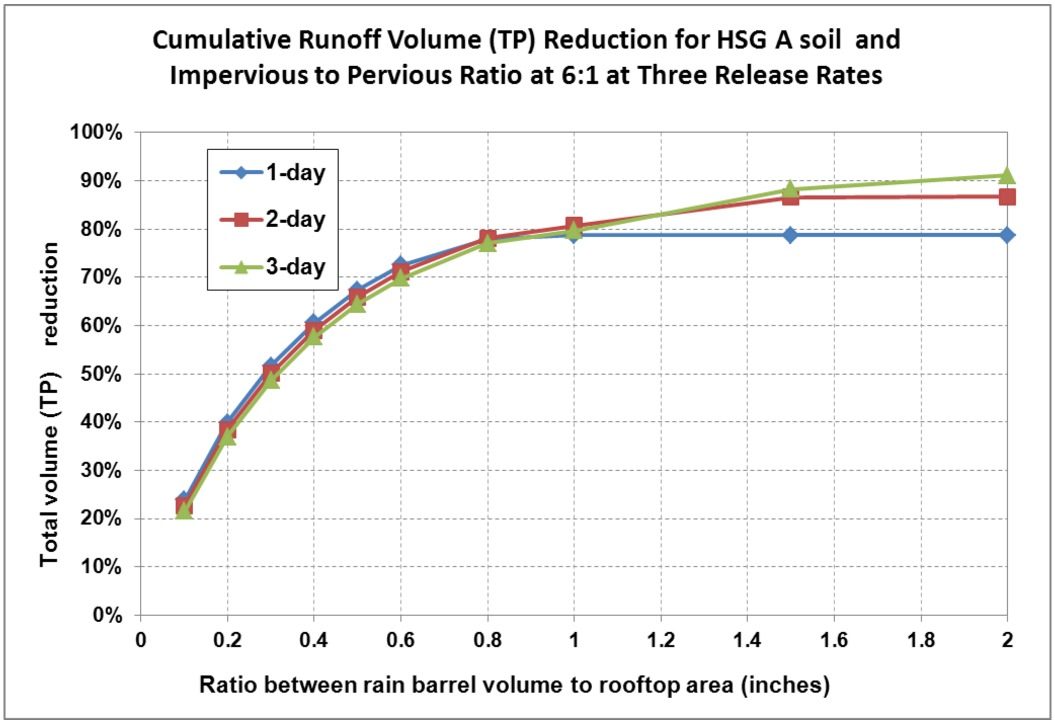


Figure 2-32. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG B Soils

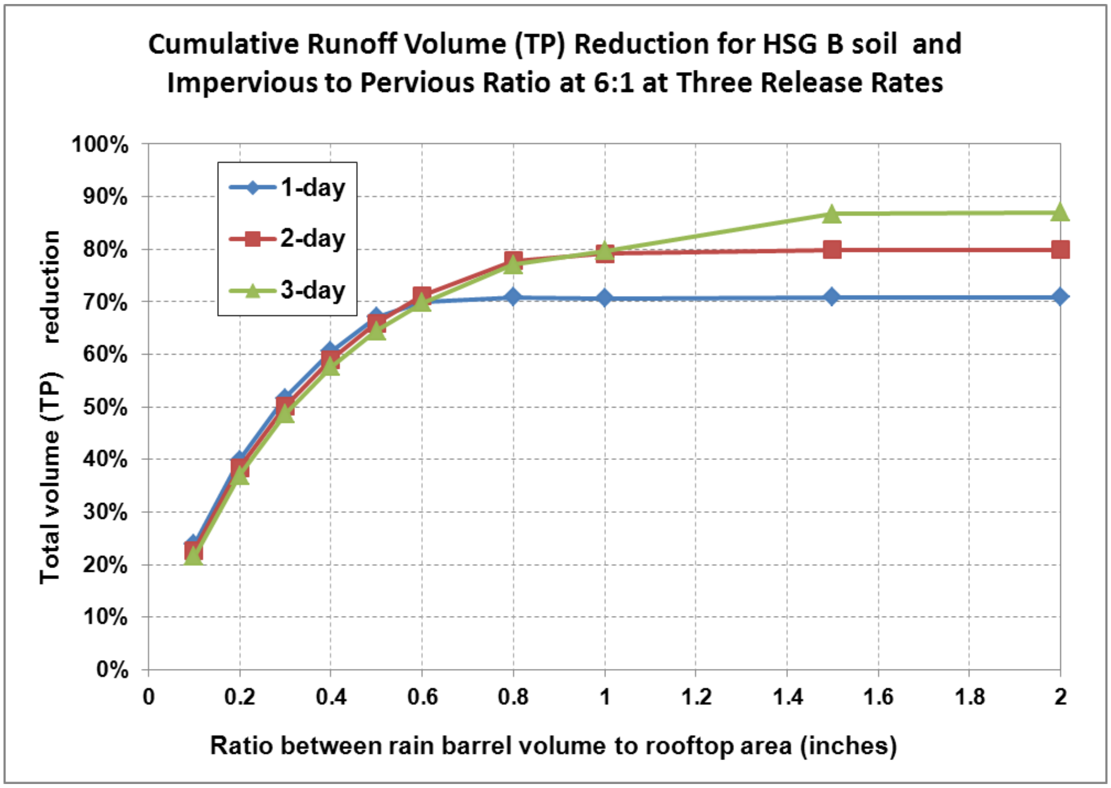


Figure 2-33. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG C Soils

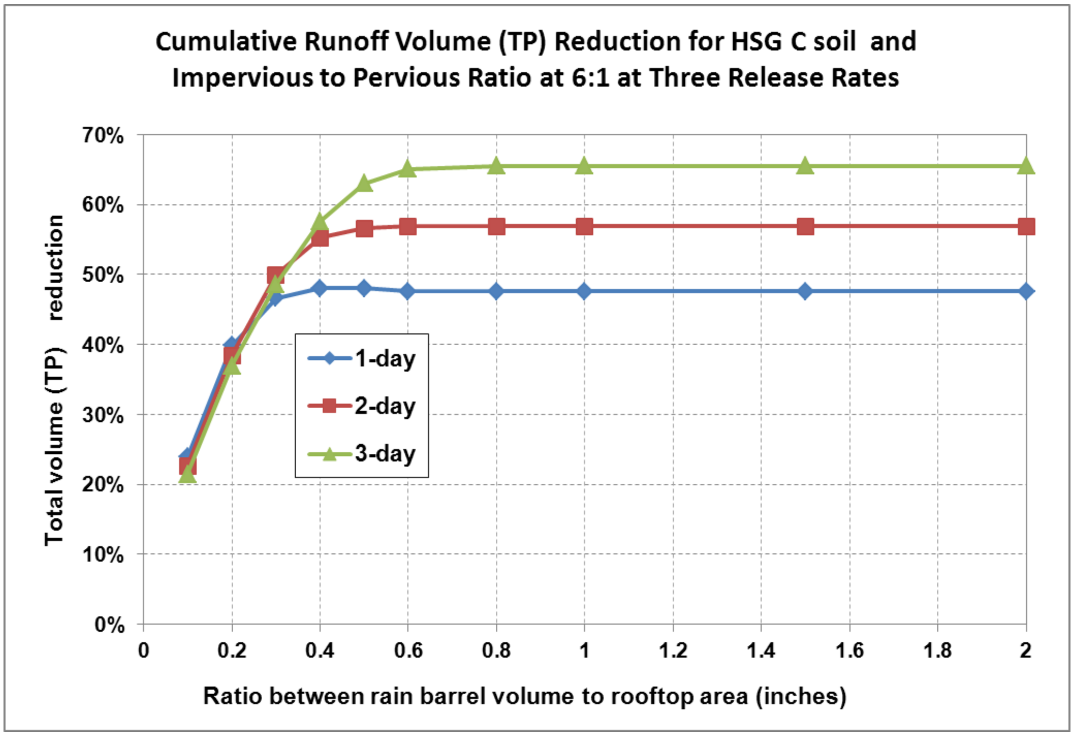
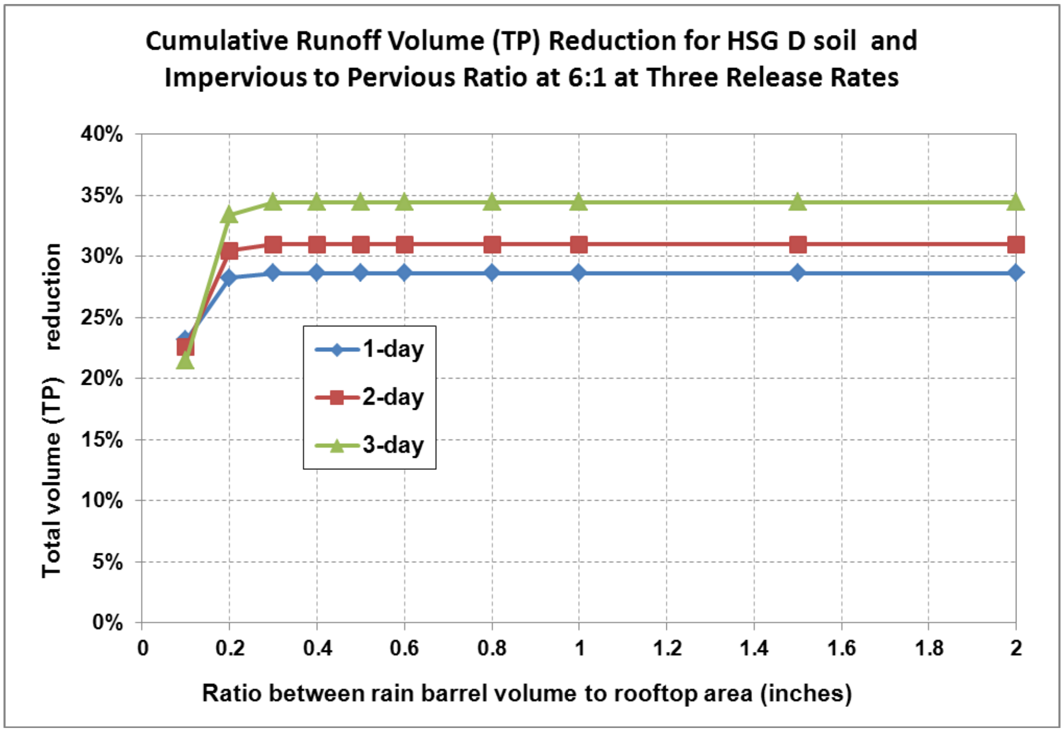


Figure 2-34. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 6:1 for HSG D Soils



2.5.25. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 Table and Curves

Table 2-27. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1												
Storage volume to impervious area ratio	**Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages**											
	HSG A			**HSG B**			**HSG C**			**HSG D**		
	1-day	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	37%	37%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	39%	42%	45%
0.4 in	61%	59%	58%	61%	59%	58%	58%	59%	58%	39%	42%	47%
0.5 in	67%	66%	64%	67%	66%	64%	60%	65%	64%	40%	42%	47%
0.6 in	73%	71%	70%	73%	71%	70%	61%	68%	70%	40%	42%	47%
0.8 in	79%	78%	77%	79%	78%	77%	61%	69%	75%	40%	42%	47%
1.0 in	82%	81%	80%	80%	81%	80%	61%	69%	76%	40%	42%	47%
1.5 in	87%	89%	88%	80%	87%	88%	61%	69%	76%	40%	42%	47%
2.0 in	87%	91%	91%	80%	88%	91%	61%	69%	76%	40%	42%	47%

Figure 2-35. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG A Soils

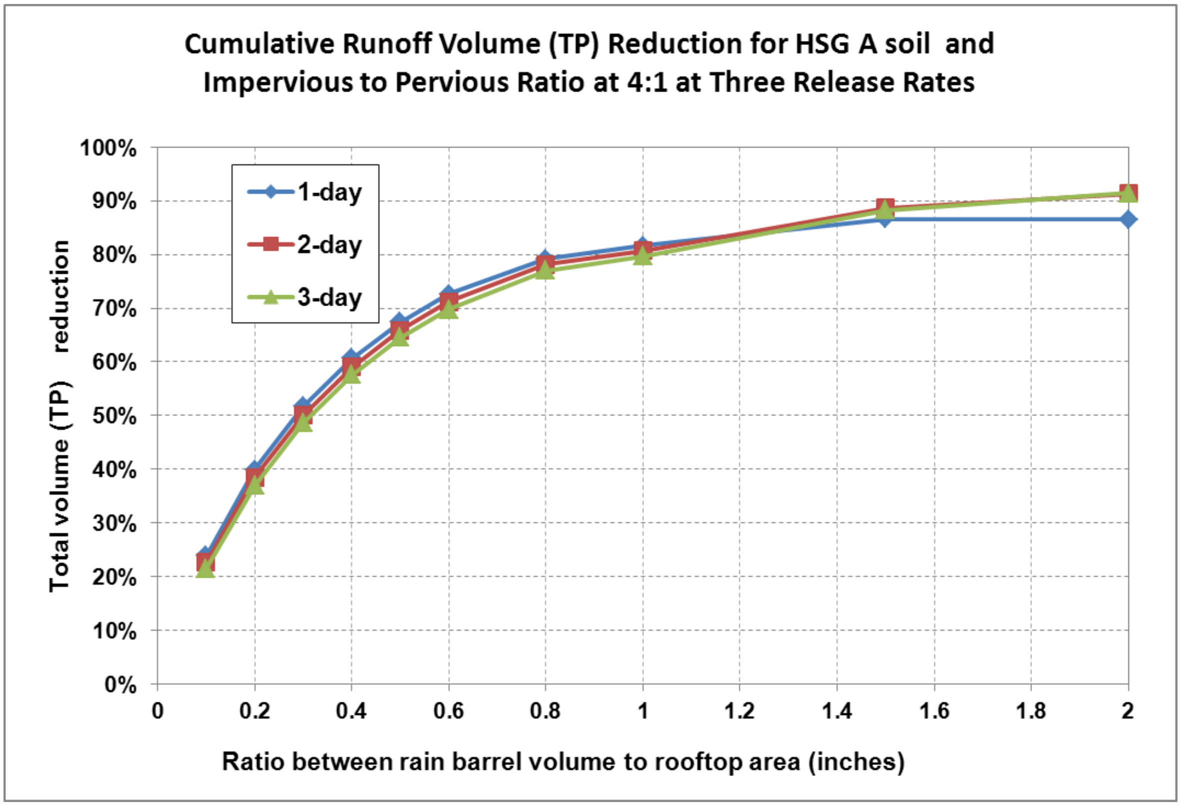


Figure 2-36. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG B Soils

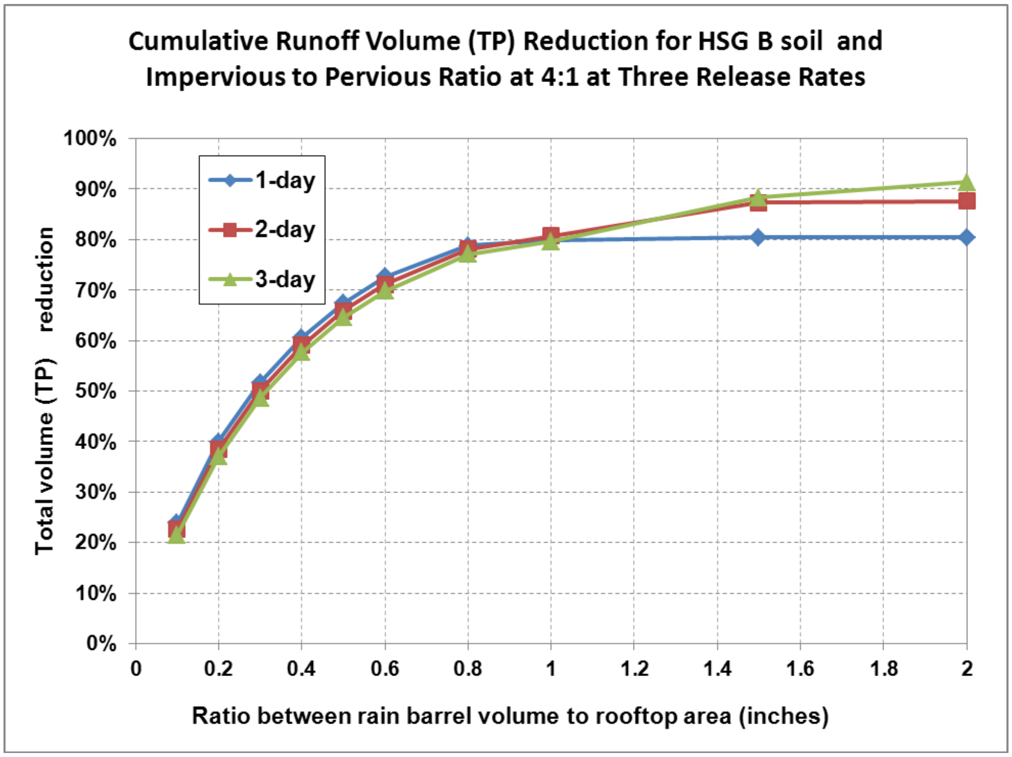


Figure 2-37. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG C Soils

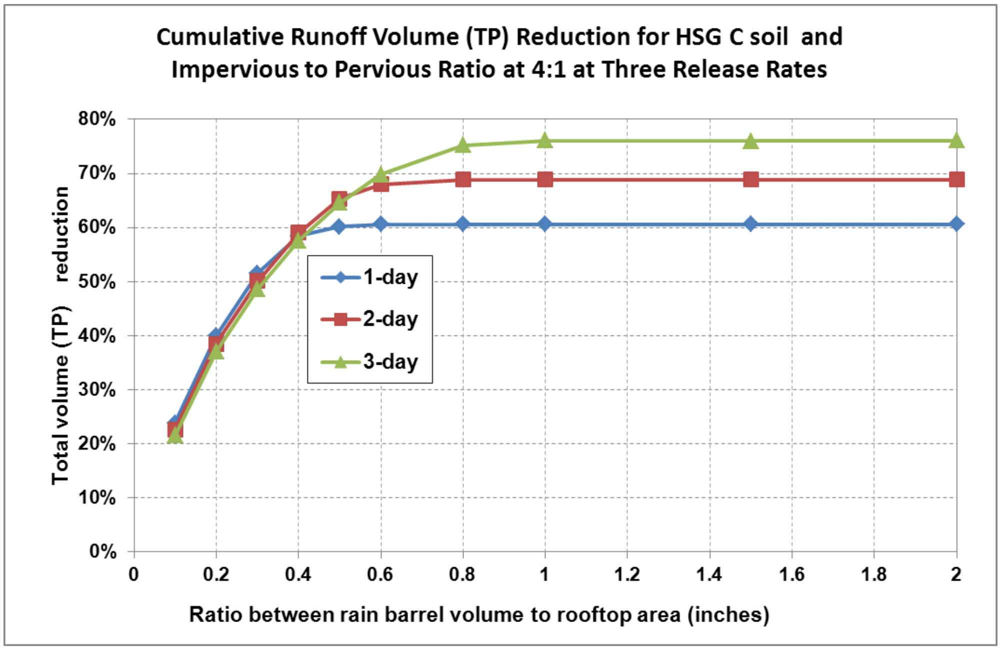
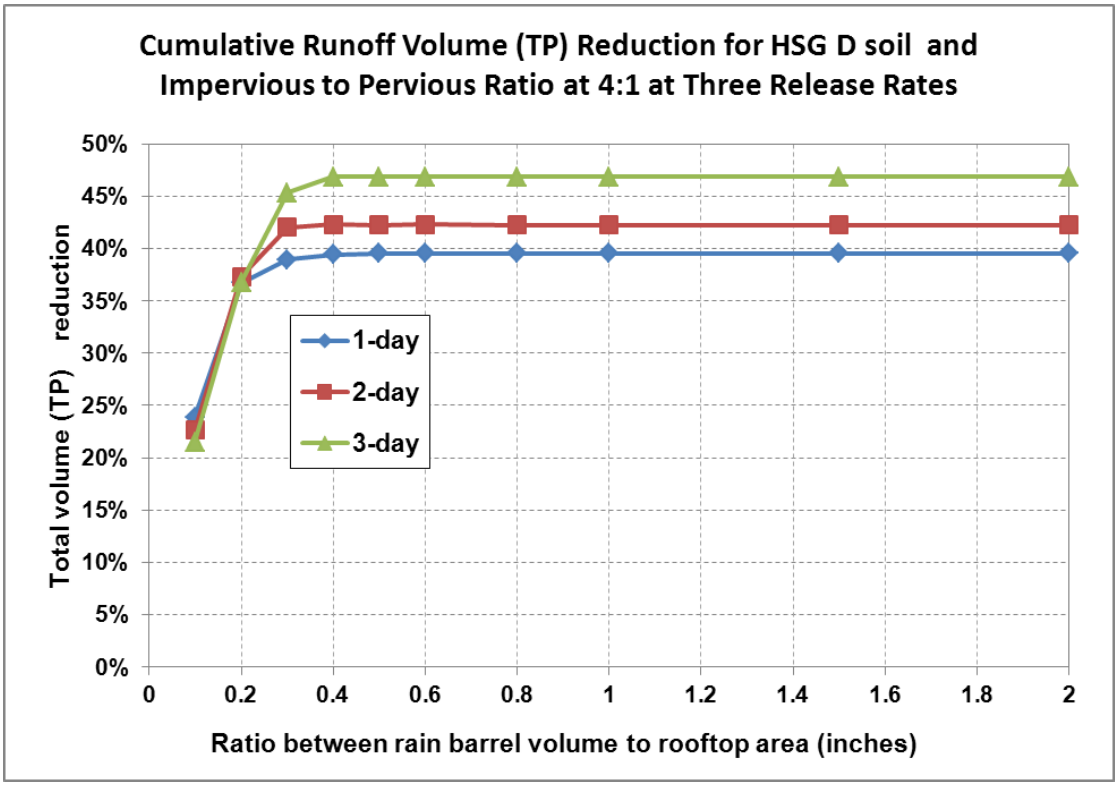


Figure 2-38. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 4:1 for HSG D Soils



2.5.26. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1 Table and Curves

Table 2-28. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1												
Storage volume to impervious area ratio	Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages											
	HSG A			HSG B			HSG C			HSG D		
	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day	1-day	2-day	3-day
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	40%	38%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	51%	50%	49%
0.4 in	61%	59%	58%	61%	59%	58%	61%	59%	58%	57%	58%	57%
0.5 in	67%	66%	64%	67%	66%	64%	67%	66%	64%	59%	62%	63%
0.6 in	73%	71%	70%	73%	71%	70%	72%	71%	70%	59%	62%	67%
0.8 in	79%	78%	77%	79%	78%	77%	77%	78%	77%	59%	62%	67%
1.0 in	82%	81%	80%	82%	81%	80%	78%	81%	80%	59%	62%	67%
1.5 in	89%	89%	88%	89%	89%	88%	78%	84%	88%	59%	62%	67%
2.0 in	92%	92%	91%	91%	92%	91%	78%	84%	89%	59%	62%	67%

Figure 2-39. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG A Soils

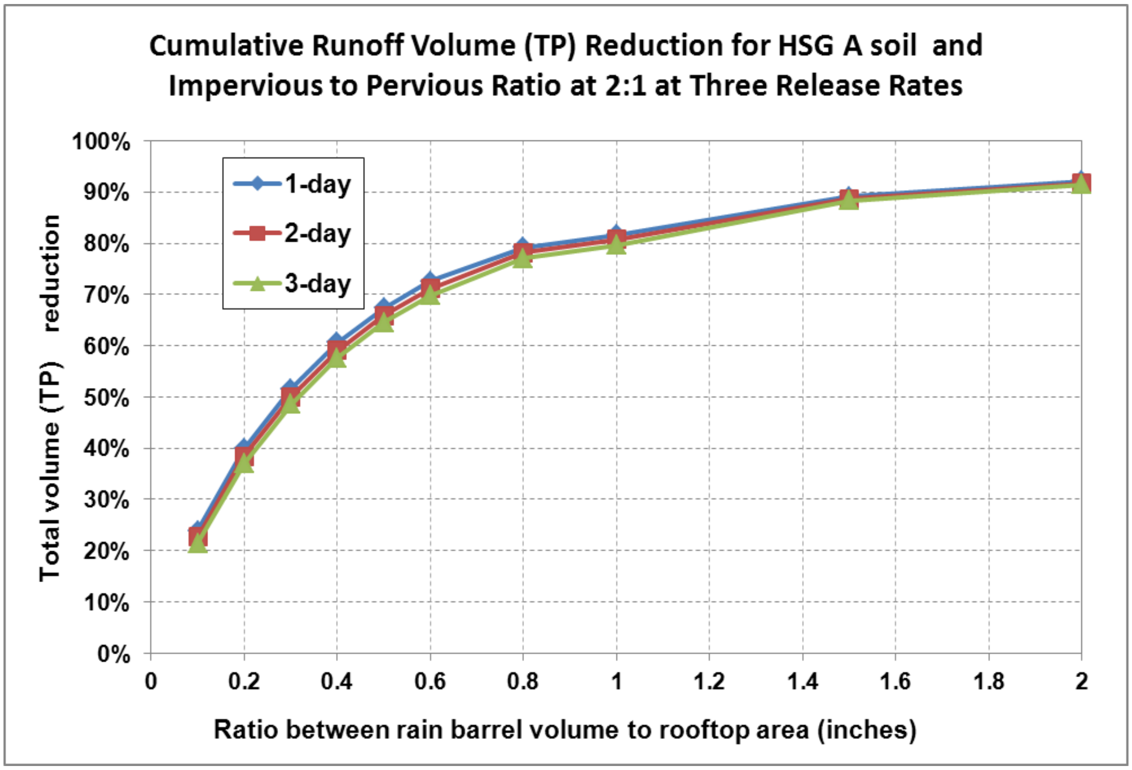


Figure 2-40. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG B Soils

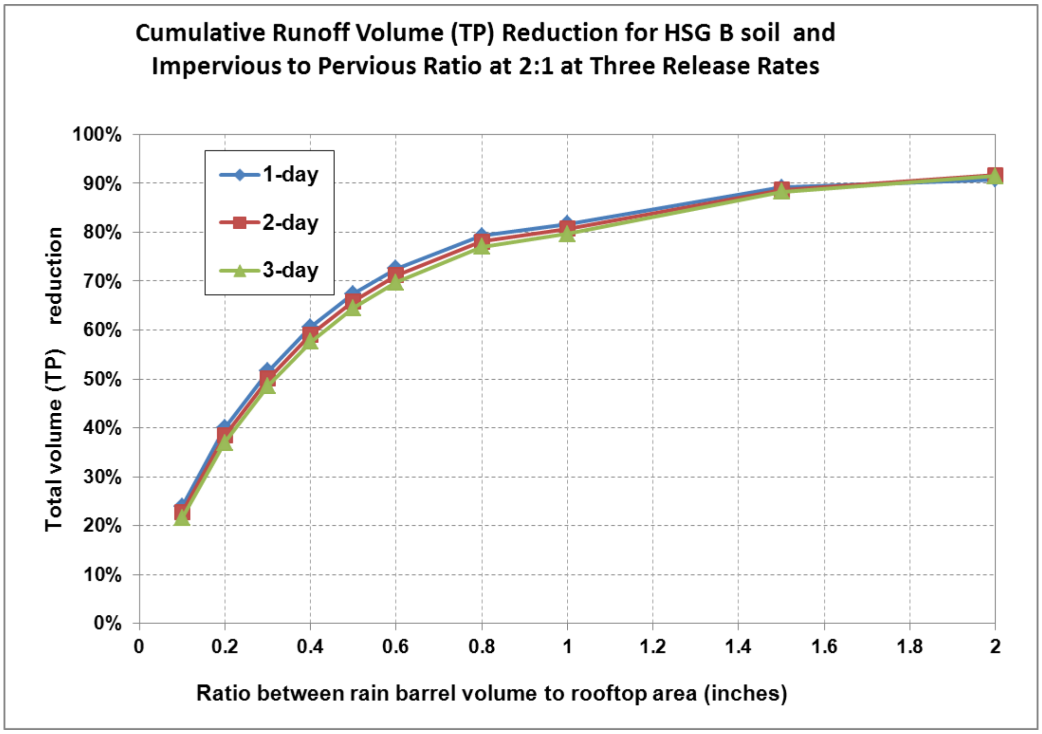


Figure 2-41. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG C Soils

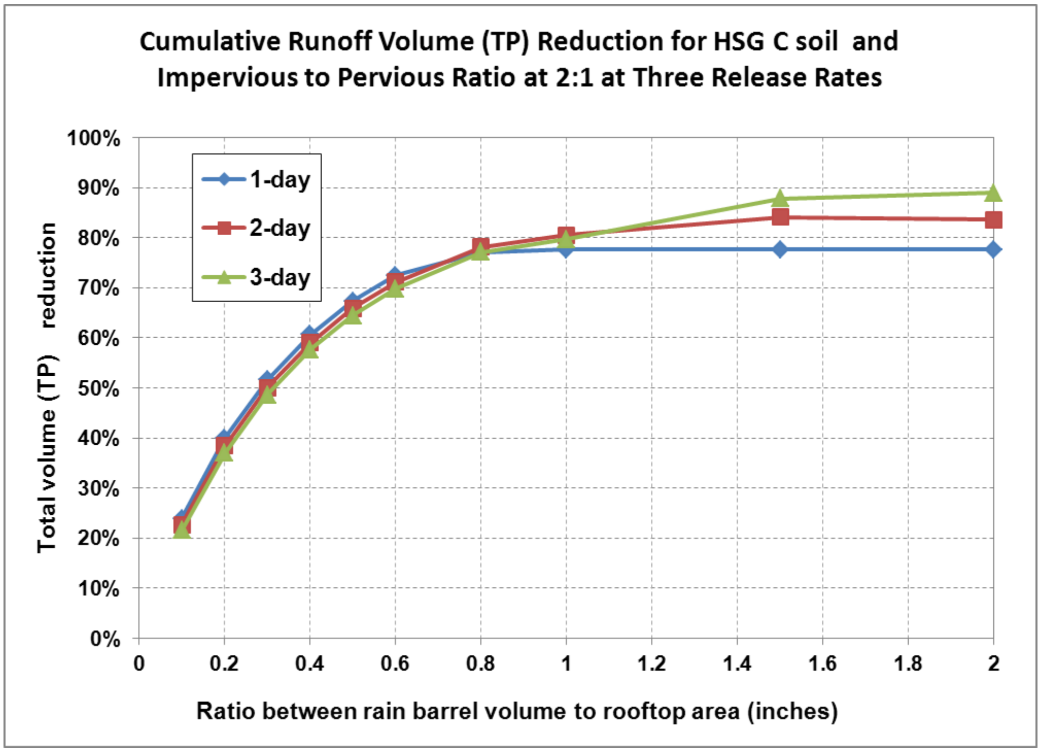
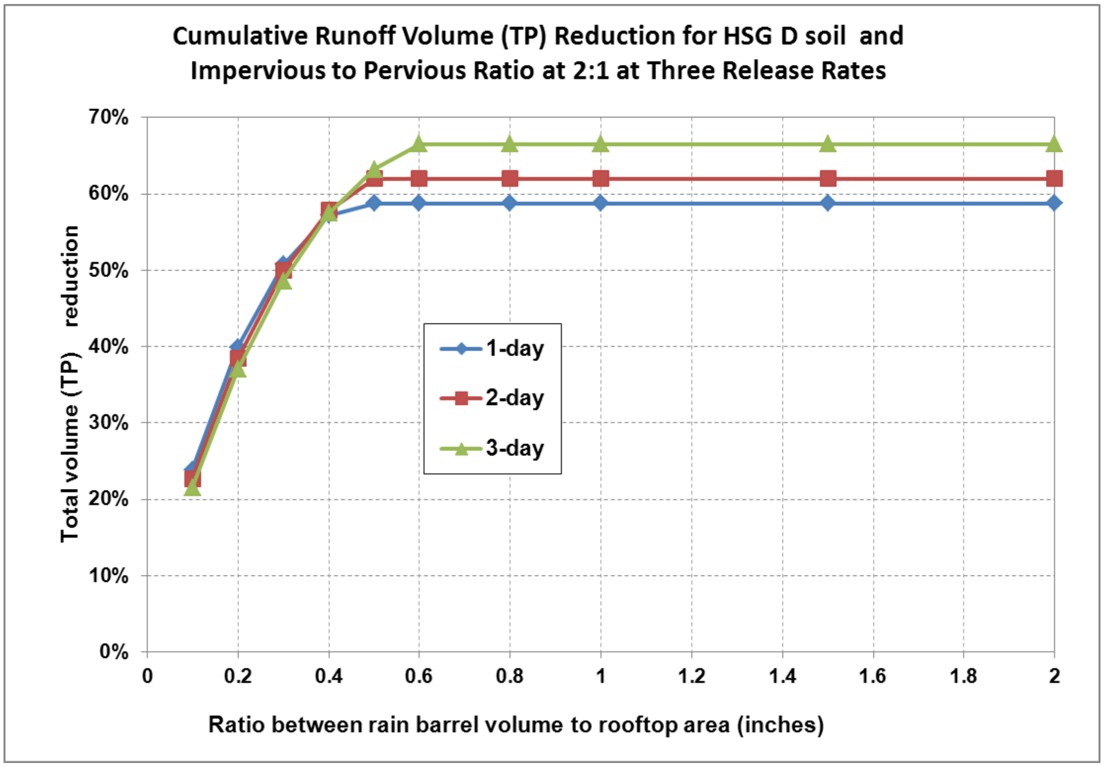


Figure 2-42. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio= 2:1 for HSG D Soils



2.5.27. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 Table and Curves

Table 2-29. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 2:1

Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1												
Storage volume to impervious area ratio	**Total Runoff Volume and Phosphorus Load (TP) Reduction Percentages**											
	HSG A			**HSG B**			**HSG C**			**HSG D**		
	1-day	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**	**1-day**	**2-day**	**3-day**
0.1 in	24%	23%	22%	24%	23%	22%	24%	23%	22%	24%	23%	22%
0.2 in	40%	38%	37%	40%	38%	37%	40%	38%	37%	40%	38%	37%
0.3 in	52%	50%	49%	52%	50%	49%	52%	50%	49%	52%	50%	49%
0.4 in	61%	59%	58%	61%	59%	58%	61%	59%	58%	61%	59%	58%
0.5 in	67%	66%	64%	67%	66%	64%	67%	66%	64%	67%	66%	64%
0.6 in	73%	71%	70%	73%	71%	70%	73%	71%	70%	72%	71%	70%
0.8 in	79%	78%	77%	79%	78%	77%	79%	78%	77%	78%	78%	77%
1.0 in	82%	81%	80%	82%	81%	80%	82%	81%	80%	79%	80%	80%
1.5 in	89%	89%	88%	89%	89%	88%	89%	89%	88%	80%	82%	86%
2.0 in	92%	92%	91%	92%	92%	91%	91%	92%	91%	80%	82%	86%

Figure 2-43. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG A Soils

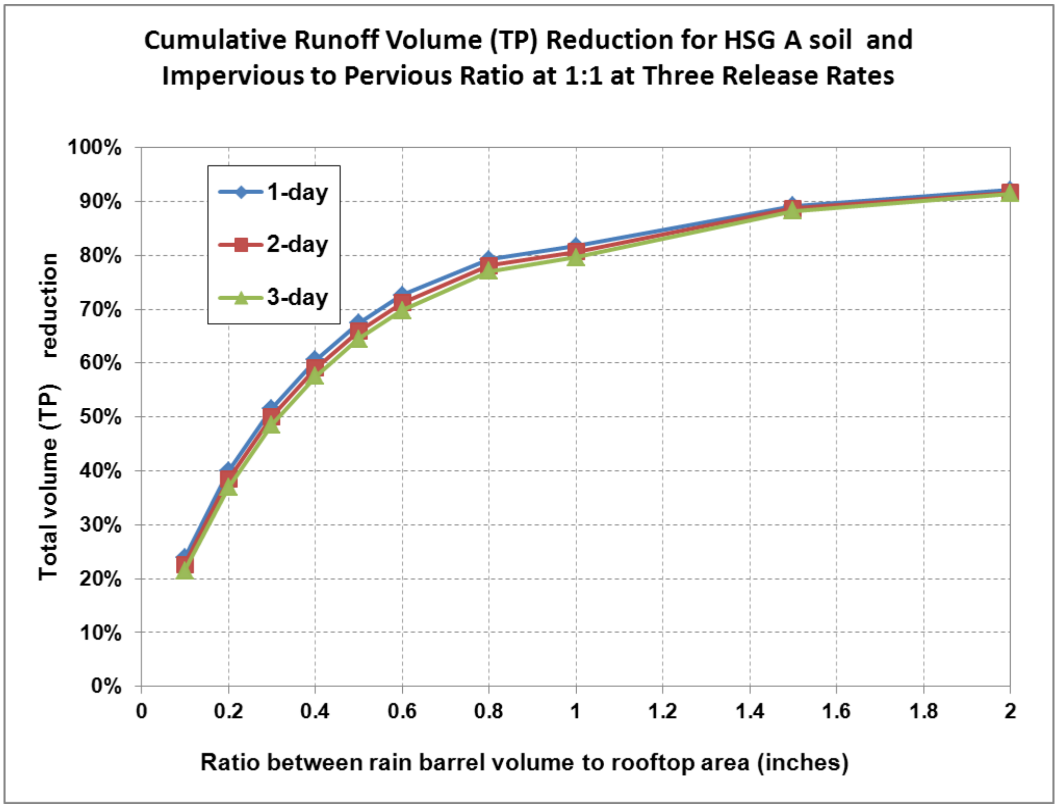


Figure 2-44. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG B Soils

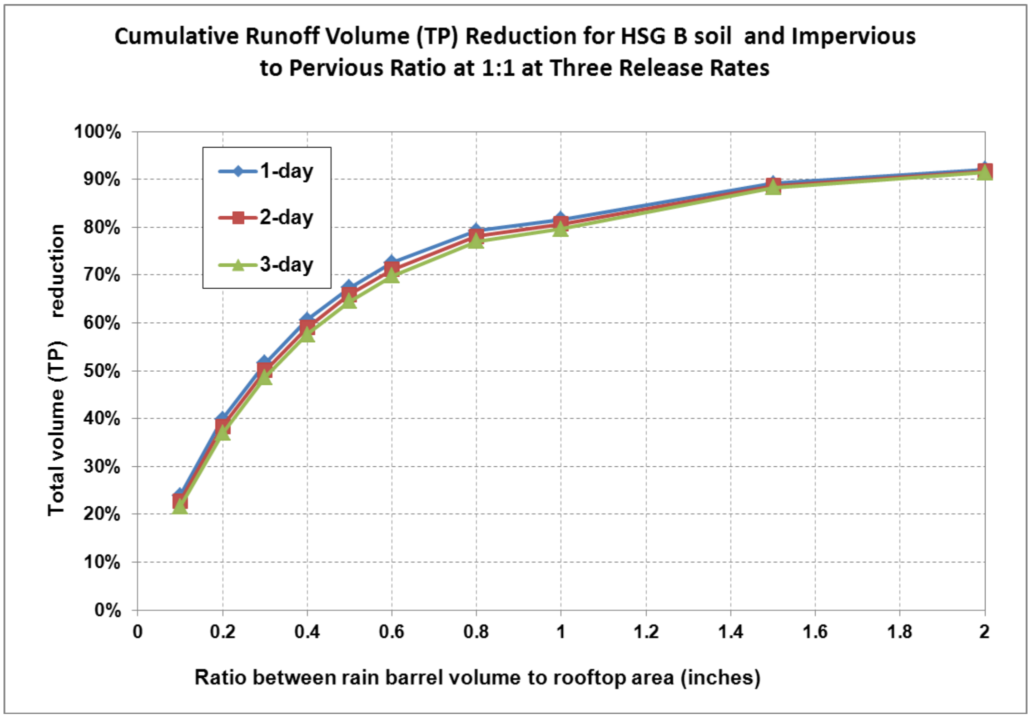


Figure 2-45. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG C Soils

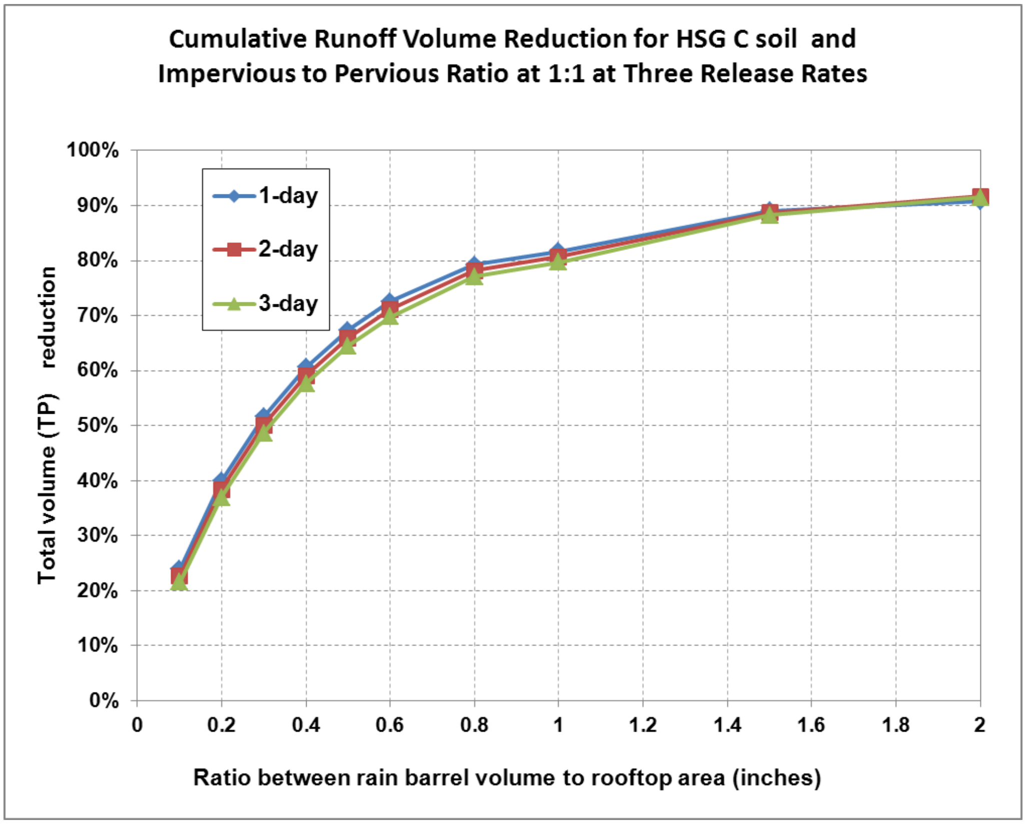
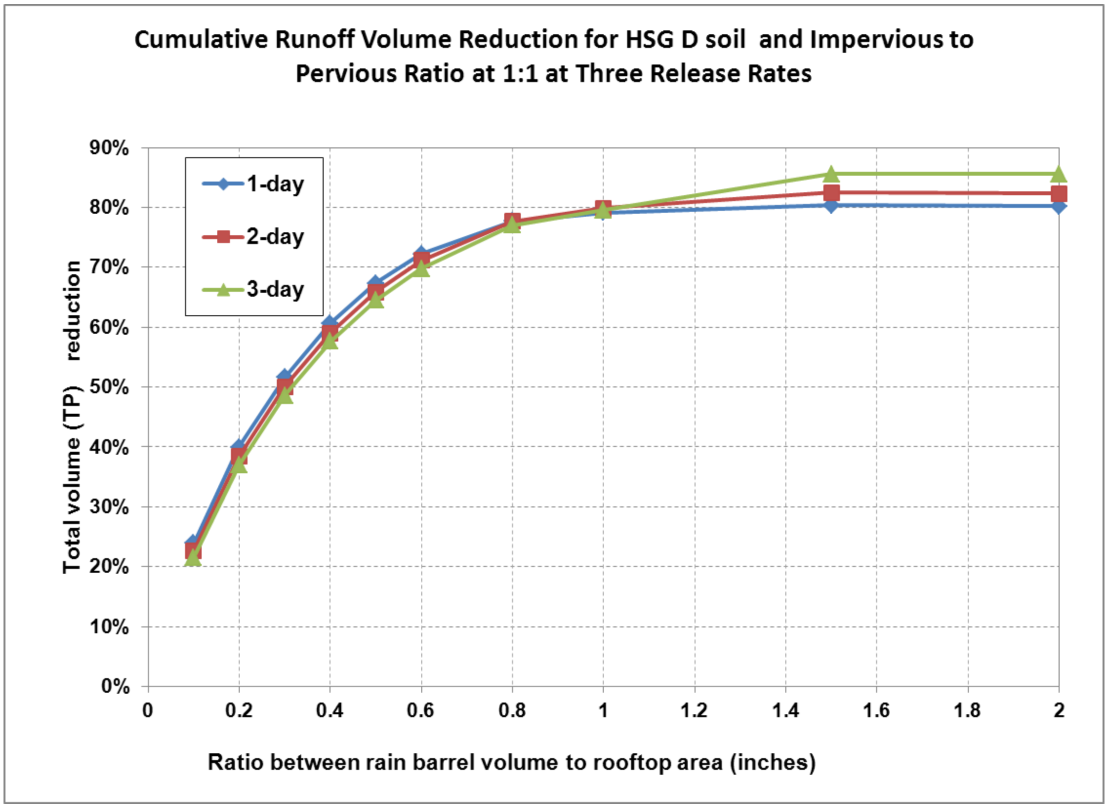


Figure 2-46. Impervious Area Disconnection through Storage: Impervious Area to Pervious Area Ratio = 1:1 for HSG D Soils

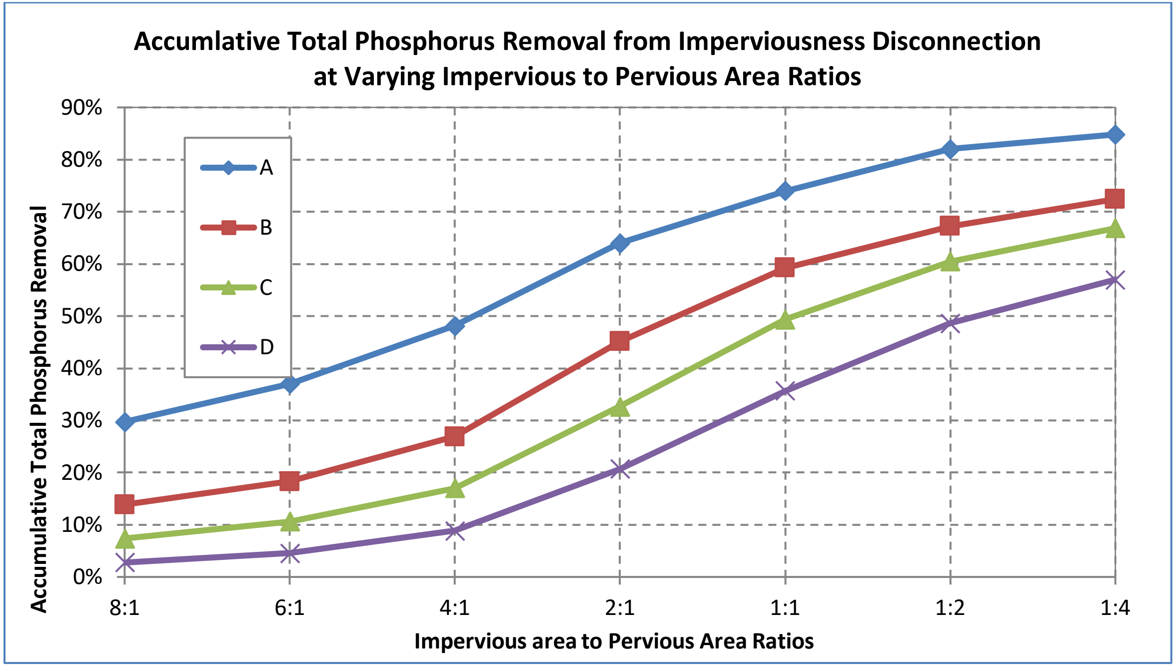


2.5.28. Impervious Area Disconnection Performance Table and Curve

Table 2-30. Impervious Area Disconnection Performance Table

Impervious area to pervious area ratio	Soil type of Receiving Pervious Area			
	HSG A	HSG B	HSG C	HSG D
8:1	30%	14%	7%	3%
6:1	37%	18%	11%	5%
4:1	48%	27%	17%	9%
2:1	64%	45%	33%	21%
1:1	74%	59%	49%	36%
1:2	82%	67%	60%	49%
1:4	85%	72%	67%	57%

Figure 2-47. Impervious Area Disconnection Performance Curves



2.5.29. Conversion of Impervious Areas to Pervious Area based on Hydrological Soil Groups Performance Table

Table 2-31. Conversion of Impervious Areas to Pervious Area based on Hydrological Soil Groups Performance Table

Land-Use Group	**Cumulative Reduction in Annual Stormwater Phosphorus Load**			
	Conversion of impervious area to pervious area-HSG A	**Conversion of impervious area to pervious area-HSG B**	**Conversion of impervious area to pervious area-HSG C**	**Conversion of impervious area to pervious area-HSG D**
Commercial (Com) and Industrial (Ind)	98.33%	93.89%	88.33%	79.44%
Multi-Family (MFR) and High-Density Residential (HDR)	98.74%	95.38%	91.18%	84.45%
Medium -Density Residential (MDR)	98.48%	94.42%	89.34%	81.22%
Low Density Residential (LDR) - "Rural"	98.48%	94.42%	89.34%	81.22%
Highway (HWY)	97.85%	92.11%	84.94%	73.46%
Forest (For)	98.00%	92.68%	86.02%	75.37%
Open Land (Open)	98.00%	92.68%	86.02%	75.37%
Agriculture (Ag)	98.00%	92.68%	86.02%	75.37%

2.5.30. Conversion of Low Permeable Pervious Area to High Permeable Pervious Area based on Hydrological Soil Group Performance Table

Table 2-32. Conversion of Low Permeable Pervious Area to High Permeable Pervious Area based on Hydrological Soil Group Performance Table

Land Cover	**Cumulative Reduction in Annual SW Phosphorus Load from Pervious Area**				
	Conversion of pervious area HSG D to pervious area-HSG A	Conversion of pervious area HSG D to pervious area-HSG B	Conversion of pervious area HSG D to pervious area-HSG C	Conversion of pervious area HSG C to pervious area-HSG A	Conversion of pervious area HSG C to pervious area-HSG B
Developed Pervious Land	91.89%	70.27%	43.24%	85.71%	47.62%

2.6. Alternative Methods:

A permittee may propose alternative long-term cumulative performance information or alternative methods to calculate phosphorus load reductions for the SCMs identified above or for other SCMs not identified in this Attachment.

EPA will consider alternative long-term cumulative performance information and alternative methods to calculate phosphorus load reductions for SCMs provided that the permittee provides EPA with adequate supporting documentation. At a minimum, the supporting documentation shall include:

1. Results of continuous SCM model simulations representing the SCM, using a verified SCM model and representative long-term (i.e., 10 years) climatic data including hourly rainfall data;
2. Supporting calculations and model documentation that justify use of the model, model input parameters, and the resulting cumulative phosphorus load reduction estimates;
3. If pollutant removal performance data are available for the specific SCM, model calibration results should be provided; and
4. Identification of references and sources of information that support the use of the alternative information and method.

If EPA determines that the long-term cumulative phosphorus load reductions developed based on alternative information are not adequately supported, EPA will notify the permittee in writing, and the permittee may receive no phosphorus reduction credit other than a reduction credit calculated by the permittee using the default phosphorus reduction factors provided in this Attachment for the identified practices. The permittee is required to submit to EPA valid phosphorus load reductions for SCMs in accordance with the submission schedule requirements specified in the permit and Appendix F.