Chapter 8 – Selection Considerations for Stormwater BMPs

Introduction

This chapter provides guidance on selecting appropriate structural stormwater Best Management Practices (BMPs) based on the type of proposed land development activity, the applicable stormwater management requirements, the physical characteristics of the site, and other factors. The information presented in this chapter is intended to help designers and reviewers:

- Screen out unsuitable BMPs for a project site
- Select the most appropriate BMPs for a project site
- Locate stormwater BMPs appropriately on a project site
- Demonstrate that all reasonable efforts have been taken to comply with the stormwater management standards and performance criteria.

What's New in this Chapter?

- Updated BMP selection matrices consistent with re-organized functional classifications
- New flowchart to aid in the BMP selection process for a given project and site
- Prioritization of retention BMPs in the selection process consistent with updated stormwater management standards and performance criteria
- New selection factors related to climate resilience

The BMP selection process and factors presented in this chapter are applicable to new development and redevelopment activities, as well as stormwater retrofits. Chapter 9 - Stormwater Retrofits contains additional information on selection considerations specifically for stormwater retrofits. Other selection factors may also be considered in addition to those described in this chapter.

Stormwater BMP Selection Process

The flowchart in Figure 8- 1 outlines a recommended process for selecting stormwater BMPs for a given project and site to meet the applicable retention, treatment, and peak runoff attenuation requirements addressed in Chapter 4 - Stormwater Management Standards and Performance Criteria of this Manual. The process is focused on selection of structural stormwater BMPs after:

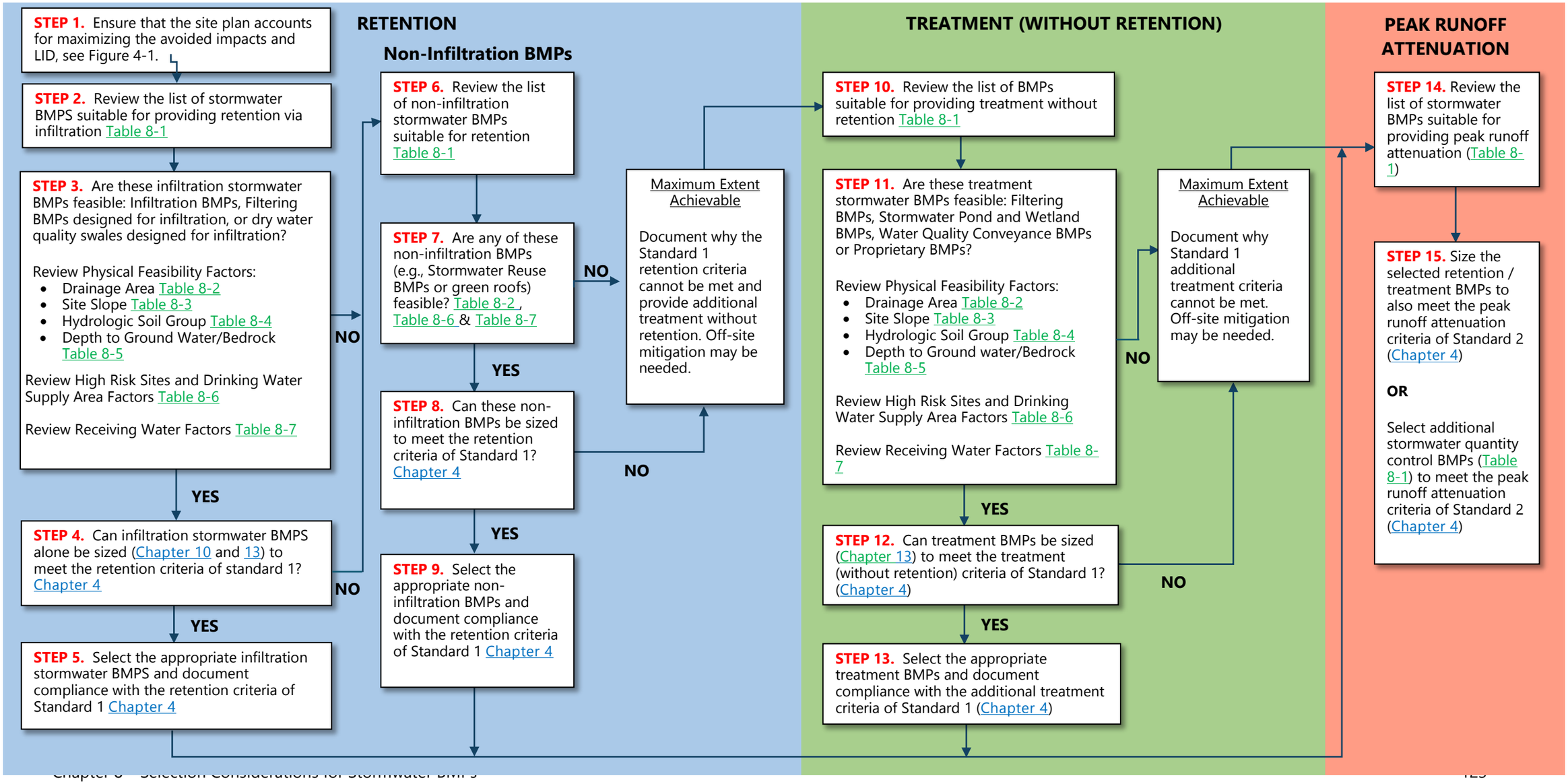
- Initial data has been collected to define existing site conditions
- Stormwater retention, treatment, and peak runoff attenuation requirements have been determined based on the stormwater management standards and performance criteria (Chapter 4 - Stormwater Management Standards and Performance Criteria)

- LID site planning and design approaches, including the use of Impervious Area (Simple) Disconnection, have been considered and applied to the MEA (Chapter 5 - Low Impact Development Site Planning and Design Strategies).

The recommended process incorporates the BMP selection factors and summary matrix tables that are presented in the following sections of this chapter. This process is meant to help the designing qualified professional[65]select stormwater BMP(s) using good engineering/design judgement and a consistent and repeatable approach that also demonstrates compliance with the stormwater management standards and performance criteria, while promoting creative and site-specific stormwater management design.

[65] As defined in the General Permit for the Discharge of Stormwater and Dewatering Wastewaters from Construction Activities.

Figure 8- 1 Recommended Stormwater BMP Selection Process



Stormwater BMP Selection Factors

Stormwater Management Suitability

Table 8- 1 provides a summary comparison of the structural stormwater BMPs addressed in this Manual relative to their suitability for providing various stormwater management functions and their ability to provide credit toward meeting the standards and performance criteria described in Chapter 4 - Stormwater Management Standards and Performance Criteria, including stormwater retention and treatment (Standard 1) and peak runoff attenuation (Standard 2).

As described in Chapter 7 - Overview of Structural Stormwater Best Management Practices and Chapter 10 - General Design Guidance for Stormwater Infiltration Systems, stormwater BMPs designed specifically for infiltration (i.e., Infiltration BMPs, Filtration BMPs, and dry water quality swales) are the preferred practices for meeting the stormwater retention requirement because they reduce stormwater runoff volumes and pollutant loads and provide groundwater recharge. Many of these practices can also be designed to attenuate peak runoff rates, providing both stormwater quality and quantity control in a single facility.

Stormwater Reuse BMPs (rain barrels and cisterns) and green roofs can also be used to satisfy the retention requirements although these practices do not infiltrate runoff or provide groundwater recharge. Filtering BMPs (bioretention systems, tree filters, and sand filters) can provide stormwater retention when specifically designed for infiltration, although they are generally less cost-effective than Infiltration BMPs and therefore are typically used where site characteristics limit the use of Infiltration BMPs.

Most Infiltration BMPs, Filtering BMPs, Stormwater Pond and Wetland BMPs, and Water Quality Conveyance BMPs are suitable choices for stormwater treatment, and most require the use of one of the Pretreatment BMPs identified in this Manual to preserve the pollutant removal efficiency, extend the service life, and reduce maintenance costs of the main stormwater BMP. In addition to pretreatment, Proprietary BMPs can also be used as stand-alone treatment systems (without retention) when selected and designed in accordance with the evaluation criteria described in Chapter 11 - Proprietary Stormwater BMPs.

Table 8- 1 Stormwater Management Suitability

BMP Category	BMP Type	Retention		Treatment	Pretreatment	Peak Runoff Attenuation (5)	Requires Pretreatment?
		Volume Reduction	Infiltration/ Recharge				
Pretreatment BMPs	Sediment Forebay				●		No
	Pretreatment Vegetated Filter Strip				●		No
	Pretreatment Swale				●		No
	Deep Sump Hooded Catch Basin				●		No
	Oil Grit Separator				●		No
	Proprietary Pretreatment Device				(1)		No
Infiltration BMPs	Infiltration Trench	●	●	●		●	**Yes**
	Underground Infiltration System	●	●	●		●	**Yes**
	Infiltration Basin	●	●	●		●	**Yes**
	Dry Well	(2)	(2)	(2)			No
	Infiltrating Catch Basin	(3)	(3)	(3)			**Yes**
	Permeable Pavement	●	●	●		●	No
Filtering BMPs	Bioretention	(4)	(4)	●		●	**Yes**
	Sand Filter	(4)	(4)	●		●	**Yes**
	Tree Filter	(4)	(4)	●			**Yes**
Stormwater Pond BMPs	Wet Pond			●		●	**Yes**
	Micropool Extended Detention Pond			●		●	**Yes**
	Wet Extended Detention Pond					●	**Yes**
	Multiple Pond System			●		●	**Yes**
Stormwater Wetland BMPs	Subsurface Gravel Wetland			●			**Yes**
	Shallow Wetland			●			**Yes**
	Extended Detention Shallow Wetland			●		●	**Yes**
	Pond/Wetland System			●		●	**Yes**

BMP Category	BMP Type	Retention		Treatment	Pretreatment	Peak Runoff Attenuation (5)	Requires Pretreatment?
		Volume Reduction	Infiltration/ Recharge				
Water Quality Conveyance BMPs	Dry Water Quality Swale	●	●	●		●	**Yes**
	Wet Water Quality Swale			●		●	**Yes**
Stormwater Reuse BMPs	Rain Barrel	●					No
	Cistern	●				(7)	**Yes**
Proprietary BMPs	Manufactured Treatment System			(6)	●		No
Other BMPs and BMP Accessories	Green Roof	●				●	No
	Dry Extended Detention Basin					●	**Yes**
	Underground Detention (no infiltration)					●	**Yes**

Notes:

(1) When used for pretreatment. See Proprietary BMPs for use as stand-alone treatment.
(2) Clean roof runoff only.
(3) Requires pretreatment BMP separate from the infiltrating catch basin itself.
(4) When designed for infiltration.
(5) When designed as an on-line system.
(6) See Chapter 11 - Proprietary Stormwater BMPs for use of proprietary stormwater BMPs as stand-alone treatment.
(7) May provide peak runoff attenuation depending on the volume of water in the cistern at the start of a storm event.

Legend	●	●	●	Suitable for providing stormwater management function
	(See notes)	(See notes)	(See notes)	Suitable for providing stormwater management function under certain conditions or with design restrictions as noted
				Generally not suitable for providing stormwater management function

Physical Feasibility Factors

The physical characteristics of a site can dictate the feasibility of specific stormwater BMPs. A site's physical characteristics may restrict or preclude the use of certain BMPs or make a particular BMP too costly or ineffective for meeting stormwater management objectives. While every site has its own individual characteristics that need to be evaluated, the primary physical feasibility factors that should be considered for most sites are (Table 8-2):

- Contributing drainage area
- Site slope
- Soil infiltration capacity (Hydrologic Soil Group)
- Depth to seasonal high groundwater and bedrock

These factors are discussed in general terms below, followed by color-coded matrix tables that summarize the factors for each type of stormwater BMP. Chapter 13 - Structural Stormwater BMP Design Guidance contains additional information on physical feasibility and selection considerations for specific BMPs. Chapter 10 provides minimum required horizontal setback distances for stormwater infiltration systems.

Screening-level information may be used to initially evaluate soil characteristics and subsurface conditions at a site for the purpose of stormwater management planning, concept design, and retrofit screening, as described in the Initial Screening step of the soil evaluation guidance in Chapter 10. For final selection and design of stormwater BMPs, soil characteristics and subsurface conditions (soil infiltration capacity, depth to seasonal high groundwater table, and depth to bedrock) should be based on the results of test pits/soil borings and field infiltration testing (if necessary), which is also addressed in Chapter 10 and the BMP-specific design guidance presented in Chapter 13 - Structural Stormwater BMP Design Guidance.

Contributing Drainage Area

The efficiency of many stormwater BMPs decreases with increasing drainage area, runoff volume, and hydraulic load. Other BMPs require a minimum drainage area to maintain a permanent pool, wetlands, or submerged conditions. Table 8-2 indicates the general suitability of stormwater BMPs for various drainage areas, included minimum and maximum drainage areas, where applicable. Table 8-2 also identifies contributing drainage areas that may be suitable under certain conditions or with design restrictions. The minimum and maximum drainage areas presented in Table 8-2 should not be considered inflexible limits and may be increased or decreased slightly where a stormwater BMP supports other management objectives.

Site Slope

The ground slope at and immediately adjacent to the location of a stormwater BMP, as well as the slope of the contributing drainage area and drainage flow paths, are important factors in determining the feasibility of stormwater practices. As summarized in Table 8-3, most stormwater BMPs are limited to sites with slopes less than 10% to 15%, while the use of some

BMPs such as water quality swales and permeable pavement is restricted to slopes of approximately 5% or less.

Soil Infiltration Capacity

The feasibility and effectiveness of stormwater BMPs can be heavily influenced by soil infiltration capacity. As such soil health and soil type are incredibly important factors to the planning and ultimately the success of stormwater design. Table 8-4 summarizes the suitability of various types of stormwater BMPs based on Hydrologic Soil Group (as determined in the field from soil texture class), which is an indicator of the runoff potential and infiltration capacity of the underlying soils.

As described in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems, stormwater infiltration systems are most suitable in soils with infiltration rates of 0.3 inch per hour or greater, at the location of the proposed infiltration system (or within the allowable horizontal testing distances as described above) and at or below the bottom of the system. Soils with infiltration rates of 0.3 inch per hour or greater generally correspond to Natural Resources Conservation Service Hydrologic Soil Group (HSG) A and B soils. Stormwater infiltration systems can also be suitable in soils with lower infiltration rates, including HSG C and D soils, provided the recommended sizing, drain time, horizontal setbacks, and vertical separation criteria are met and the system is designed with an underdrain. Research by the University of New Hampshire Stormwater Center and EPA Region 1 has shown that substantial stormwater infiltration and recharge can occur in lower infiltration rate soils. Ultimately, providing some infiltration is better than none, particularly for retrofit applications.

Other BMPs such as Stormwater Ponds, Stormwater Wetlands, and wet water quality swales rely on a permanent pool or saturated soil conditions and are best suited to sites with poorly drained soils such as HSG C and D soils.

Depth to Seasonal High Groundwater

The depth to the seasonal high groundwater table (SHGT) is a key factor in evaluating the feasibility and ultimately the design of many types of stormwater BMPs. For infiltration systems, adequate vertical separation between the bottom of the system and SHGT (generally 3 feet or more, but as low as 2 feet in some instances) is necessary to ensure adequate pollutant removal in the unsaturated zone and sufficient hydraulic capacity for proper functioning of the system. For filtering systems designed for infiltration, the vertical separation may consist of a combination of the filter layer (e.g., bioretention soil media) and the underlying native soil, provided that the bottom of the system is at least 1 foot above the SHGT. Stormwater BMPs designed with an underdrain and impermeable liner may be used in areas where the required vertical separation to SHGT cannot be met.

For stormwater ponds and wetlands, SHGT should be at or above the bottom of the system to maintain a permanent pool and wetland vegetation. An impermeable liner may be required for stormwater detention basins where SHGT is above the bottom of the basin to maximize the available storage volume within the basin.

Table 8-5 summarizes the suitability of stormwater BMPs based on depth to SHGT as determined from test pits or soil borings (refer to Chapter 10 for soil evaluation methods).

Depth to Bedrock

Depth to bedrock is another key consideration in the selection and design of stormwater BMPs. A minimum separation distance of 3 feet between the bottom of the system and bedrock or other impermeable material or subsurface layer is required for most BMPs. This distance can be reduced in some situations.

Table 8-5 summarizes the suitability of stormwater BMPs based on depth to bedrock as determined from test pits or soil borings (refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation methods).

Table 8-2. Physical Feasibility – Contributing Drainage Area

BMP Category	BMP Type	Contributing Drainage Area				
		< 0.5 ac	0.5 - 1 ac	1 - 5 ac	5 - 10 ac	> 10 ac
Infiltration BMPs	Infiltration Trench	💧	💧	💧		
	Underground Infiltration System	💧	💧	💧		
	Infiltration Basin	💧	💧	💧	💧	
	Dry Well	💧	💧	Multiple connected		
	Infiltrating Catch Basin	💧	💧	Multiple connected		
	Porous Asphalt	Not Cost Effective	(1)	(1)	(1)	(1)
	Pervious Concrete	(1)	(1)	(1)	(1)	(1)
	Permeable Concrete Interlocking Pavers	(1)	(1)	(1)	(1)	(1)
Filtering BMPs	Bioretention	(2)	💧	💧		
	Sand Filter	💧	💧	💧		
	Tree Filter	💧	Multiple connected			
Stormwater Pond BMPs	Wet Pond	(4)	(4)	(4)	(4)	💧
	Micropool Extended Detention Pond	(4)	(4)	(4)	(4)	💧
	Wet Extended Detention Pond	(4)	(4)	(4)	(4)	💧
	Multiple Pond System	(4)	(4)	(4)	(4)	💧
Stormwater Wetland BMPs	Subsurface Gravel Wetland	(4)	(4)	(4)	💧	💧
	Shallow Wetland	(4)	(4)	(4)	(4)	💧
	Extended Detention Shallow Wetland	(4)	(4)	(4)	(4)	💧

BMP Category	BMP Type	Contributing Drainage Area				
		< 0.5 ac	0.5 - 1 ac	1 - 5 ac	5 - 10 ac	> 10 ac
	Pond/Wetland System	(4)	(4)	(4)	(4)	♦
Water Quality Conveyance BMPs	Dry Water Quality Swale	(3)	(3)	(3)		
	Wet Water Quality Swale	(3)	(3)	(3)		
Stormwater Reuse BMPs	Rain Barrel	Small roof areas only				
	Cistern	♦	♦	Larger systems based on water demand		
Proprietary BMPs	Manufactured Treatment System	♦	♦	♦	Larger systems if allowed by manufacturer	
Other BMPs and BMP Accessories	Green Roof	♦	♦	♦	♦	♦
	Dry Extended Detention Basin			(5)	(5)	♦
	Underground Detention (no infiltration)	♦	♦	♦	♦	Max 25 AC

Notes:

(1) Contributing drainage area should not exceed 3 times area of permeable pavement.

(2) Rain gardens and other small-scale bioretention systems. For curb inlet planters, the recommended maximum ratio of contributing impervious drainage area to planter bed area is 10:1.

(3) No limit if runoff enters swale as sheet flow. May be suitable for larger areas, but limitations are most often associated with linear projects. The aid of a level spreader and larger filter strips will enhance these practices.

(4) Smaller drainage areas may be suitable if intercepting groundwater or with sufficient surface runoff to support permanent pool, required wetland depths, or submerged gravel bed. An impermeable liner may be required if the system is located in permeable soils and the bottom of the system does not intercept groundwater.

(5) Drainage areas smaller than 10 acres may require an excessively small outlet structure susceptible to clogging.

Legend	♦	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable

Table 8-3. Physical Feasibility – Site Slope

BMP Category	BMP Type	Site Ground Slope (1)		
		Less than 2%	2% - 6%	6% - 10%
Infiltration BMPs	Infiltration Trench	●	●	●
	Underground Infiltration System	●	●	●
	Infiltration Basin	●	●	●
	Dry Well	●	●	●
	Infiltrating Catch Basin	●	●	●
	Porous Asphalt	●	5% max	
	Pervious Concrete	●	5% max	
	Permeable Concrete Interlocking Pavers	●	5% max	
Filtering BMPs	Bioretention	●	●	●
	Sand Filter	●	●	●
	Tree Filter	●	●	●
Stormwater Pond BMPs	Wet Pond	●	●	(2)
	Micropool Extended Detention Pond	●	●	(2)
	Wet Extended Detention Pond	●	●	(2)
	Multiple Pond System	●	●	(2)
Stormwater Wetland BMPs	Subsurface Gravel Wetland	●	●	(2)
	Shallow Wetland	●	●	(2)
	Extended Detention Shallow Wetland	●	●	(2)
	Pond/Wetland System	●	●	(2)

BMP Category	BMP Type	Site Ground Slope (1)		
		Less than 2%	2% - 6%	6% - 10%
Water Quality Conveyance BMPs	Dry Water Quality Swale	💧	Check dams required	
	Wet Water Quality Swale	💧	Check dams required	
Stormwater Reuse BMPs	Rain Barrel	Not Applicable		
	Cistern	Not Applicable		
Proprietary BMPs	Manufactured Treatment System	Not Applicable		
Other BMPs and BMP Accessories	Green Roof	Ground Slope Not Applicable (max 20% roof slope)		
	Dry Extended Detention Basin	💧	💧	(2)
	Underground Detention (no infiltration)	💧	💧	💧

Notes:

(1) Refers to post-construction slope at the BMP site.

(2) More difficult and costly installation for site slopes of greater than 6% due to the need for a potentially large embankment and other design modifications. Limited to 9.4% resultant slope. Embankment slope may be 2-33% with a level spreader and 2-15% without.

Legend	💧	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable

Table 8-4. Physical Feasibility – Soil Infiltration Capacity (Hydrologic Soil Group)

BMP Category	BMP Type	Hydrologic Soil Group (HSG)			
		A	B	C	D
Infiltration BMPs	Infiltration Trench	💧	💧	(4)(5)	
	Underground Infiltration System	💧	💧	(4)(5)	
	Infiltration Basin	💧	💧	(4)(5)	
	Dry Well	💧	💧	(4)(5)	
	Infiltrating Catch Basin	💧	💧	(4)(5)	
	Porous Asphalt	💧	💧	(4)(5)	
	Pervious Concrete	💧	💧	(4)(5)	
	Permeable Concrete Interlocking Pavers	💧	💧	(4)(5)	
Filtering BMPs	Bioretention	💧	💧	(4)(5)	(4)(5)
	Sand Filter	💧	💧	(4)(5)	(4)(5)
	Tree Filter	💧	💧	(4)(5)	(4)(5)
Stormwater Pond BMPs	Wet Pond	(1)	(1)	(1)	💧
	Micropool Extended Detention Pond	(1)	(1)	(1)	💧
	Wet Extended Detention Pond	(1)	(1)	(1)	💧
	Multiple Pond System	(1)	(1)	(1)	💧
Stormwater Wetland BMPs	Subsurface Gravel Wetland	(2)	(2)	(2)	💧
	Shallow Wetland	(1)	(1)	(1)	💧
	Extended Detention Shallow Wetland	(1)	(1)	(1)	💧
	Pond/Wetland System	(1)	(1)	(1)	💧

BMP Category	BMP Type	Hydrologic Soil Group (HSG)			
		A	B	C	D
Water Quality Conveyance BMPs	Dry Water Quality Swale	♦	♦	(4)(5)	(4)(5)
	Wet Water Quality Swale	(3)	(3)	♦	♦
Stormwater Reuse BMPs	Rain Barrel	Not Applicable			
	Cistern	Not Applicable			
Proprietary BMPs	Manufactured Treatment System	Not Applicable			
Other BMPs and BMP Accessories	Green Roof	Not Applicable			
	Dry Extended Detention Basin	♦	♦	Liner recommended to prevent groundwater inflow	
	Underground Detention (no infiltration)	♦	♦	♦	♦

Notes:

NRCS Hydrologic Soil Group (HSG) as determined from field-verified soil textural class of the soil (refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation methods).

(1) An impermeable liner is required if the bottom of the system does not intercept groundwater.
(2) The system should be lined with an impermeable liner to prevent groundwater exchange with runoff in the subsurface gravel bed.
(3) Feasible if constructed with an impermeable liner but wet water quality swales are generally impractical in HSG A and B soils
(4) Underdrain Recommended
(5) Dispersed/Sheet flow

Legend	♦	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable or very limited suitability

Table 8-5. Physical Feasibility – Depth to Seasonal High Groundwater Table and Bedrock

BMP Category	BMP Type	Depth to Seasonal High Groundwater Table (1)				Depth to Bedrock		
		< 1 ft	1 – 2 ft	2 – 3 ft	> 3 ft	< 2 ft	2 – 3 ft	> 3 ft
Infiltration BMPs	Infiltration Trench			(2)	💧		(2)	💧
	Underground Infiltration System			(2)	💧		(2)	💧
	Infiltration Basin			(2)	💧		(2)	💧
	Dry Well			(2)	💧		(2)	💧
	Infiltrating Catch Basin			(2)	💧		(2)	💧
	Porous Asphalt			(2)	💧		(2)	💧
	Pervious Concrete			(2)	💧		(2)	💧
	Permeable Concrete Interlocking Pavers			(2)	💧		(2)	💧
Filtering BMPs	Bioretention		(3)	(2)	💧	(3)	(2)	💧
	Sand Filter		(3)	(2)	💧	(3)	(2)	💧
	Tree Filter		(3)	(2)	💧	(3)	(2)	💧
Stormwater Pond BMPs	Wet Pond	💧	💧	(4)		💧	💧	💧
	Micropool Extended Detention Pond	💧	💧	(4)		💧	💧	💧
	Wet Extended Detention Pond	💧	💧	(4)		💧	💧	💧
	Multiple Pond System	💧	💧	(4)		💧	💧	💧
Stormwater Wetland BMPs	Subsurface Gravel Wetland	💧	💧	(4)		💧	💧	💧
	Shallow Wetland	💧	💧	(4)		💧	💧	💧
	Extended Detention Shallow Wetland	💧	💧	(4)		💧	💧	💧
	Pond/Wetland System	💧	💧	(4)		💧	💧	💧

BMP Category	BMP Type	Depth to Seasonal High Groundwater Table (1)				Depth to Bedrock		
		< 1 ft	1 – 2 ft	2 – 3 ft	> 3 ft	< 2 ft	2 – 3 ft	> 3 ft
Water Quality Conveyance BMPs	Dry Water Quality Swale			(2)	💧		(2)	💧
	Wet Water Quality Swale	💧	💧	(4)		💧	💧	💧
Stormwater Reuse BMPs	Rain Barrel	Not Applicable				Not Applicable		
	Cistern	Not Applicable				Not Applicable		
Proprietary BMPs	Manufactured Treatment System	Not Applicable				Not Applicable		
Other BMPs and BMP Accessories	Green Roof	Not Applicable				Not Applicable		
	Dry Extended Detention Basin	(6)	💧	💧	💧	(5)	💧	💧
	Underground Detention (no infiltration)	💧	💧	💧	💧	💧	💧	💧

Notes:

Depth from bottom of infiltration systems or top of filtering systems to seasonal high groundwater table and bedrock or other impermeable material or subsurface layer as determined from test pits or soil borings (refer to Chapter 10 - General Design Guidance for Stormwater Infiltration Systems for soil evaluation methods).

(1) Stormwater BMPs designed with an underdrain system and impermeable liner may be used in areas where the required vertical separation to SHGT and bedrock cannot be met. Such systems are suitable for providing treatment but do not provide retention credit.

(2) Strictly residential uses or for stormwater retrofits where the minimum 3-foot separation cannot be met due to existing site constraints and there is little risk to groundwater quality, or where groundwater is already impacted (classified as GB) and there is little risk to groundwater quality from the infiltrated stormwater.

(3) For unlined filtering systems, the bottom of the filtering system should be at least 1 foot above SHGT and bedrock.

(4) Liner required in permeable soils.

(5) At least 1 foot of separation required.

(6) Liner recommended.

Legend	💧	💧	Suitable
	(See notes)	(See notes)	Suitable under certain conditions or with design restrictions as noted
			Generally not suitable

High Risk Sites and Drinking Water Protection Areas

Certain land use activities and site characteristics restrict or preclude the use of some stormwater BMPs, particularly near groundwater and surface drinking water supplies. Table 8-6 summarizes the suitability of stormwater BMPs based on the following factors:

- Land Uses with Higher Potential Pollutant Loads
- Contaminated sites
- Groundwater drinking water supply areas
- Surface drinking water supply areas

Land Uses with Higher Potential Pollutant Loads

Certain land uses or land use activities can result in higher potential stormwater pollutant loads. Chapter 10 - General Design Guidance for Stormwater Infiltration Systems identifies designated Land Uses with Higher Potential Pollutant Loads (LUHPPLs), which include a number of specific industrial and commercial uses and activities. Infiltration of stormwater from LUHPPLs is only allowed for the specific LUHPPLs identified in Table 10-4, at the discretion of the review authority and under the conditions listed in Chapter 10. An impermeable liner is generally required for stormwater BMPs that receive stormwater from LUHPPLs and that could potentially discharge to groundwater, including BMPs that intercept groundwater (Stormwater Pond and Wetland BMPs and wet water quality swales) and dry detention basins, to reduce the risk of groundwater contamination.

Contaminated Sites

As addressed in Chapter 10 - General Design Guidance for Stormwater Infiltration Systems, infiltration of stormwater in areas with soil or groundwater contamination such as brownfield sites and urban redevelopment areas can mobilize contaminants. Infiltration BMPs should not be used where subsurface contamination is present from prior land use due to the increased threat of pollutant migration associated with increased hydraulic loading from infiltration systems, unless contaminated soil is removed and the site is remediated, or if approved by CT DEEP on a case-by-case basis. Filtering BMPs and dry water quality swales may be used in areas with subsurface contamination if designed with an underdrain system and impermeable liner. Other non-infiltration BMPs may also be used on such sites with an impermeable liner.

Groundwater Drinking Water Supply Area

Groundwater is a major source of drinking water in Connecticut for residences that rely on small private wells and larger water distributors. This applies to both water supply aquifers and Class GA and GAA groundwaters as defined by CT DEEP. Groundwater is also the source of dry weather flows (baseflow) in watercourses, which is critical for maintaining suitable habitat. It is important to maintain a high-quality recharge to groundwater in water supply aquifers and Class GA and GAA waters.

Infiltration of stormwater within Aquifer Protection Areas and other groundwater drinking water supply areas can potentially contaminate groundwater drinking water supplies. As discussed in Chapter 10, aboveground Infiltration BMPs such as infiltration basins or bioretention systems designed for infiltration should be used for paved surface runoff to provide an opportunity for volatilization of volatile organic compounds to the extent possible before the stormwater can infiltrate into the ground. Subsurface Infiltration BMPs (i.e., infiltration trenches, infiltration chambers, dry wells, infiltrating catch basins) should only be used to infiltrate clean roof runoff.

Infiltration of stormwater within public or private wellhead protection areas (see minimum horizontal setback distances for public and private wells in Recommended Minimum Horizontal Setback Distances for Stormwater Infiltration Systems) should be limited to clean roof runoff only.

Surface Drinking Water Supply Areas

Surface waters that supply drinking water are especially susceptible to contamination by bacteria and other pathogens. Other contaminants-of-concern may be defined for specific water supply systems by the owner/operator or the State Department of Health. Stormwater BMPs for sites within drinking water supply watersheds should target these potential contaminants. The Public Health Code also requires a 100-foot separation distance between drainage or treatment practice outlets and public water supply tributaries.

Stormwater infiltration or surface stormwater discharges in close proximity to surface drinking water supply reservoirs or tributaries to such water supplies can threaten drinking water quality. Stormwater infiltration systems should be located a minimum distance horizontally from surface drinking water supplies as described in Chapter 10 (Recommended Minimum Horizontal Setback Distances for Stormwater Infiltration Systems). Infiltration of clean roof runoff is allowed within the horizontal setback distances. Outlets of stormwater BMPs should be located at least 200 feet from a public water supply reservoir and 100 feet from streams tributary to a public water supply reservoir, consistent with the Connecticut Public Health Code.

Table 8-6. High Risk Sites and Drinking Water Supply Area Suitability

BMP Category	BMP Type	Land Uses with Higher Potential Pollutant Loads	Contaminated Sites (2)	Groundwater Drinking Water Supply Areas (3)	Surface Drinking Water Supply Areas (4)
Infiltration BMPs	Infiltration Trench	(1)		Clean roof runoff only	(5)
	Underground Infiltration System	(1)		Clean roof runoff only	(5)
	Infiltration Basin	(1)		💧	(5)
	Dry Well	(1)		Clean roof runoff only	(5)
	Infiltrating Catch Basin	(1)		Clean roof runoff only	(5)
	Porous Asphalt	(6)	(6)	💧	(5)
	Pervious Concrete	(6)	(6)	💧	(5)
	Permeable Concrete Interlocking Pavers	(6)	(6)	💧	(5)
Filtering BMPs	Bioretention	(1)	(6)	💧	(5)
	Sand Filter	(1)	(6)	💧	(5)
	Tree Filter	(1)	(6)	💧	(5)
Stormwater Pond BMPs	Wet Pond	Liner required	Liner required	💧	(5)
	Micropool Extended Detention Pond	Liner required	Liner required	💧	(5)
	Wet Extended Detention Pond	Liner required	Liner required	💧	(5)
	Multiple Pond System	Liner required	Liner required	💧	(5)
Stormwater Wetland BMPs	Subsurface Gravel Wetland	Liner required	Liner required	💧	(5)
	Shallow Wetland	Liner required	Liner required	💧	(5)
	Extended Detention Shallow Wetland	Liner required	Liner required	💧	(5)

BMP Category	BMP Type	Land Uses with Higher Potential Pollutant Loads	Contaminated Sites (2)	Groundwater Drinking Water Supply Areas (3)	Surface Drinking Water Supply Areas (4)
	Pond/Wetland System	Liner required	Liner required	♦	(5)
Water Quality Conveyance BMPs	Dry Water Quality Swale	(1)	(6)	♦	(5)
	Wet Water Quality Swale	Liner required	Liner required	♦	(5)
Stormwater Reuse BMPs	Rain Barrel	♦	♦	♦	♦
	Cistern	♦	♦	♦	♦
Proprietary BMPs	Manufactured Treatment System	♦	♦	♦	(5)
Other BMPs and BMP Accessories	Green Roof	♦	♦	♦	♦
	Dry Extended Detention Basin	Liner required	Liner required	♦	(5)
	Underground Detention (no infiltration)	♦	♦	♦	(5)

Notes:

(1) Infiltration of stormwater from Land Uses with Higher Potential Pollutant Loads (LUHPPLs) is only allowed for the specific LUHPPLs listed in Table 10-4, at the discretion of the review authority and under the conditions listed in Chapter 10 (i.e., receive treatment by another BMP prior to infiltration).

(2) Infiltration BMPs should not be used where site contamination is present unless contaminated soil is removed and the site is remediated, or if approved by CT DEEP on a case-by-case basis. An impermeable liner may also be required.

(3) Aquifer Protection Areas and other groundwater drinking water supply areas. Infiltration within public or private wellhead protection areas should be limited to clean roof runoff only.

(4) Infiltration systems should be located a minimum distance horizontally from surface drinking water supplies as described in Table 10-3. Infiltration of clean roof runoff is allowed within the horizontal setback distances.

(5) Outlets of stormwater BMPs should be located at least 200 feet from a public water supply reservoir and 100 feet from streams tributary to a public water supply reservoir.

(6) Liner and underdrain required.

Legend		
	♦	Suitable
	(See notes)	Suitable under certain conditions or with design restriction as noted
		Generally not suitable

Receiving Waters

Selection of stormwater BMPs should consider the type and sensitivity of the downstream receiving waters. All stormwater BMPs should be selected and designed with consideration of stormwater pollutants of concern for the receiving waterbody, such as pollutants associated with a known water quality impairment or Total Maximum Daily Load (TMDL). Table 8-7 summarizes the suitability of stormwater BMPs based on some of the several common types of receiving waters and associated pollutants of concern:

- Coldwater streams (thermal/temperature)
- Freshwater lakes and ponds (phosphorus and sediment)
- Coastal waters and estuaries (nitrogen and bacteria)

Note that this is just a summary of some of the common types of receiving waters and the associated pollutant types (for example bacteria can often be associated with freshwater lakes and ponds too).

Coldwater Streams

Coldwater streams are areas or reaches of streams with water cold enough throughout the year to support coldwater fish species. Coldwater streams, including Class B streams or managed stocked streams, can be adversely impacted by stormwater runoff with elevated temperatures. In addition, the rate and volume of stormwater discharges from new developments are especially critical to these systems, as they could impact the flood carrying capacity of the watercourse and increase the potential for channel erosion.

Infiltration BMPs and Filtering BMPs are recommended for sites that discharge to or are located within the drainage areas of coldwater streams. Stormwater BMPs that provide treatment by infiltration and filtration can moderate runoff temperatures by thermal exchange with cooler subsurface materials. Stormwater BMPs with large permanent pools that are exposed to direct sunlight such as Stormwater Pond and Wetland BMPs can discharge stormwater with increased temperatures and should not be used for sites that discharge within 200 feet of coldwater streams.

Freshwater Lakes and Ponds

Lakes and ponds are especially sensitive to sediment and nutrient loadings. Excess sediments and nutrients are the cause of algal blooms in these surface waters, leading to eutrophication and degradation. These conditions often result in costly dredging and rehabilitation projects. In freshwater systems, phosphorus is typically the limiting nutrient, that is, much less phosphorus is needed compared to other nutrients such as nitrogen to create eutrophic conditions. As a result, stormwater BMPs should focus on phosphorus removal for stormwater discharges to lakes and ponds and watercourses that feed lakes and ponds. Infiltration BMPs and Filtering BMPs are generally most effective for removing phosphorus.

Coastal Waters and Estuaries

Coastal and estuarine waters are more sensitive to nitrogen loadings than freshwater systems. In saltwater systems, nitrogen tends to be the limiting nutrient as opposed to phosphorus. Excess loading of nitrogen is a major source of water quality impairments in Connecticut's coastal embayments and Long Island Sound. Bacteria are also a concern given the sensitivity of public swimming areas and shellfish beds to bacterial loadings and the many bacteria-impaired waters along Connecticut's highly urbanized coastline.

Stormwater BMPs that incorporate vegetative uptake and microbial nitrogen removal in an anaerobic subsurface zone (anoxic conditions) such as Stormwater Pond and Wetland BMPs (e.g., subsurface gravel wetlands) are generally more effective for nitrogen removal, while Infiltration and Filtering BMPs are generally more effective for reducing bacteria loads. Bioretention systems can also be designed with a submerged Internal Water Storage zone within the lower gravel storage reservoir for enhanced nitrogen removal.

Stormwater BMPs that rely on adequate vertical separation distance to groundwater (e.g., infiltration systems) are also more vulnerable to rising groundwater levels when located in coastal areas that are predicted to experience substantial sea level rise.

Other Selection Factors

Other factors should be considered when selecting the most appropriate stormwater BMP for a project site. These include but are not limited to:

Maintenance

Although all stormwater BMPs require regular maintenance, some BMPs require more frequent inspection and cleaning, special equipment, and/or staff training. BMPs should be selected that are compatible with the equipment, labor resources, and available funding of the parties responsible for maintenance. Refer to Chapter 7 - Overview of Structural Stormwater Best Management Practices and Chapter 13 - Structural Stormwater BMP Design Guidance of this Manual for general and BMP-specific maintenance requirements.

Affordability

Construction costs of stormwater BMPs vary considerably depending on system type (surface versus subsurface), configuration (on-line versus off-line), materials, pretreatment requirements, and system sizing. BMPs should be selected for maximum cost-effectiveness to meet the stormwater management standards and performance criteria outlined in this Manual. Long-term operation and maintenance costs, including periodic replacement of the entire system or system components (e.g., clogged filter media), should also be considered.

Community Acceptance and Co-Benefits

Certain stormwater BMPs may have stronger community acceptance than others based on aesthetics and reported nuisance problems. Stormwater BMPs that provide other benefits in

addition to stormwater management (i.e., green infrastructure) such as streetscape improvements, reduction in heat island effect, greening of public spaces, and flood resilience may be preferred and have stronger acceptance by the community than traditional gray infrastructure systems.

Table 8-7. Receiving Water Selection Factors

BMP Category	BMP Type	Coldwater Streams (Thermal)	Freshwater Lakes & Ponds (Phosphorus & Sediment)	Coastal Waters & Estuaries (5) (Nitrogen & Bacteria)
Infiltration BMPs	Infiltration Trench	♦	♦	♦
	Underground Infiltration System	♦	♦	♦
	Infiltration Basin	♦	♦	♦
	Dry Well	♦	♦	♦
	Infiltrating Catch Basin	♦	♦	♦
	Porous Asphalt	♦	♦	♦
	Pervious Concrete	♦	♦	♦
	Permeable Concrete Interlocking Pavers	♦	♦	♦
Filtering BMPs	Bioretention	(1)	♦	(4)
	Sand Filter	(1)	♦	♦
	Tree Filter	(1)	♦	♦
Stormwater Pond BMPs	Wet Pond	(6)	♦	(2)
	Micropool Extended Detention Pond	(6)	(3)	(2)
	Wet Extended Detention Pond	(6)	(3)	(2)
	Multiple Pond System	(6)	(3)	(2)
Stormwater Wetland BMPs	Subsurface Gravel Wetland	♦	(3)	(2)
	Shallow Wetland	(6)	(3)	(2)
	Extended Detention Shallow Wetland	(6)	(3)	(2)

BMP Category	BMP Type	Coldwater Streams (Thermal)	Freshwater Lakes & Ponds (Phosphorus & Sediment)	Coastal Waters & Estuaries (5) (Nitrogen & Bacteria)
	Pond/Wetland System	(6)	(3)	(2)
Water Quality Conveyance BMPs	Dry Water Quality Swale	(1)	●	●
	Wet Water Quality Swale		(3)	(2)
Stormwater Reuse BMPs	Rain Barrel	●	●	●
	Cistern	●	●	●
Proprietary BMPs	Manufactured Treatment System		●	
Other BMPs and BMP Accessories	Green Roofs	●		
	Dry Extended Detention Basin	(6)		
	Underground Detention (no infiltration)	●		

Notes:

(1) When designed for infiltration. When not designed for infiltration, surface discharge should be greater than 200 feet from coldwater stream.
(2) Provide long detention times (greater than 48 hours extended detention) for more effective bacteria removal.
(3) Provide larger permanent pool and/or longer flow path through system to increase residence time for more effective phosphorus removal.
(4) Design with submerged filter bed (Internal Water Storage zone or Internal Storage Reservoir) for enhanced nitrogen removal.
(5) Design to account for projected sea level rise and associated rise in groundwater to maintain required depth to seasonal high groundwater table.
(6) Discharge not allowed within 200 feet of coldwater streams.

Legend	●	Suitable
	(See notes)	Suitable under certain conditions or with design restrictions as noted
		Generally not suitable