GREEN INFRASTRUCTURE DESIGN MANUAL

CITY OF LANCASTER
A City Authentic

FEBRUARY 2019

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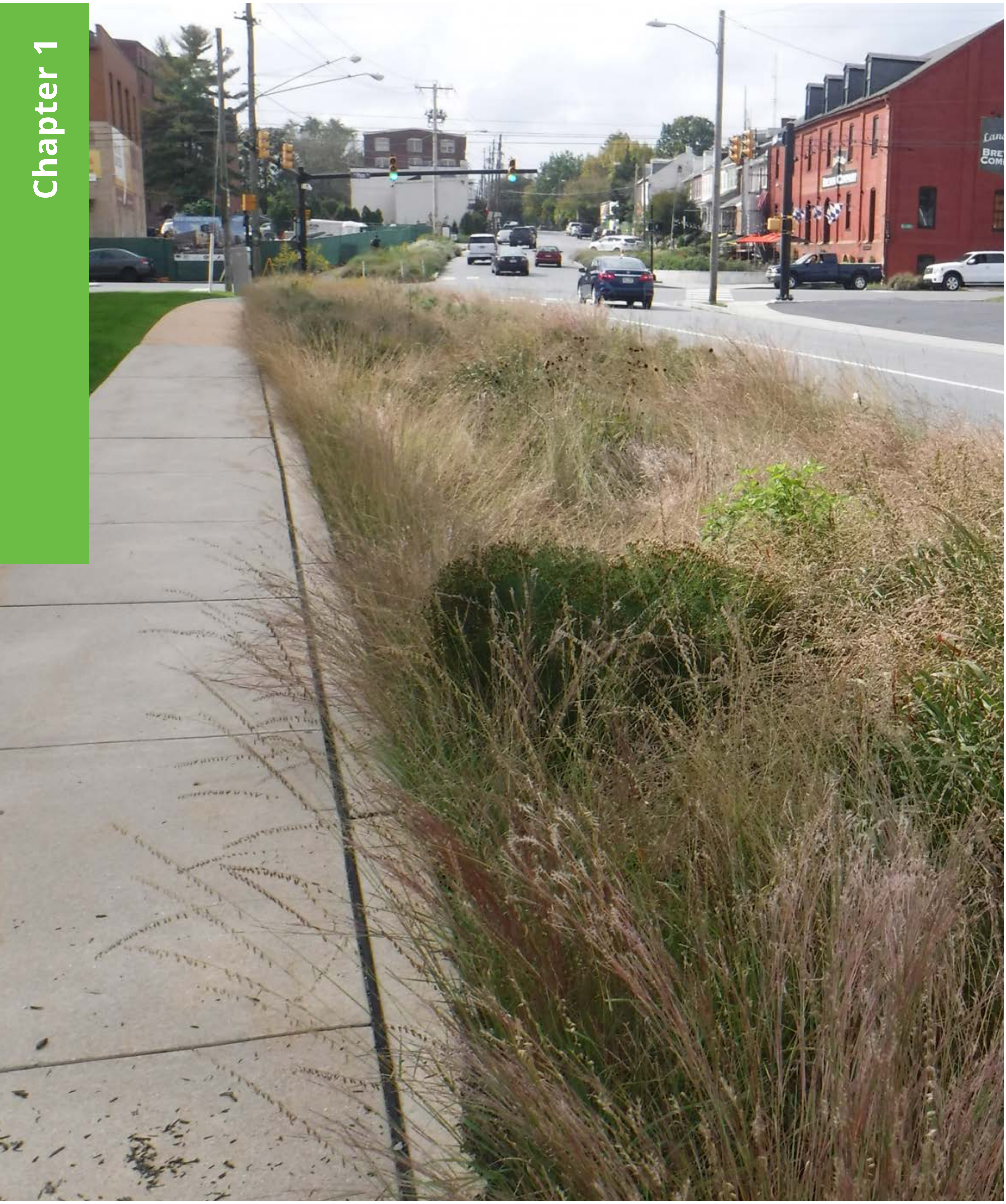

1. INTRODUCTION AND PURPOSE

The City of Lancaster (City) uses a combination of traditional stormwater infrastructure and innovative green infrastructure (GI) to manage stormwater runoff and reduce pollution to the City's streams, rivers, and waterways. Within the GI program, decentralized systems known as Stormwater Best Management Practices (BMPs)—such as bioretention/bioinfiltration, porous pavement, and green roofs—are used to add capacity to the combined stormwater and wastewater sewer system, reduce the peak discharge rates of runoff during storm events, and improve water quality while creating additional green space benefits for the community. Stormwater runoff collected by GI is returned to the water cycle through natural processes such as infiltration and evapotranspiration.

This GI Design Manual (Manual) provides technical guidance for the planning, design, and construction of GI systems in the City. The Manual is intended to be used by design professionals such as engineers, construction contractors, landscape architects, and urban planners working with the City or their partners.

1.1 GREEN INFRASTRUCTURE IN THE CITY OF LANCASTER

The City captures and conveys stormwater in part through the use of a combined sewer system (CSS). The CSS collects and transports a combination of stormwater runoff and domestic sewage from approximately 45% of the City's total area. During typical conditions, the City's Advanced Wastewater Treatment Facility is able to manage and treat water collected by the CSS. Heavy storm events, however, create flow volumes that exceed the treatment facility's capacity, resulting in combined sewer overflow (CSO) discharges into the Conestoga River eventually leading into the Chesapeake Bay.

The Clean Water Act of 1972 established water quality standards for surface waters in the United States. The Commonwealth of Pennsylvania enforces these standards by issuing permits that regulate combined sewer overflows and stormwater runoff in areas with separate sewer systems. To comply with the Clean Water Act, the Pennsylvania Department of Environmental Protection (PA DEP), through the Pennsylvania Storm Water Management Act (Act 167), issued a Consent Decree to the City to reduce CSO discharges. The City has agreed to develop and implement an Amended Long Term Control Plan (LTCP) to achieve these regulatory requirements. The City's commitment to sustainable solutions is made evident in a LTCP that prioritizes the use of decentralized GI systems to reduce the combined sewer load on the wastewater treatment facilities.

The remaining portion of the City's sewer system separates stormwater from the sanitary system. These areas also become inundated during intense storm events, resulting in surcharges, localized drainage issues, and increased conveyance of pollutants to local waterways. In these areas, the City must adhere to certain pollution reduction requirements set by the PA DEP via the National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permit program. The City has outlined an approach to mitigating pollution loads in their Chesapeake Bay Pollution Reduction Plan (CBPRP).

Green Infrastructure

GI is a key component of the City's CSO and pollution reduction strategy and can also provide additional benefits beyond pollution and stormwater volume reduction. For example, by choosing GI over traditional infrastructure upgrades to manage stormwater, the City may see reduced energy demands through cooling effects during warmer months. GI practices often utilize native vegetation as part of the treatment process, which can improve the environment by filtering pollutants from the air and providing habitat for birds and pollinator insects.

The City of Lancaster Green Infrastructure Plan (2019 Update) outlines strategies for utilizing GI to create livable, sustainable, and safer communities, while reducing pollution associated with CSOs and direct discharges to the MS4. GI can be located on public land (e.g., parks and schools), private land (e.g., private parking lots), and within the right-of-way (ROW) (e.g., within sidewalks). GI is versatile in its application and can be implemented on rooftops; the ground surface; or underground. These installations commonly employ design elements such as porous pavements, native plantings, shade trees, or artistic signs or murals.

To confront the challenges of stormwater runoff and meet regulatory requirements, the Lancaster Department of Public Works (DPW) has developed regulations and guidance that ensure a modern and effective stormwater management program. These regulations are found in the City of Lancaster Stormwater Management Ordinance (City of Lancaster Code, Chapter 260). Other relevant chapters within the City of Lancaster Code include, but are not limited to, the Tree Ordinance (Chapter 273), Parking Lots Ordinance (Chapter 202), Streets and Sidewalks Ordinance (Chapter 262), and Right of Way Management Ordinance (Chapter 263).

1.2 PURPOSE OF THE GREEN INFRASTRUCTURE DESIGN MANUAL

The GI Design Manual provides technical guidance for the planning, design, and construction of individual GI systems. The Manual serves as a technical reference for the design of both public GI installations implemented by the City and for private GI installations implemented on private property to meet regulatory requirements associated with land development activities and achieve stormwater fee credits. The guidance provided in this manual is supplemental to the City of Lancaster Stormwater Management (SWM) Ordinance.

The City's Stormwater Plan Review process and other permitting/approval processes are not contained within this manual. Please refer to the SWM Ordinance for guidance on the Stormwater Plan Review process.

This document is one of three documents developed to work in concert to ensure that the goals and requirements set forth by the LTCP are met. The other two documents, the Green Infrastructure Operations and Maintenance Plan (O&M Plan) and the Green Infrastructure Monitoring Plan (Monitoring Plan), are described in the following sections.

1.2.1 Relationship to the Green Infrastructure Operations and Maintenance Plan

An operations and maintenance plan is essential for the functional success of a GI program. The O&M Plan establishes protocols to ensure the proper function and long-term sustainability of the City's GI program. Using an adaptive management approach, the O&M Plan outlines inspection-driven protocols and recurring maintenance tasks, as well as data collection processes and format needed to continually evaluate financial requirements of the growing program.

Though the O&M Plan is under separate cover, its purpose is closely intertwined with that of this manual. It is critical to the success of the program that designers understand the maintenance impacts of their designs, and that maintenance personnel understand the intent of the design. Prior lessons learned from peer cities with regards to maintenance considerations—and their implications for design—have been incorporated into the GI Design Manual.

1.2.2 Relationship to the Green Infrastructure Monitoring Plan

In addition to the O&M Plan, this manual was developed to work alongside the Monitoring Plan to ensure that the goals and requirements set forth by the LTCP are met. The Monitoring Plan describes the process for testing GI elements related to performance, including functional testing during and/or after construction and long-term monitoring.

The Monitoring Plan has been developed to aid the City in evaluating the performance of the GI program at various levels. The Monitoring Plan outlines strategies for monitoring BMP performance metrics, which will inform future development of standards set forth in the Design Manual and the O&M Plan.

1.3 USING THE GREEN INFRASTRUCTURE DESIGN MANUAL

The Manual is organized into seven chapters and a series of appendices as follows:

HOW TO USE THE GREEN INFRASTRUCTURE DESIGN MANUAL	
Chapter	How to Use
Chapter 1 – Introduction and Purpose	• Context of the GI program in the City of Lancaster and overview of the Manual
Chapter 2 – Regulatory Requirements	• Introduction to the SWM Ordinance and its requirements for volume, rate, and erosion and sedimentation controls as they relate to the design of GI systems
Chapter 3 – Integrating Site Design and Stormwater Management	• Description of how the City's SWM Ordinance guides site assessment, recognizes SWM opportunities and constraints, and informs strategic approaches to GI system design • Concludes with examples of integrated stormwater management
Chapter 4 – Design Calculation Methodology	• Standard calculation methodologies for volume control, rate control, and stormwater conveyance to demonstrate compliance with SWM Ordinance requirements • Provides iterative steps using control and conveyance calculations in an effort to more easily size BMPs and route flows according to requirements
Chapter 5 – Design Guidelines	• Description of the six main types of structural BMPs including a summary of general guidelines for their design • Provides detailed guidance and key considerations specific to the siting, design, materials, construction, and O&M of each BMP type
Chapter 6 – Construction Guidance and Documentation	• Overview of construction, inspection and testing, and post-construction requirements • Highlights commonly observed construction issues and information regarding certificates of completion and as-built documentation • Example construction notes and sequence conclude the chapter
Chapter 7 – Operation and Maintenance	• List and general description of O&M tasks that must be performed to meet SWM Ordinance regulations • Provides references and resources to support O&M activities
Appendix A – Infiltration and Soil Testing Requirements	• Approved forms of soil characterization and infiltration testing requirements as well as standard testing methods and required number of testing locations
Appendix B – GI Standard Details	• Standard design details to be used or modified for future design projects
Appendix C – Developer's Checklist	• Checklist of design requirements for project approval
Appendix D – Green Infrastructure Planting List	• List of approved plants to be used on landscape plans including information on plant size, color, and other characteristics
Appendix E – Stormwater Management Ordinance	• The City's SWM Ordinance as referenced throughout design process • Note: Appendix E is the most up to date version of the ordinance at the time of publication
Appendix F – Acronyms and Abbreviations	• Typical acronyms and abbreviations within the Manual

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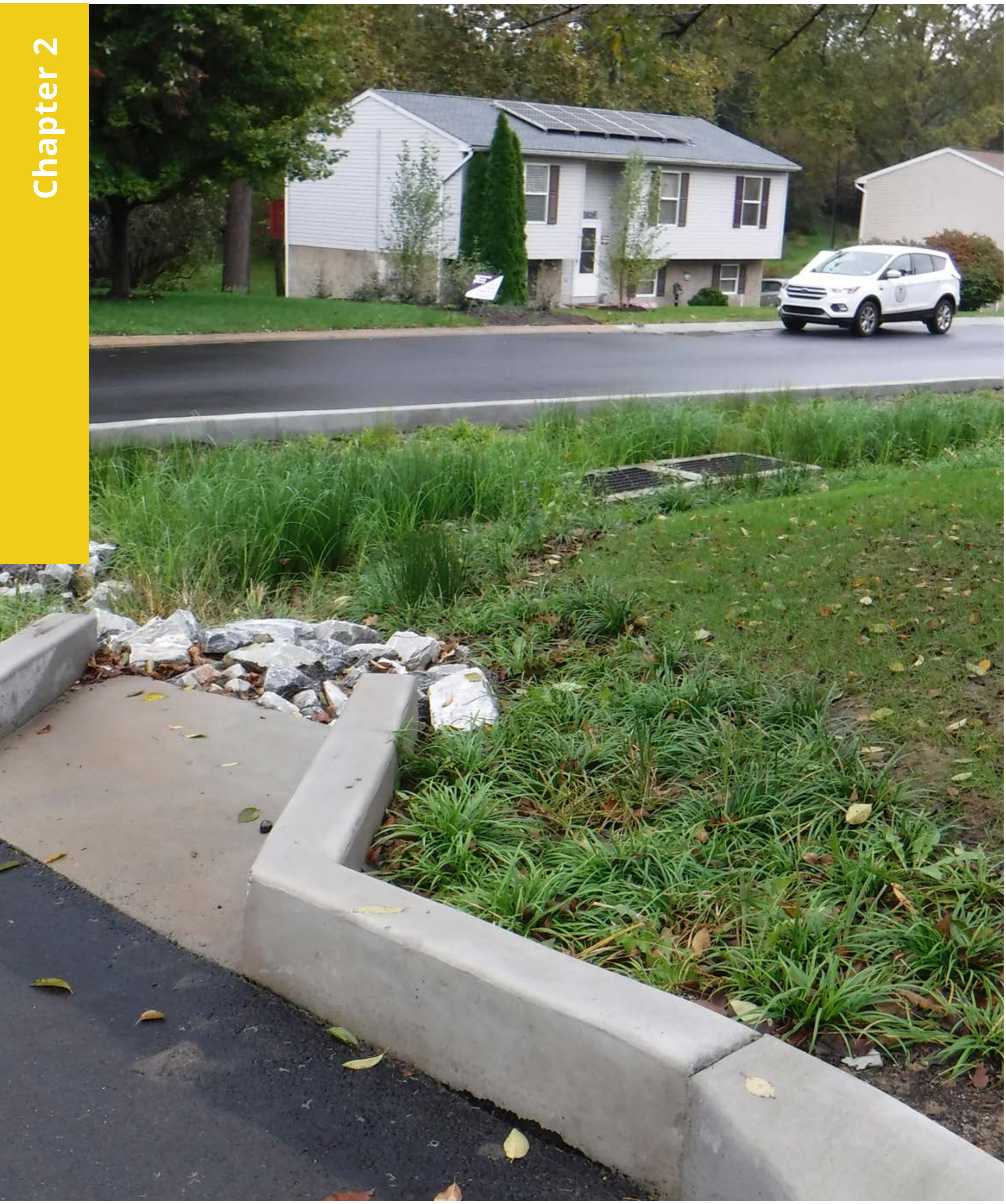

2. REGULATORY REQUIREMENTS

The negative impacts of unmanaged stormwater runoff from impervious surfaces present a challenge to the City. Such negative impacts include increased runoff pollutant concentrations, reduced groundwater recharge, increased stream channel and bank erosion, loss of aquatic habitat, increased flood frequency, and increased quantity, frequency, and duration of combined sewer overflows.

To confront these challenges, the City has developed a SWM Ordinance to ensure it has an up-to-date and effective stormwater management program that meets State and Federal requirements. This GI Design Manual provides detailed guidance on how to design GI systems to meet the requirements of the City's SWM Ordinance and LTCP.

The requirements set out in the City's SWM Ordinance are divided into three major sections: volume control requirements, rate control requirements, and erosion and sedimentation (E&S) control requirements. The goal of volume controls is to manage site specific hydrology closer to natural conditions both quantitatively and qualitatively for surface and groundwater through runoff management. Rate control requirements are designed to reduce peak flows, to protect existing channels and mitigate flood impacts. E&S control requirements focus on minimizing accelerated erosion and sedimentation during periods of earth disturbance.

This chapter provides an overview of the requirements of the SWM Ordinance as they relate to the design of GI BMPs. For an overview for assessing and implementing GI systems into site development designs see Chapter 3. GI calculation methodology and design standards can be found in Chapters 4 and 5, respectively.

2.1 REGULATED ACTIVITIES

The SWM Ordinance (§260-301) requires all regulated activities to:

A. Receive approval of the SWM site plan and stormwater permit application;

B. Provide E&S control; and

C. Meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law.

Regulated activities are defined in the SWM Ordinance §260-202 as "activities, including earth disturbance activities, that involve the alteration or development of land in a manner that may affect stormwater runoff". Regulated activities include but are not limited to land development, site work, construction of buildings, diversion or piping of any watercourse, and demolition. Refer to §260-301 for a complete list of regulated activities and to §260-502 for a list of exemptions.

2.2 PROJECT CHARACTERISTICS

Project characteristics, including project type, project watershed, and project release rate area, define specific stormwater management requirements for a project. These characteristics are described in the following sections.

Chapter 2

2.2.1 Project Type

Project type determines applicable stormwater management requirements per the SWM Ordinance. Project types are defined based on "the impervious area in the total proposed development" (§260-301 H(1)) or total earth disturbance associated with a project. Project types, including associated impervious area and earth disturbance thresholds, are as follows (§260-202):

- **Regulated Very Small Project:** Regulated activities that have negligible impervious coverage of less than or equal to 100 square feet measured in aggregate.
- **Regulated Small Project:** Regulated activities that, measured on a cumulative basis, create additional impervious areas of 1,000 square feet or less or involve removal of ground cover, grading, filling, or excavation of an area less than 5,000 square feet and do not involve the alteration of stormwater facilities or watercourses.
- **Regulated Large Project:** Regulated activities that create additional impervious area of greater than 1,000 square feet or involve removal of ground cover, grading, filling, or excavation of an area greater than 5,000 square feet.

Table 2.1-1 defines stormwater management requirements triggered by each project type.

TABLE 2.1-1. STORMWATER MANAGEMENT REQUIREMENT BY PROJECT TYPE

Project Type	Volume Control (Section 2.3.1)	Rate Control (Section 2.3.2)	E&S Control (Section 2.3.3)
Regulated Very Small Project	Not Required	Not Required	Required
Regulated Small Project	Required	Not Required	Required
Regulated Large Project	Required	Required	Required

Stormwater retrofit projects follow requirements that differ from those in Table 2.1-1. A stormwater retrofit project is defined as a project that is limited to the rehabilitation and/or installation of stormwater BMPs on a property or within the public right-of-way to better manage stormwater runoff. Coordinate with the City for any requirements associated with stormwater retrofit projects.

2.2.2 Project Watershed

There are three major watersheds in the City of Lancaster (Appendix E):

- Little Conestoga;
- Conestoga River; and
- Mill Creek.

The SWM Ordinance rate control requirements vary by the watershed in which a project site is located in accordance with Section 5 of Act 167. Section 2.3.2 describes rate control requirement exceptions that may be granted to projects within the Little Conestoga Watershed and the Mill Creek Watershed.

2.2.3 Project Release Rate Area

The release rate is defined by SWM Ordinance §260-202 as "the percentage of peak flow rate for existing conditions which may not be exceeded for the proposed conditions" for a specific design storm. The SWM Ordinance rate control requirements vary based on the project's location within a release rate area. Section 2.3.2 describes variations in the rate control requirement based on project release rate area. The release rate map found in Appendix E provides a graphical depiction of these release rate areas along with peak flow reduction percentage thresholds.

2.3 STORMWATER MANAGEMENT REQUIREMENTS

The SWM Ordinance has three major requirements: volume control, rate control, and erosion and sedimentation control. The sections below summarize these requirements and associated exceptions/ exemptions.

2.3.1 Volume Control

Objectives

The objectives of the volume control requirement (SWM Ordinance §260-303) are as follows:

- Reduce pollution in runoff;
- Recharge the groundwater table and increase stream base flows;
- Restore more natural site hydrology; and
- Reduce CSOs from the City's combined sewer systems.

Infiltration of stormwater runoff can significantly reduce pollutant loads reaching surface water as well as reducing the quantity of water in the sewer system which could otherwise contribute to CSOs and pollution of receiving waters. As such, infiltration is a major objective of the volume control requirement.

Requirements

A. Volume control for regulated projects:

   1. "Do not increase the postdevelopment total runoff volume and, at a minimum, permanently removes the first one inch of runoff, for all storms equal to or less than the two-year, twenty-four-hour storm event" (SWM Ordinance §260-303.A.1).

B. Volume control for small projects:

   1. "At least the first one inch of runoff from new impervious surfaces or an equivalent volume shall be permanently removed from the runoff flow, that is, it shall not be released into the surface waters of the commonwealth or combined sewer system. Removal options include reuse, evaporation, transpiration, and infiltration" (SWM Ordinance §260-303.B.1).

C. Drawdown for volume control BMPs:

   1. "Storage facilities, including normally dry, open-top facilities, shall completely drain the volume control storage over a period of time not less than 24 hours and not more than 72 hours from the end of the design storm. Any designed infiltration at such facilities is exempt from the minimum twenty-four-hour standard, that is, may infiltrate in a shorter period of time, provided that none of this water will be discharged into waters of the commonwealth or combined sewer system" (SWM Ordinance §260-303. D).

D. Volume control for projects within karst geology:

1. "When existing karst conditions, as determined by the City or its designee, do not allow for the installation of infiltration BMPs, the design volume of stormwater runoff shall be kept out of the combined sewer system and detained on site until the overflow event subsides" (SWM Ordinance §260-303.A.1.d).

Exceptions/Exemptions

The following regulated activities are exempt from volume control requirements (SWM Ordinance §260-502). However, the submission of a stormwater permit application is required for all regulated and exempt activities. The City of Lancaster may deny or revoke any exemption pursuant to this section at any time for any project that the City of Lancaster believes may pose a threat to public health, safety, property or the environment.

A. Very Small Projects;

B. Agricultural activity, provided that the activities are performed according to the requirements of 25 Pa. Code Chapter 102;

C. Forest management and timber operations, provided that the activities are performed according to the requirements of 25 Pa. Code Chapter 102;

D. Conservation practices being installed as part of the implementation of a conservation plan written by a Natural Resources Conservation Service (NRCS) certified planner;

E. Repair, reconstruction or restoration of public roadways; repair, reconstruction or restoration of rail lines; construction, repair, reconstruction; or restoration of utility infrastructure when the site will be returned to existing condition; and

F. Gardens and vegetative landscaping that do not increase impervious coverage and meet the following criteria:

- Located on slopes less than 8%;
- Not within 150 feet of any permanent watercourse;
- Less than 1,000 square feet in aggregate area; and
- Hardscaped areas within gardens and vegetated landscape areas, such as patios, walls, paved walkways and pools or ponds, shall be considered impervious areas (IA) and are not exempt if the total hardscaped area exceeds 100 square feet

2.3.2 Rate Control

Objectives

The objectives of the rate control requirement are as follows:

- Protect against immediate downstream erosion;
- Reduce or prevent the occurrence of flooding in areas downstream of the development site, as may be caused by inadequate sewer capacity or stream bank overflow; and
- Reduce the frequency, duration, and quantity of CSOs.

Requirements

A. Rate control for regulated projects:

1. "Provide infiltration facilities or utilize other techniques which will allow the postdevelopment one-hundred-year hydrograph to match the predevelopment one-hundred-year hydrograph, along all parts of the hydrograph, for the developement site; To match the predevelopment hydrograph, the postdevelopment peak rate must be less than or equal to the predevelopment peak rate, and the postdevelopment runoff volume must be less than or equal to the predevelopment volume for the same storm event" (SWM Ordinance §260-304.A).

B. Drawdown for rate control BMPs:

1. Normally dry, open-top storage facilities "shall completely drain the rate control storage over a period of time less than or equal to 24 hours from the peak one-hundred-year water surface design elevation" (SWM Ordinance §260-304.C).

Exceptions/Exemptions

The following regulated activities are exempt from rate control requirements (SWM Ordinance §260-502). The submission of a stormwater permit application shall be required for all regulated and exempt activities. The City of Lancaster may deny or revoke any exemption pursuant to this section at any time for any project that the City of Lancaster believes may pose a threat to public health, safety, property or the environment.

A. Small projects and very small projects, but calculations documenting rates must be submitted.

B. Agricultural activity, provided that the activities are performed according to the requirements of 25 Pa. Code Chapter 102.

C. Forest management and timber operations, provided that the activities are performed according to the requirements of 25 Pa. Code Chapter 102.

D. Conservation practices being installed as part of the implementation of a conservation plan written by an NRCS certified planner.

E. Repair, reconstruction or restoration of public roadways, or repair, reconstruction or restoration of rail lines, or construction, repair, reconstruction, or restoration of utility infrastructure when the site will be returned to existing condition.

F. Gardens and vegetative landscaping that do not increase impervious coverage and meet the following criteria:

- Located on slopes less than 8%.
- Not within 150 feet of any permanent watercourse.
- Less than 1,000 square feet in aggregate area.
- Hardscaped areas within gardens and vegetated landscape areas, such as patios, walls, paved walkways and pools or ponds, shall be considered impervious areas and are not exempt if the total hardscaped area exceeds 100 square feet

The following exceptions can be made for the rate control requirements.

G. If the predevelopment hydrograph cannot be matched:

1. Little Conestoga Creek Watershed or Mill Creek Watershed:

   a) "Postdevelopment rate of runoff from any regulated activity within the Little Conestoga Creek Watershed or Mill Creek Watershed shall not exceed 50% of the peak rates of runoff prior to development for all design storms unless the pre-existing hydrograph is not exceeded at all points in time" (SWM Ordinance §260-304.B.2).

2. For areas not covered by a release rate map from an approved Act 167:

   a) "Postdevelopment discharge rates shall not exceed the predevelopment discharge rates for the two-, ten-, twenty-five-, fifty-, and one-hundred-year, twenty-four-hour storm events" (SWM Ordinance §260-304.B.1).

3. For areas covered by a release rate map from an approved Act 167 plan:

   a) "For the two-, ten-, twenty-five-, fifty-, and one-hundred-year, storm events, the postdevelopment peak discharge rates will follow the applicable approved release rate maps" (SWM Ordinance §260-304.B.3).

2.3.3 Erosion and Sediment Control

Objectives

Effective stormwater management is critical during the construction process. Clearing, grading, and other site development activities expose soil surfaces, leaving them vulnerable to erosion. Soil erosion and sediment loss not only affect the development site, but can also block downstream inlets and sewers, causing localized flooding. Soil erosion and sediment loss can carry sediment and associated pollutants to the City's wastewater treatment plant or receiving waters. These impacts can contribute to flooding, maintenance concerns, and significant environmental issues.

Requirements

The SWM Ordinance states that "for all regulated activities, erosion and sediment control BMPs shall be designed, implemented, operated, and maintained to meet the purposes and requirements of this chapter and to meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law. Various BMPs and their design standards are listed in the Erosion and Sediment Pollution Control Program Manual (E&S Manual), No. 363-2134-008 (March 2012), as amended and updated" (§260-301.E).

Refer to Appendix E for complete E&S control requirements.

Exceptions/Exemptions

There are no exceptions or exemptions to the Erosion and Sediment Control requirement.

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3. INTEGRATING SITE DESIGN AND STORMWATER MANAGEMENT

This chapter details how to successfully incorporate stormwater management strategies into site development designs, while meeting the SWM Ordinance requirements. While this chapter does not specifically cover stormwater retrofits, there is information within this chapter that would be useful in the conceptual design of stormwater retrofit projects.

Chapter 2 details the regulatory requirements in the design of GI improvements. Calculation methodology is provided in Chapter 4 and GI design standards and guidelines are provided in Chapter 5.

3.1 SITE ASSESSMENT

This section provides guidance on conducting a site assessment – the first step in designing a project that complies with the SWM Ordinance.

A site assessment is an investigation of the physical factors that shape the development and stormwater management plan for a proposed site and consists of the following three components:

- Collection of background site factors;
- Site factors inventory; and
- Site factors analysis.

This section can help the designer to:

- Understand a site's existing condition and natural systems;
- Determine the most appropriate site layout of proposed features; and
- Develop an effective stormwater management approach and design.

Documentation for many of the site factors is required as part of the City's Stormwater Plan Review requirements per the SWM Ordinance (§260-403) and the PA DEP NPDES Permit Applications, as applicable. The site assessment process in this manual was adapted from the site assessment process documented in the PA DEP BMP Manual for applicability to the City projects.

3.1.1 Background Site Factors

Background site factors consist of macro-scale project site characteristics that describe how a site functions within its watershed. These factors include:

- Project watershed;
- Project sewershed;
- Flooding;
- Brownfield status;
- Prior land use; and
- Prior plans.

Project Watershed

A watershed is defined as an area of land that contains a common set of drainage pathways, streams, and rivers that all discharge to a single, larger body of water, such as a large river, lake, or ocean. The SWM Ordinance rate control requirements have slight variations by the watershed in which a project site is located. The City of Lancaster has three major watersheds:

- Conestoga River;
- Little Conestoga Creek; and
- Mill Creek.

Section 2.3.2 describes rate control requirement exceptions that may be granted to projects within the Little Conestoga Watershed and the Mill Creek Watershed. The Watersheds Map in Appendix E can be used to determine a site's watershed location.

Project Sewershed

A sewershed is a defined area of land, or catchment, which drains via storm drain infrastructure to a common outlet point. As opposed to natural watersheds, the boundaries of which are defined by natural ridges and high points and that drain to a single point in a stream network, sewershed boundaries are determined by stormwater infrastructure such as inlets, outfalls, and CSS pump stations. Sewershed boundaries often differ from watershed boundaries because stormwater infrastructure may cross watershed boundaries that predate urbanization.

It is important to determine if the project is within a CSS, MS4, or discharges directly into a waterbody through surface runoff.

- In CSS sewersheds, overflows occur when a large storm introduces flow that exceeds the capacity of the existing sewer infrastructure. The untreated mixed stormwater and wastewater enters local water bodies without treatment, introducing pathogens and other pollutants into the waterways.
- In MS4 sewersheds, stormwater enters local water bodies often without treatment. This stormwater becomes a form of non-point source pollution and contributes to water quality impairments.

A project's sewershed must be determined for reporting requirements. The project's sewershed can be determined by identifying the ultimate discharge point of runoff from the project site. Project sites may span multiple sewersheds, and runoff may leave different portions of the site via different methods.

The City of Lancaster Green Infrastructure Plan (2019 Update), City of Lancaster SWM Ordinance (§260), and/or the City of Lancaster Department of Public Works Geographic Information System (GIS) data (2010 or latest) can be used to determine the project sewershed. The latest data shall always be used in the event of contradicting sources.

Flooding

It is important to evaluate any existing flooding issues on a project site, surrounding areas, existing sewer network and/or the receiving waterbody as flooding conditions can impact a project's design. For example, there may be a high tail water condition at the outfall or connection point during a relatively small rainfall event. If a project's design proposes overflow connection to this existing system, the design would need to account for this condition.

Although Federal Emergency Management Agency (FEMA) flood maps and related studies show flood-prone areas along the City's streams and rivers, these resources do not adequately address this issue at the site scale. Prior property owners, neighbors, and other local sources may be able to indicate anecdotally the extent to which on-site or downstream flooding is already a problem. Published FEMA Flood Maps are available online at FEMA's Flood Map Service Center.

3.1.2 Site Factors Inventory

Site factors are smaller, site-scale features including property/land use boundaries and physical features that may affect the site layout or stormwater management compliance strategy. Understanding these factors is important in the development of a stormwater management plan that reduces the impacts of proposed earth disturbance and impervious area. A proper inventory also helps reduce the likelihood of risks to public health and safety as well as damage to public and private property.

Table 3.1.2-1 describes site factors and inventory examples, as well as how to obtain and use the information collected. Refer to the SWM Ordinance §260-403 for reporting requirements.

TABLE 3.1.2-1. SITE FACTORS INVENTORY DETAIL

Site Factors	Inventory Examples	Usage	Reference
Non-Physical Features	• Property Boundary • Land Use • Zoning • Drainage Easements • Access Easements • Extent of the upstream area draining through the development site.	Identify available area for development and BMPs.	City records, deeds, County records
Special Value Areas	Location and drainage conditions of: • Woodlands • Wetlands • Floodplains • Flood hazard boundaries • Streams, lakes, ponds, and other waterbodies • Drainage courses • Riparian areas and easements • State-designated special protection waters • Cold-water fisheries • Tree (DBH ≥ 6")	Identify special value areas that shall be conserved and protected during development.	Topographic survey, aerial photography, Geographic Information Systems (GIS) mapping, local and regional natural resources inventories, Pennsylvania Natural Diversity Inventory (PNDI) surveys
Existing Structures and Paved Areas	• Buildings • Parking Lots • Driveways	Identify areas that produce runoff and can be managed by BMPs.	Topographic survey, aerial photography
Existing Stormwater Infrastructure	• Pipes • Inlets • Manholes • Outfalls	Identify locations from which to convey stormwater to BMPs or overflow from BMPs	Topographic survey, utility records
Existing Utilities (gas, electric, sewer, water, etc.)	• Service laterals • Mains • Valve boxes • Lot disposal systems* • Well*	Identify vertical and horizontal constraints for development and BMPs.	Topographic survey, utility records, utility locator services (PA One Call, private contractors)
Steep Slopes	• Location of slopes >= 10%	Identify areas susceptible to erosion.	Topographic survey, GIS topographic data

TABLE 3.1.2-1. SITE FACTORS INVENTORY DETAIL (CONT.)			
Site Factors	Inventory Examples	Usage	Reference
Existing Soils and Geology	• Permeability • Hydrologic soil group(s) • Depth to high seasonal groundwater table	Determine siting constraints.	SWM Ordinance Section 260-405; United States Department of Agriculture (USDA) Soil Surveys; United States Geological Survey (USGS) karst maps, quadrangle maps, and historic fill maps; hydrologic soil maps; geotechnical reports; existing soil investigation or infiltration reports;, historical aerial photography; local or regional groundwater studies or well data; local/ state records; city/state regulatory databases. (Note: Usefulness of soil survey data for soils in urban settings may be limited)
	Carbonate geology (karst) features such as: ** • Sinkholes • Fracture Traces • Caverns	Use to develop a detailed geologic evaluation of karst areas.	
	• Locations of potential contamination and/or historic fill***	Determine if any environmental hazards are present and if further investigation will be required.	

* These structures are not permitted in the City. The City Engineer must be contacted upon discovery of these structures.
**Contact City Engineer if development is proposed in areas of karst, contamination, and/or historic fill.
*** Contamination must be evaluated per PA DEP guidelines.

3.1.3 Site Factors Analysis

The final step in the site assessment is to review the information obtained in the background and site factors inventories and perform a stormwater management constraints and opportunities analysis. A stormwater constraints and opportunities analysis identifies areas where stormwater management may or may not be appropriate and assists the designer in making preliminary determinations regarding the size and layout of any development features.

Stormwater Management Constraints

Stormwater management constraints are existing aspects of a project site that create difficult, infeasible, or inadvisable conditions for stormwater management per the SWM Ordinance. These constraints may or may not be the same as site development constraints.

Examples of stormwater management constraints include but are not limited to:

- Existing utilities and associated easements. This includes lot disposal systems and wells, gas, electric, communication, storm sewer, sanitary sewer, and potable water infrastructure;
- Building foundations; and
- Areas of karst geology.

Refer to Article IV of the SWM Ordinance for existing feature mapping requirements.

Stormwater Management Opportunities

Stormwater management opportunities can be evaluated once the stormwater management constraints have been determined.

Site characteristics that are favorable to stormwater management include but are not limited to:

- Soils with infiltration rates exceeding 0.1 inches per hour;
- Areas with limited subsurface conflicts that can be utilized for subsurface infiltration/detention (e.g., underneath parking lot or sidewalk); and
- Proximity to existing stormwater infrastructure for overflow.

Refer to Section 3.2 for guidance on applying information determined during site assessment to develop a site-specific strategy for managing stormwater in accordance with the requirements of the City's SWM Ordinance. Refer to Section 3.3 for examples of integrated stormwater management strategies for different project types.

3.2 STORMWATER MANAGEMENT DESIGN STRATEGIES

This section provides guidance on applying information determined during site assessment (Section 3.1) to develop a site-specific strategy for managing stormwater in accordance with the requirements of the City's SWM Ordinance. The development of a site-specific stormwater management strategy is performed prior to the finalization of the site layout. The planned site layout is modified, if needed, based on stormwater management needs.

Design Approach

Site layout and building arrangement is a critical aspect of stormwater management design. For development and redevelopment projects, stormwater management design is a key consideration in arranging site and building features during the early stages of design. Good stormwater management design begins with smart building layout and site design that takes into consideration the natural features, opportunities, and constraints documented during the site assessment process (Section 3.1).

During the initial building and site layout phase, designers must apply the design process documented in this manual to carefully consider how the arrangement of building and site elements will influence stormwater management requirements. It is beneficial to create a building and site layout that minimizes the creation of stormwater runoff and provides adequate room for GI systems to treat remaining runoff. For effective integration of these stormwater management features into the overall site design, the designer shall also look to develop relationships between GI systems and architectural features. As site features such as buildings, sidewalks, hardscape plazas, courtyards, entryways, parking lots, and others are added to the site layout, consideration shall be given to how GI systems can complement these features in ways that enhance the aesthetics, safety, and overall experience of the those that will ultimately use the site.

Design Process

Stormwater management strategy development shall be in accordance with the City of Lancaster Code, including but not limited to the Surface Parking Lots Ordinance (§202), SWM Ordinance (§260), and the Trees Ordinance (§273). The Manual's design strategy can be divided into three steps, each focusing on a subsection of BMPs as shown in Figure 3.2-1.

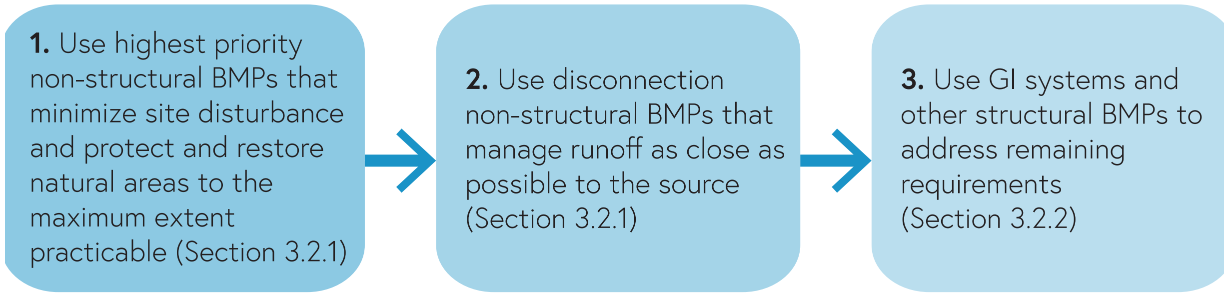


Figure 3.2-1. Design Strategy Steps

This GI Design Manual provides abbreviated guidance for the design of non-structural BMPs (Section 3.2.1). The PA DEP BMP Manual provides detailed guidance for the design of non-structural BMPs and guidance for associated stormwater credit calculations. Per the SWM Ordinance, stormwater credits for non-structural BMPs shall be in accordance with Chapter 5 of the PA DEP BMP Manual and the allowable credits will be determined by the City. Chapter 4 and 5 of this manual provide detailed guidance on the calculation methodology and design of non-structural BMPs and GI systems.

3.2.1 Non-Structural BMPs

Non-structural BMPs are "planning and design approaches, operational and/or behavior-related practices which minimize stormwater runoff generation resulting from an alteration of the land surface or limit contact of pollutants with stormwater runoff" (SWM Ordinance § 260-202).

Designers shall first use the highest priority non-structural BMPs (as identified in Table 3.2.1-1) to the maximum extent practicable (MEP) and next consider disconnection non-structural BMPs when developing a site-specific stormwater management strategy.

Non-structural BMPs can generate stormwater credits in accordance with the PA DEP BMP Manual that contribute to meeting the City's SWM Ordinance requirements in two ways – (1) self-crediting and (2) quantitative runoff volume reduction. Self-crediting BMPs automatically provide a reduction in impervious area and a corresponding reduction in the stormwater impacts that are required to be mitigated through the City's volume control (see Section 2.3.1) and rate control (see Section 2.3.2) requirements. Non-structural BMPs that provide quantitative runoff volume reductions offer volume reduction credits in accordance with the PA DEP BMP Manual. Reduction in rate control requirements can also be credited for certain BMPs. Refer to the PA DEP BMP Manual for complete design and credit calculation guidance for non-structural BMPs.

Highest Priority Non-Structural BMPs

The City requires the protection and conservation of natural areas that provide inherent stormwater management functions such as filtration, infiltration, evapotranspiration, and rainfall interception. Non-structural BMPs that minimize site disturbance and protect, utilize, and/or restore these existing natural areas shall be used to the MEP prior to considering other stormwater management strategies. Following the completion of the site assessment (Section 3.1), the first step in the stormwater design process is to thoroughly explore the use of these highest priority non-structural BMPs.

The highest priority non-structural BMPs fall within three categories: clustering and concentrating, protecting sensitive and special value resources, and minimizing disturbance and maintenance. A brief description of these BMPs and identification of associated potential stormwater credits, per the PA DEP BMP Manual, are provided in Table 3.2.1-1 and an example is provided in Figure 3.2.1-1.

TABLE 3.2.1-1. HIGHEST PRIORITY NON-STRUCTURAL BMPS

BMP Category	Description	Stormwater Benefit	Reference
Clustering and Concentrating	Limiting the footprints of buildings, parking areas, and other impervious areas, either through stacking or clustering structures on the site, leaving areas for green space.	Impervious area reduction to reduce volume of stormwater generated	PA DEP BMP Manual §5.5.1-5.5.2 and §5.7.1-5.7.2
Protecting Sensitive and Special Value Resources	Avoiding encroaching on areas that provide important natural stormwater functions, such as floodplains, wetlands, riparian areas, natural flow pathways, existing trees and shrubs Avoiding encroaching on areas that are especially sensitive to stormwater impacts, such as slopes greater than 15%, shallow bedrock (located within six feet of ground surface)	Preservation of areas with natural stormwater management functions	SWM Ordinance §260-202 Definitions of Terms and §260-301 General Requirements PA DEP BMP Manual §5.4.1-5.4.3
Minimizing Disturbance and Maintenance	Conforming to the existing topography to the greatest extent possible, reducing soil compaction, ensuring that healthy topsoil remains on the surface, and preserving existing vegetation Restoring disturbed areas with native plant species that do not require chemical maintenance and are selected for the appropriate hydrologic regime	Maximizing stormwater management capabilities of site	PA DEP BMP Manual §5.6.1-5.6.3

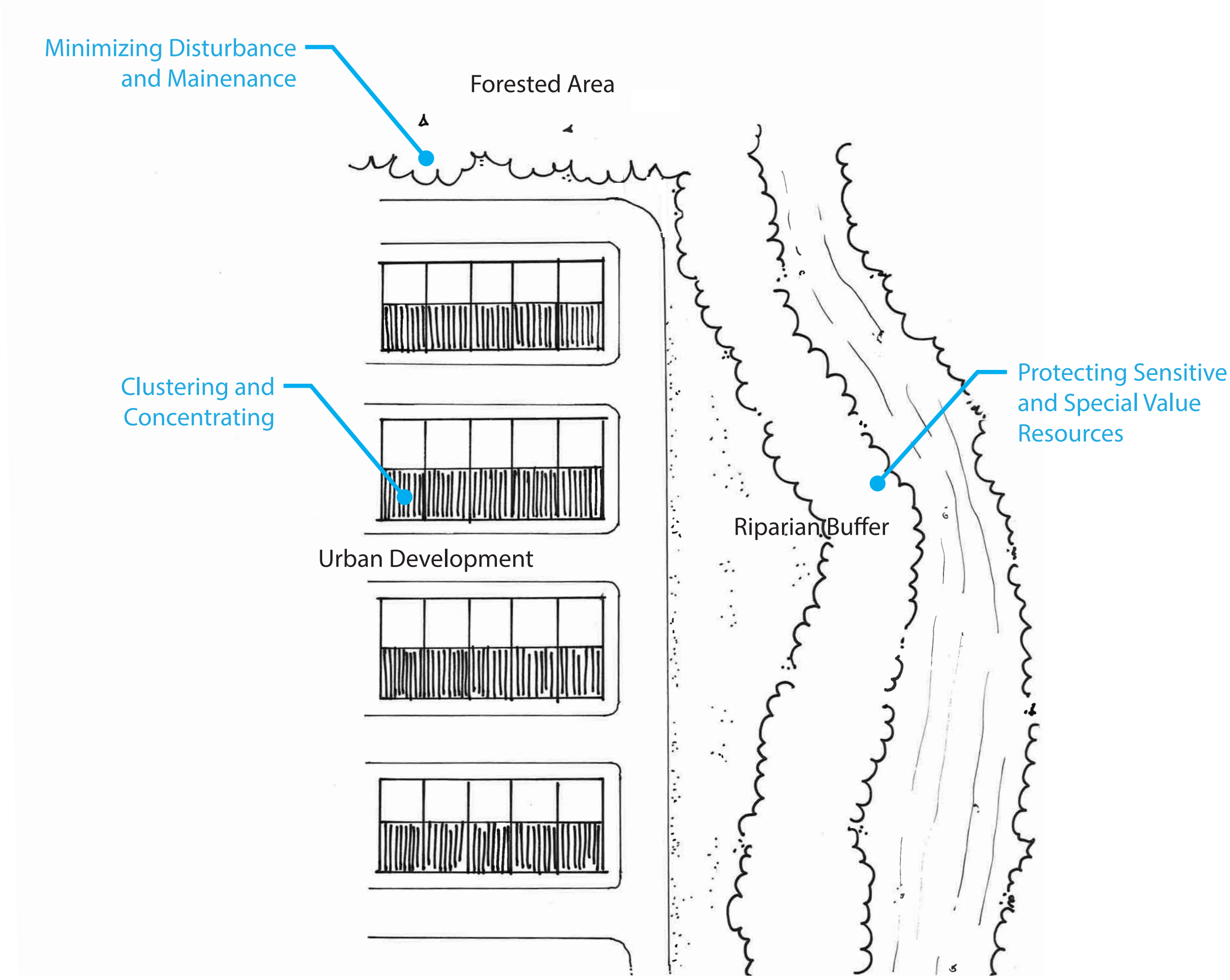


Figure 3.2.1-1. Highest Priority Non-Structural BMPs Example

Disconnection Non-Structural BMPs

Disconnection non-structural BMPs are stormwater management strategies that manage impervious area runoff through diversion to adjacent on-site vegetated areas that meet the requirements for disconnection as well as tree canopies over impervious areas that can intercept rainfall. There are three categories of disconnection non-structural BMPs: tree canopy disconnection, rooftop disconnection, and pavement disconnection. An example of disconnection non-structural BMPs is provided in Figure 3.2.1-2. Refer to Chapter 4 for methodology to calculate stormwater management volumes for disconnection non-structural BMPs.

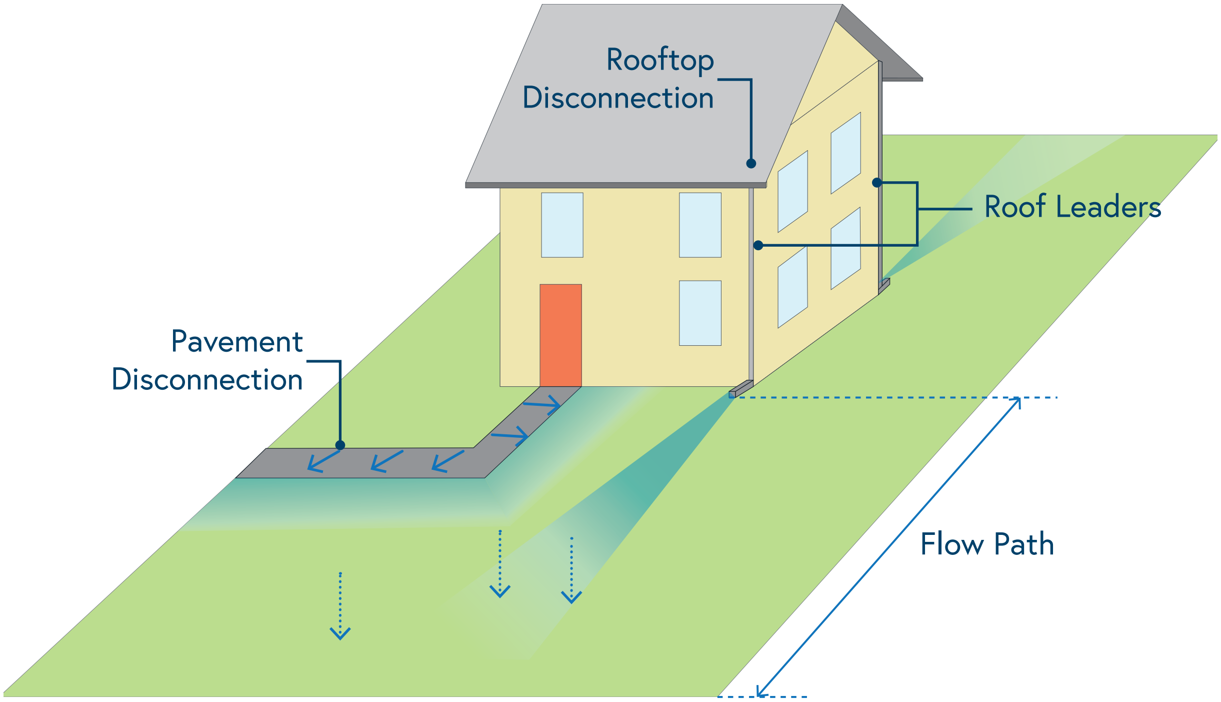


Figure 3.2.1-2. Disconnection Non-Structural BMPs Example

3.2.2 Green Infrastructure Systems and Other Structural BMPs

When developing a site-specific stormwater management strategy, designers shall implement non-structural BMPs (as defined in Section 3.2.1) to the MEP prior to considering structural BMPs. Structural BMPs are "physical devices and practices that capture and treat stormwater runoff. Structural stormwater BMPs are permanent appurtenances to the development site" (SWM Ordinance §260-202). Examples of typical structural BMPs include bioretention/bioinfiltration, green roofs, and porous pavement.

Step-by-step guidance on the conceptual design process for selecting and siting appropriate structural BMPs is summarized in Figure 3.2.2-1 and described in the following sections. Guidance on the detailed design of structural BMPs is provided in Chapter 5.

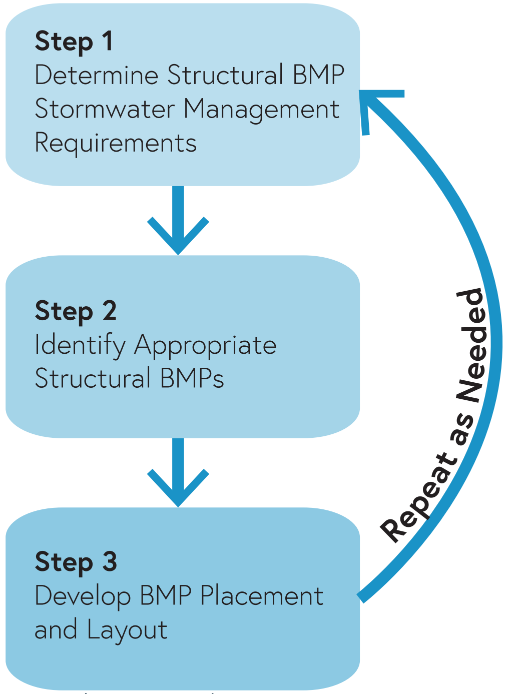


Figure 3.2.2-1. Structural BMP Selection and Conceptual Design Process

This process of selecting the appropriate structural BMPs for a site is typically an iterative process, particularly for constrained sites. During the BMP selection process (Step 2) and layout process (Step 3) the designer will select and perform an initial layout of BMPs, incorporating: site assessment data (Section 3.1); an understanding of the structural BMP stormwater management requirements (Step 1); as well as other factors such as cost, BMP maintenance requirements, and aesthetics. At the end of the first iteration of this process, designers shall revisit Step 1 to confirm regulatory requirements have been met and adjust BMP selection (Step 2) and layout (Step 3) as needed until regulatory requirements can be achieved.

Further adjustments may be needed to BMP selection and layout based on the results of soil testing for BMP design (Appendix A), which shall be conducted at the conclusion of the process documented in this section, after final conceptual BMP layout. Refer to Chapter 4 of this manual for Design Calculation Methodology and Chapter 5 for BMP specific design and siting considerations.

Step 1. Determine Remaining Stormwater Management Requirements

As described in Section 3.2.1, the designer may be able to partially satisfy the SWM Ordinance requirements for volume control (see Section 2.3.1) and rate control (see Section 2.3.2) through the use of non-structural BMPs. Refer to Chapter 4 for calculation methodology for non-structural BMPs. If the volume control and rate control requirements are not completely met by the non-structural BMPs, structural BMPs must be incorporated into the design.

Step 2. Identify Appropriate Structural BMPs

Once the structural BMP stormwater management requirements have been determined by accounting for proposed non-structural BMPs (Step 1), the designer must identify appropriate structural BMP types needed to satisfy the remaining requirements. GI system types defined in this manual that are typically utilized to comply with the volume control and rate control requirement of the SWM Ordinance are listed in Table 3.2.2-1. This list is not exhaustive and the City will consider proposed alternative GI system types and structural BMPs that can meet the performance standards of the SWM Ordinance (Section §260-302).

TABLE 3.2.2-1. TYPICAL GREEN INFRASTRUCTURE SYSTEM TYPES FOR VOLUME CONTROL AND RATE CONTROL

GI System Type	GI Design Manual Reference[1]	Typical Application	
		Volume Control	Rate Control
Bioinfiltration and Bioretention	Section 5.2	Applicable (Infiltration)	Applicable (Retention)
Porous Pavement	Section 5.3	Applicable	Applicable
Green Roofs	Section 5.4	Applicable	Not Applicable
Subsurface Infiltration and Detention	Section 5.5	Applicable (Infiltration)	Applicable (Detention)
Cisterns	Section 5.6	Applicable (Reuse)	Applicable
Naturalized Basins	Section 5.7	Not Applicable	Applicable

[1]Refer to Chapter 4 of this manual for design calculation methodology and Chapter 5, Section 5.1 for general design standards and design considerations.

The designer must keep in mind that some GI systems types cannot fully meet all applicable stormwater management requirements on their own, and a network of GI systems is sometimes needed to meet the requirements of the SWM Ordinance for a given site. For example, the rate control requirement can be achieved through flow attenuation in a series of smaller, linked BMPs, as opposed to a single large BMP. GI systems in series can also be used to meet the volume control requirement by providing cumulative storage equal to the total storage volume needed to meet the requirement.

Placing BMPs in series may also allow the designer to minimize the disrupted space, limit the construction or maintenance costs of a system, or meet the SWM Ordinance on a constrained or complex site. Particular approaches will vary by site and the designer is encouraged to use creativity to combine GI systems in ways that achieve site-wide compliance. Some examples of these approaches are provided in Section 3.3 – Integrated Stormwater Management Project Examples.

Chapter 3

Step 3 – Develop BMP Placement and Layout

After determining appropriate structural BMP types to meet regulatory requirements (Step 2), the designer develops conceptual BMP placements and layouts that integrate with the layout of proposed site and building features.

Some sites will offer numerous options for locating BMPs - on rooftops, on the ground surface, or underground - while other sites, particularly "full build-out" sites (where ground-level open space is not available in the proposed site layout), will have fewer options for BMP placement. The following tables provide designers with guidance to develop conceptual BMP layouts. This guidance includes strategies related to:

- Working within Existing Site Features – Table 3.2.2-2
- Creating Efficient Stormwater Conveyance –Table 3.2.2-3
- Enhancing Ultimate Site Use / Operations – Table 3.2.2-4

Design strategies provided in this section offer general guidance for conceptual design of BMPs. Chapter 4 provides more information on design calculation methodology while Chapter 5 outlines design standards for specific BMP types. Appendix B also provides layout schematics for specific BMP types that can be used to help inform proper siting and layout. Additionally, further adjustments may be needed for BMP selection and layout based on the results of soil testing (Appendix A), which shall be conducted at the conclusion of the conceptual BMP layout process documented in this section.

TABLE 3.2.2-2. WORKING WITHIN EXISTING SITE FEATURES	
Strategy	**Description**
Assessing Space Constraints	BMPs rely on storage volume to achieve performance. The availability of space for BMPs will often dictate the location and type of BMPs that can work on a site. The designer shall calculate approximate design requirements (e.g.,, total required storage volume) to allocate space for stormwater management within the site layout. If insufficient space is available to incorporate surface-vegetated GI systems such as bioretention/bioinfiltration, the designer may need to consider alternatives such as porous pavement or subsurface infiltration. The use of BMPs in series, including adding subsurface infiltration storage to a bioretention system, can help the designer maximize the use of landscaped GI systems, even on constrained sites.
Choosing Areas with Infiltration Potential	Although the infiltration rate at a particular location within a site may not be known during the initial structural BMP selection and conceptual design process, the designer shall use existing information to locate BMPs in areas that have a strong potential for infiltration as identified during site assessment (Section 3.1), such as Hydrologic Soil Group based on NRCS Soil Survey. Designers should avoid areas with possible physical limitations of infiltration potential using data on seasonal high groundwater, depth to limiting layers, and karst geology.
Avoiding Utilities	Careful mapping of surface and subsurface utilities on-site is necessary to reduce conflicts and relocation of existing utilities. A designer can obtain available records by contacting PA One Call. The designer shall also consider onsite utility locating concurrent with survey and soil testing work on the site.
Avoiding Sensitive Features	BMPs shall be placed in locations that avoid sensitive features, such as mature tree stands, wetlands, steep slopes, and floodplains, and constraints, such as shallow bedrock. These areas will have been mapped during the site assessment process in Section 3.1. Many of these areas are regulated by State and Federal agencies and/or City ordinances.
Avoiding Hotspots and Contamination	Locating BMPs away from hotspots and areas of known contamination is required. The designer is referred to the hotspot investigation procedures in the PA DEP BMP Manual. During this phase, a preliminary investigation of likely hotspots is suggested. During detailed design, more exhaustive characterization of soil contamination issues may be required for individual BMP sites to determine infiltration feasibility.
Avoiding Unstable Fill	Some areas of Lancaster are underlain by historic fill, which can be loose or unstable. The designer is advised to identify areas of unstable fill through geophysical methods, exploratory geotechnical testing, or historic mapping to avoid these areas where possible.
Considering Appropriate Conditions for Vegetated BMPs	Some variables to consider include amount of sunlight received and solar orientation, wind speed and direction, temperature gain, soil type, and surface character. For example, sites facing northeast receive morning sun and tend to be cooler and wetter than those facing southwest, and runoff from asphalt will be hotter than that from concrete. Combinations of these variables create different microclimates and shall be taken into account when placing the BMP and selecting plants.

TABLE 3.2.2-3. CREATING EFFICIENT STORMWATER CONVEYANCE	
STRATEGY	DESCRIPTION
Prioritizing Low-Lying Areas	Surface-level BMPs shall be located on lower portions of a site, where stormwater can be gravity-fed from impervious area to the BMPs without making the BMPs excessively deep. These low-lying areas shall be prioritized for stormwater management early in the site design process.
Providing Downstream Points of Relief	BMPs need to provide positive overflow drainage for both overflow structures and underdrains (see Chapter 5 for specific requirements). BMP elevations must not be too low to preclude tying in underdrains and overflow structures to a downstream point of relief (e.g.,, sewer or receiving water).
Minimizing Conveyance Requirements	BMPs can be less costly and easier to maintain if the designer reduces the amount of conveyance piping. Opportunities to sheet flow stormwater from impervious areas to BMPs, or to use surface conveyance systems like swales to bring stormwater into BMPs, shall be considered along with other non-structural BMPs (see Section 3.2.1). In some cases, the designer may be able to use natural drainage features to convey stormwater with little additional cost.

TABLE 3.2.2-4. ENHANCING ULTIMATE SITE USE AND OPERATIONS	
STRATEGY	DESCRIPTION
Creating On-Site Amenities	As vegetated features, BMPs such as green roofs and bioinfiltration/bioretention basins provide on-site greening that can act as an aesthetic amenity, particularly for residential and commercial retail sites. Bioinfiltration/bioretention BMPs shall be designed in conjunction with other desired and required landscaping. Employing a mixture of above ground and below ground storage within a single BMP can create vegetated surface expressions in smaller areas that may not be suitable for full-storage above ground BMPs. Consider green roofs for low lying roof surfaces that provide viewing opportunities from high above.
Providing Maintenance Access	Locating BMPs in areas where they can be easily accessed for maintenance is an important design consideration. Vehicular access routes, if needed for sediment removal, shall be considered.
Developing smart parking lot layouts	Use of angled parking and one-way drive isles can reduce parking lot size, creating room for median bioretention systems that create visual interest, reduce heat island effect, and create pedestrian access routes.
Using alternative hardscapes	The use of porous pavements, particularly paver based systems can create visual interest within hardscape environments and work particularly well within parking stalls in parking lots (as opposed to drive isles).
Managing traffic	Consider the use of bumpouts and bump-ins for traffic calming and visual interest along entry roads.
Reducing landscape maintenance needs	The use of smaller stormwater planters can add visual interest along building exteriors and covered walkways. Use these systems in place of traditional flower boxes or landscape beds to reduce watering needs. Consider large wetland or rain garden features as aesthetic focal points for entry ways. These systems can create year-round aesthetic appeal, while reducing the need for maintenance intensive turf systems.
Using rainwater harvesting as an architectural feature	Cisterns and other rainwater collection systems can work well as designed architectural elements within atrium lobbies or adjacent to hardscape entry plazas. Decorative metal or wood facades can be designed to match building façade materials.
Maintaining Sight Lines	Clear lines of sight are critical for pedestrian and vehicular safety. BMPs shall be placed so as not to impair lines of sight, and the designer must consider full mature conditions for vegetation when assessing sight line issues.
Ensuring Safety	Many BMPs contain features such as ponded water that could be unsafe, particularly for vulnerable populations, such as young children. The designer shall consider locating BMPs with ponded water away from play yards, playgrounds, or other areas where children are playing, or installing fencing or other features to limit access to the system.
Reducing potential bird collisions	Use low-growing vegetation near reflective building surfaces. Taller vegetation reflected in windows causes higher mortality.

3.3 INTEGRATED STORMWATER MANAGEMENT EXAMPLES

After completing the design strategies shown in Sections 3.2 and 3.3, the designer should have a conceptual BMP layout that incorporates a series of structural and non-structural BMPs. Figures 3.3-1, 3.3-2, and 3.3-3 provide example layouts that integrate a series of BMPs into public, private, and new development sites.

Chapter 3

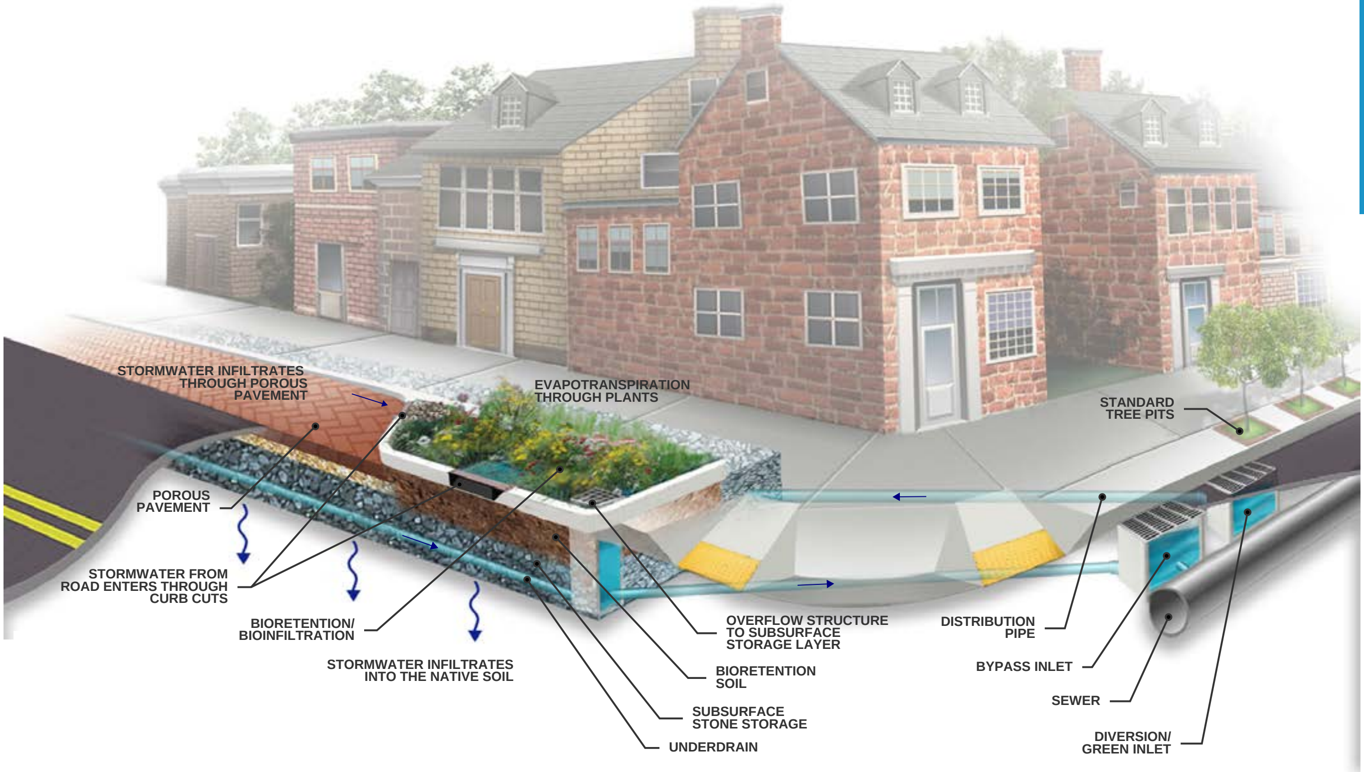


Figure 3.3-1. Project Example: ROW GI System

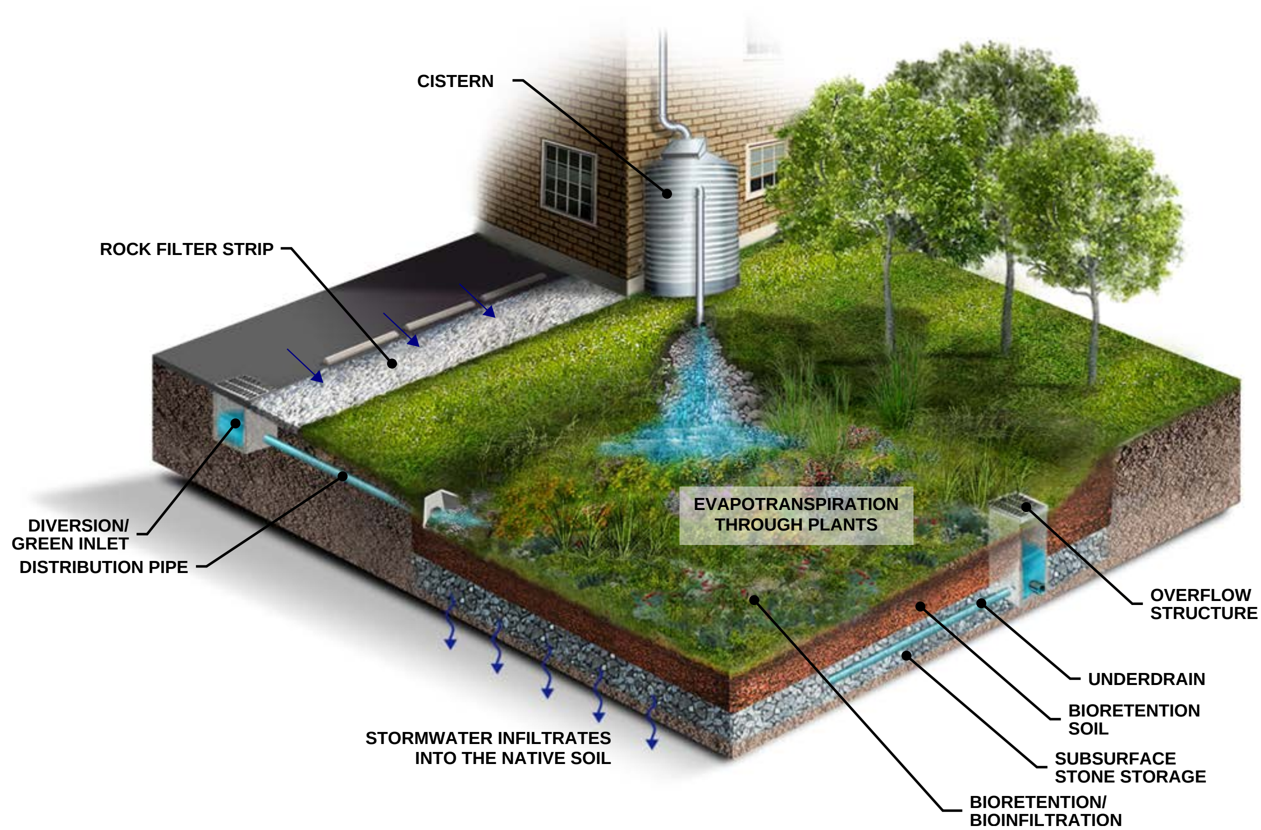


Figure 3.3-2. Project Example: On-Site GI

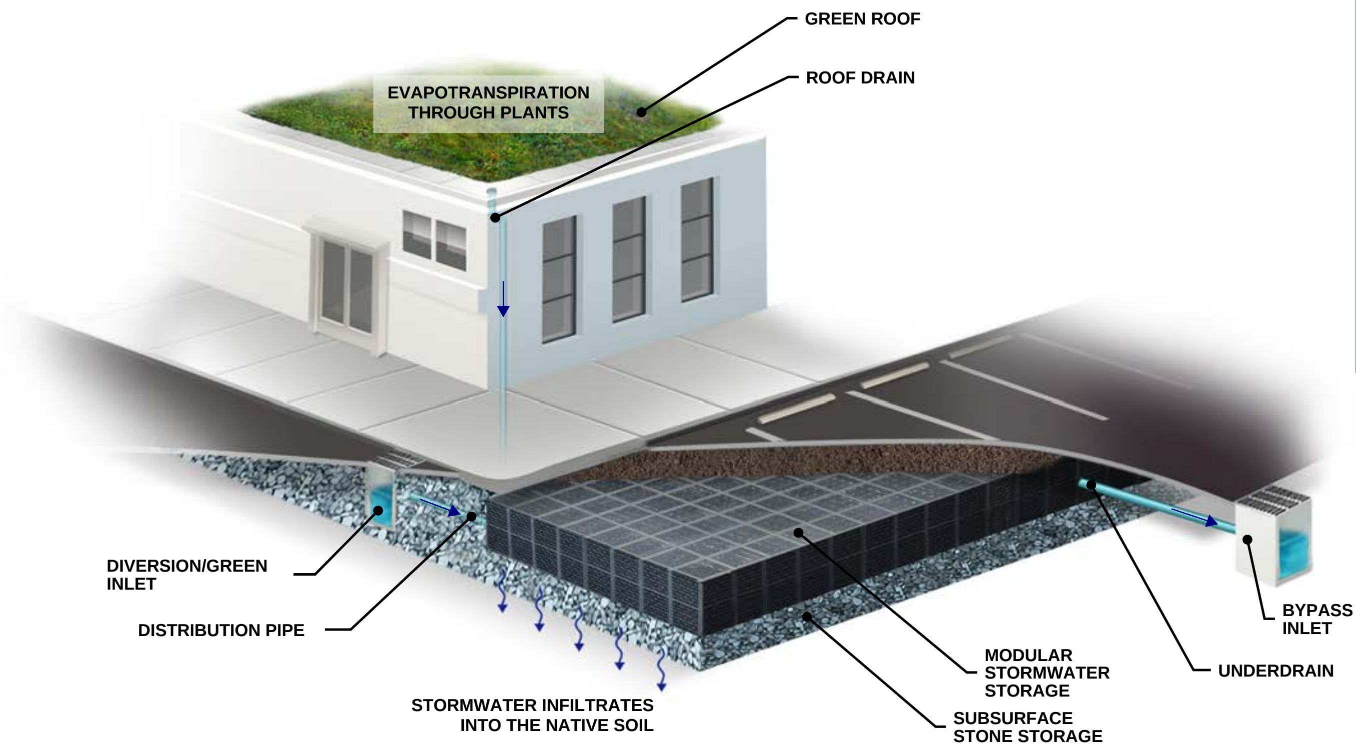


Figure 3.3-3. Project Example: Development GI

4. DESIGN CALCULATION METHODOLOGY

This chapter provides standard methods and procedures for performing design calculations to demonstrate compliance with the Stormwater Management (SWM) Ordinance requirements.

Refer to Chapter 2 for a summary of the SWM Ordinance regulatory requirements. Refer to Chapter 3 for additional guidance for non-structural BMPs. All structural BMPs must be designed in accordance with Chapter 5.

This chapter is organized into the following sections:

4.1 VOLUME CONTROL CALCULATIONS

This section provides calculation guidance to demonstrate compliance with volume control requirements and to design volume control BMPs for voluntary stormwater retrofit projects. Refer to Section 2.3.1 for volume control regulatory requirements.

Table 4.1-1. provides an overview of the volume control calculation methodology. This process may require multiple iterations to achieve a design solution that meets the project-specific needs as well as complies with all requirements of this manual and the SWM Ordinance. Detailed guidance for each step of the methodology is provided following Table 4.1-1.

TABLE 4.1-1. VOLUME CONTROL CALCULATION METHODOLOGY

Step #	Description
Step 1	For Development Projects: Within the project limits, delineate the predevelopment and postdevelopment impervious areas, as defined in the SWM Ordinance §260-301. For Retrofit Projects: Delineate the impervious area for voluntary stormwater management.
Step 2	Calculate the required retention volume necessary to meet the volume control requirement.
Step 3	Calculate the retention volume managed by existing and proposed non-structural BMPs.
Step 4	Calculate the retention volume that must be managed by structural BMPs.
Step 5	Delineate drainage areas and footprints of proposed structural BMPs.
Step 6	Calculate the loading ratios for proposed structural BMPs. Confirm that the loading ratios do not exceed the maximum allowable ratios.
Step 7	Calculate structural BMP storage volumes. Confirm BMP storage volumes are greater than or equal to that of the required retention volume.
Step 8	Calculate BMP drawdown time and confirm that drawdown requirements are met.
Step 9	For slow-release structural BMPs, calculate the maximum release rate. Confirm that the maximum release rate does not exceed the required release rate.
Step 10	Confirm that the postdevelopment runoff does not exceed the predevelopment runoff volume.
Step 11	Calculate the annual stormwater volume reduction.
Step 12	Calculate the annual pollutant load reduction.

Step 1. Delineate Predevelopment and Postdevelopment Impervious Areas

Delineate predevelopment impervious areas and postdevelopment new and reconstructed impervious areas within the project limits. For retrofit projects, delineate the impervious areas that will be managed by BMPs.

Step 2. Calculate Volume Control Retention Volume

SWM Ordinance §260-303 volume control requires retention of at least one inch of runoff from all new or reconstructed impervious areas. Using the areas delineated in Step 1, calculate the retention volume required to meet the volume control requirements using the equation below.

$$V_{RT} = DA \times \frac{R}{12}$$

(Equation 4.1-1)

Where,

V_{RT} = *Total retention volume to be managed by non-structural and/or structural BMP(s) (cubic feet)*

DA = *Impervious drainage area (square feet)*

R = *Runoff depth managed (inch) = 1 inch minimum*

Step 3. Calculate Retention Volume Managed by Non-structural BMPs

SWM Ordinance §260-301 states that non-structural BMPs "shall be utilized for all regulated activities unless proven to be impractical by the Director." The following non-structural BMPs can be utilized to reduce the amount of retention volume required to be managed by structural BMPs:

- Rooftop Disconnection
- Pavement Disconnection
- Tree Canopy Disconnection

Use the following steps to calculate retention volume managed by non-structural BMPs.

Step 3-A. Calculate Rooftop Disconnections

Rooftop impervious area disconnection can be used to manage the required retention volume by directing runoff from rooftop areas to a pervious area. This allows for infiltration, filtration, and increased time of concentration. When directing roof downspouts to a pervious area, the following criteria must be met:

- Rooftop drainage area to each disconnection point must be less than 500 square feet.
- Each disconnected roof leader must have a unique flow path over a pervious area to be considered disconnected. A single pervious area cannot be credited for multiple disconnections (pavement or rooftop).
- The average slope of the disconnection area slope must be less than or equal to 5%.
- Pervious area must not be classified as hydrologic soil group "D" or equivalent.
- Flow path over pervious area must be continuous and not interrupted by impervious area.

The depth of stormwater runoff that can be considered for managed retention volume is calculated based on the length of the uninterrupted pervious flow path measured from the point of disconnection. Table 4.1-2. defines the relationship between pervious flow path and runoff depth managed.

TABLE 4.1-2. ROOFTOP DISCONNECTION — PERVIOUS FLOW PATH VS. RUNOFF DEPTH MANAGED

Pervious Flow Path (Feet)	Runoff Depth Managed (Inches)
0-14	0.00
15-29	0.20
30-44	0.40
45-59	0.60
60-74	0.80
75+	1.00

Calculate the retention volume managed by the rooftop disconnection BMP(s) using the following equation.

$$V_R = A_R \times \frac{R}{12}$$

(Equation 4.1-2)

Where,

V_R = *Retention volume managed by rooftop disconnection (cubic feet)*

A_R = *Disconnected impervious roof area (square feet)*

R = *Runoff depth managed (inches, Table 4.1-2.)*

Step 3-B. Calculate Pavement Disconnections

Pavement disconnection can be used to manage the required retention volume by directing runoff from impervious pavement areas to an adjacent pervious area. This allows for infiltration, filtration, and increased time of concentration. When directing runoff from impervious pavement to a pervious area, the following criteria must be met:

- Pavement drainage area to each disconnection area must be less than 1,000 square feet.
- Maximum contributing impervious flow path length must be 75 feet or less.
- Each disconnected pavement area must drain to a unique pervious area to be considered disconnected. A single pervious area cannot be credited for multiple disconnections (pavement or rooftop).
- Pervious area must be contiguous to pavement area and receive runoff through sheet flow.
- The average slope of the disconnection area slope must be less than or equal to 5%.
- Pervious area must not be classified as hydrologic soil group "D" or equivalent.
- Flow path over pervious area must be continuous and not interrupted by impervious area.

The depth of stormwater runoff that can be considered for managed retention volume is calculated based on the ratio of the impervious area flow length to the pervious area flow length, or the flow path ratio. Table 4.1-3. defines the relationship between flow path ratio and runoff depth managed.

TABLE 4.1-3. PAVEMENT DISCONNECTION — FLOW PATH RATIO VS. RUNOFF DEPTH MANAGED

Flow Path Ratio	Runoff Depth Managed (Inches)
0.2:1	0.20
0.4:1	0.40
0.6:1	0.60
0.8:1	0.80
1:1	1.00

Calculate the retention volume managed by the pavement disconnection BMP(s) using the following equation.

$$V_P = A_P \times \frac{R}{12}$$

(Equation 4.1-3)

Where,

V_P = *Retention volume managed by pavement disconnection (cubic feet)*

A_P = *Disconnected impervious pavement area (square feet)*

R = *Runoff depth managed (inches, See Table 4.1-3.)*

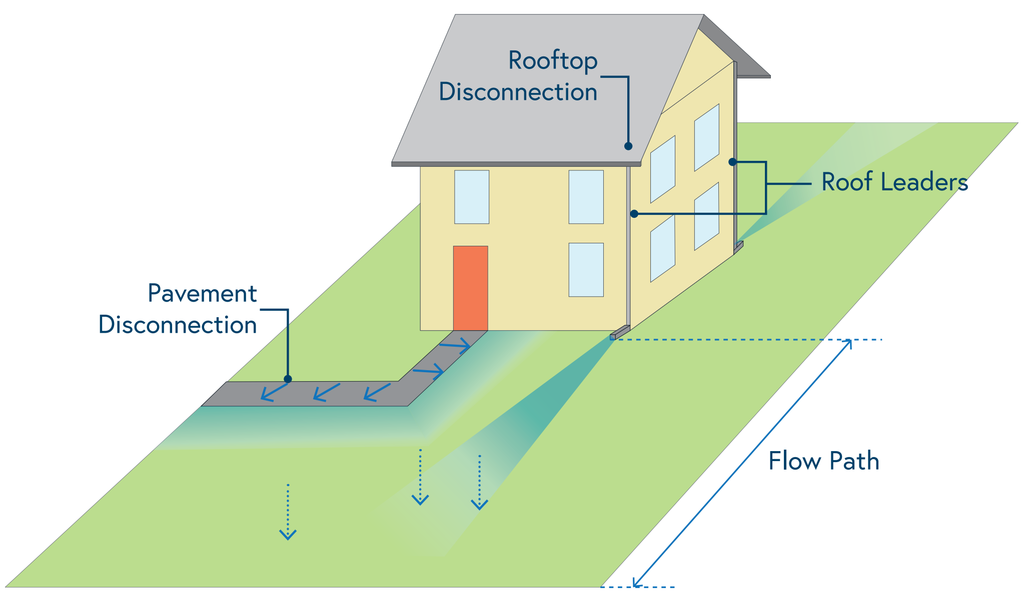


Figure 4.1-1. Illustration of Flowpath for Rooftop and Pavement Disconnection

Step 3-C. Calculate Tree Canopy Disconnections

Tree canopy disconnection can be used to manage the required retention volume where existing and proposed trees that have canopies that are directly above impervious area (IA). There are separate criteria for existing and proposed trees to qualify for disconnection. Only impervious areas directly under the tree canopy may be considered as disconnected IA (see Figure 4.1-2.).

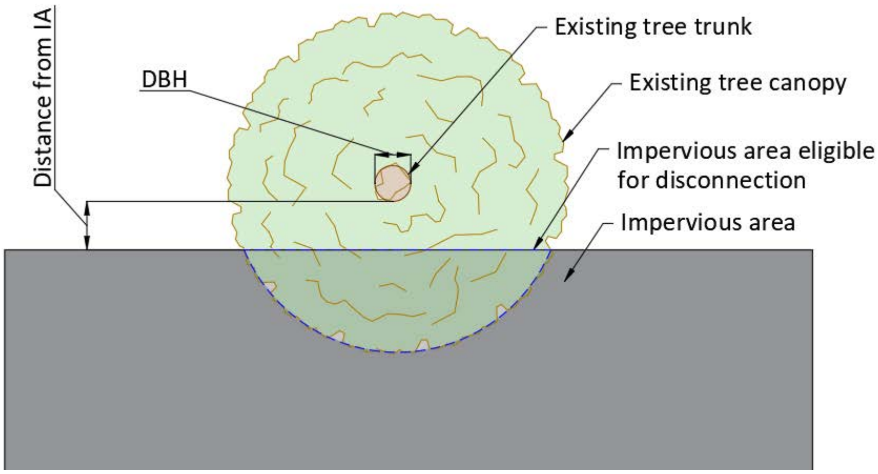


Figure 4.1-2. Illustration of Eligible Impervious Area for Tree Canopy Disconnection

Step 3-C.1. Existing Trees

Existing trees can be used as non-structural BMPs to manage the required retention volume provided the trees meet the criteria in Table 4.1-4.

TABLE 4.1-4. ROOFTOP DISCONNECTION — PERVIOUS FLOW PATH VS. RUNOFF DEPTH MANAGED

Tree Type	Minimum Size	Maximum Distance from IA (Feet)	Disconnected IA (Square Feet)
Deciduous	4 inch DBH	20	15% of Canopy Area
Coniferous	6 foot height	20	30% of Canopy Area

The following terms and requirements apply:

- All trees must be species listed in the City of Lancaster Tree Manual and Appendix D of this manual unless otherwise approved by the City Engineer.
- Tree diameter at breast height (DBH) is measured as the diameter of the tree at a height of 4.5 feet above the ground from the highest elevation adjacent to the trunk.
- Distance from impervious area is measured from the base of the trunk at ground level to the edge of the adjacent impervious area.
- Tree canopy area must be measured in the field using the International Society of Arboriculture (ISA) recommended methods.
- Total disconnected area from tree canopy shall not exceed 25% of the total impervious area within the project area.

Tree canopy disconnection area is calculated using the following equations.

$$A_{ED} = 0.15 \times CA \quad \text{(Equation 4.1-4)}$$

$$A_{EC} = 0.30 \times CA \quad \text{(Equation 4.1-5)}$$

Where,

A_{ED} = *Impervious area disconnected by an existing deciduous tree (square feet)*

A_{EC} = *Impervious area disconnected by an existing coniferous tree (square feet)*

CA = *Canopy area of an existing tree (square feet)*

Existing trees that fail to meet the size or distance requirement in Step 3-C.1 may be credited as newly planted trees if they meet the criteria in Step 3-C.2. In the event an existing tree meets both existing and newly proposed tree criteria, the designation resulting in a greater disconnection area may be used.

Step 3-C.2. Newly Proposed Trees

Newly proposed trees can be used as non-structural BMPs to manage the required retention volume provided the proposed trees meet the criteria in Table 4.1-5.

TABLE 4.1-5. DISCONNECTION AREA FOR NEW TREES

Tree Type	Minimum Size	Distance form IA	Disconnected Impervious Area (Square Feet)
Deciduous	2.5 inch DBH	10	A_{ND} = 50
Coniferous	4 foot height	10	A_{NC} = 100

The following terms and requirements apply:

- All trees must be species listed in the City of Lancaster Tree Manual and Appendix D of this manual unless otherwise approved by the City Engineer.
- Distance from impervious area is measured from the base of the trunk at ground level to the edge of the adjacent impervious area.
- Total disconnected area from tree canopy shall not exceed 25% of the total impervious area within the project area.
- Size must be clearly specified in project construction documents.

Step 3-C.3. Total Tree Canopy Retention Volume Calculation

The retention volume that is managed by tree canopy disconnection BMP(s) is calculated using the following equation.

$$V_{TC} = (\Sigma A_{EC} + \Sigma A_{ED} + \Sigma A_{NC} + \Sigma A_{ND}) \times \frac{R}{12}$$

(Equation 4.1-6)

Where,

V_{TC} = Retention volume to be managed by tree canopy disconnection (cubic feet)

ΣA_{EC} = Impervious area disconnected by all existing coniferous trees (square feet)

ΣA_{ED} = Impervious area disconnected by all existing deciduous trees (square feet)

ΣA_{NC} = Impervious area disconnected by all new coniferous trees (square feet)

ΣA_{ND} = Impervious area disconnected by all new deciduous trees (square feet)

R = Runoff depth managed (inch) = 1 inch

Step 3-D. Calculate Total Non-Structural BMP Retention Volume

The retention volume managed by all non-structural BMPs is calculated as follows:

$$V_{RN} = V_R + V_P + V_{TC}$$

(Equation 4.1-7)

Where,

V_{RN} = Retention volume to be managed by non-structural BMPs (cubic feet)

V_R = Retention volume to be managed by rooftop disconnection (cubic feet)

V_P = Retention volume to be managed by pavement disconnection (cubic feet)

V_{TC} = Retention volume to be managed by tree canopy (cubic feet)

Step 4. Calculate the Required Retention Volume for Structural BMP(s)

Once the retention volume managed by non-structural BMPs has been calculated, determine the required retention volume to be managed by structural BMPs using the following equation:

$$V_{RS} = V_{RT} - V_{RN}$$

(Equation 4.1-8)

Where,

V_{RS} = Retention volume to be managed by structural BMPs (cubic feet)

V_{RT} = Total retention volume to be managed (cubic feet)

V_{RN} = Retention volume to be managed by non-structural BMPs (cubic feet, Equation 4.1-7)

Step 5. Delineate Drainage Areas and Footprints for Structural BMPs

Delineate the pervious and impervious drainage areas to each proposed structural BMP. These areas are used to calculate loading ratios, size the BMP, and calculate peak flow rates. BMP footprints must be calculated as the area at the bottom (lowest) elevation of the BMP.

Step 6. Calculate the Loading Ratios for Structural BMPs

A loading ratio is a comparison of the impervious drainage area directed to a BMP to the BMP bottom footprint; it is a proxy for sediment and other pollutant loading to a BMP. BMP loading ratio is calculated using the following equation:

$$LR = \frac{DA}{A} \quad \text{(Equation 4.1-9)}$$

Where,

LR = Loading ratio

DA = Impervious drainage area that drains directly to the BMP, excluding any impervious area within the drainage area that is managed by non-structural BMPs (square feet)

A = Footprint of the BMP at the bottom elevation (square feet)

Loading ratio must be calculated for each BMP and compared to the maximum allowable loading ratio. If the loading ratio to a BMP is above the maximum allowable ratio, the BMP must be resized.

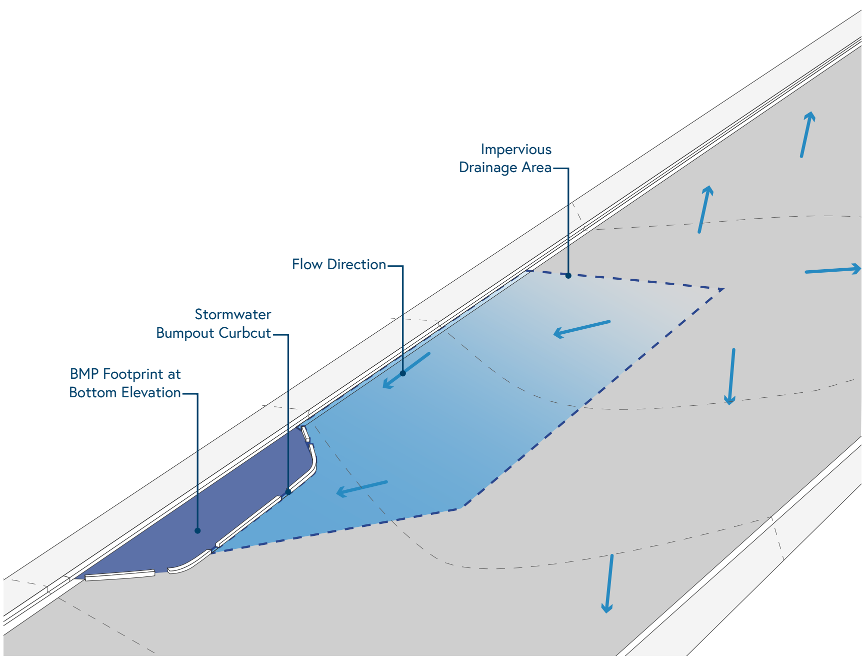


Figure 4.1-3. Illustration of Impervious Drainage Area and BMP Bottom Footprint

Maximum Allowable Loading Ratio

The maximum allowable loading ratio of a BMP is determined by the BMP type and by the pollutant loading characteristics of the contributing impervious drainage area to the BMP.

Pollutant loading characteristics of a drainage area can be represented by the event mean concentration (EMC) of total suspended solids (TSS). Table 4.1-6 groups the land uses into three categories to represent low, medium, and high loading conditions with TSS EMC ranges for each group.

All impervious drainage areas to BMPs must be classified into one of the three categories listed in Table 4.1-6 to determine the maximum loading ratio requirements. Table 4.1-7 defines maximum loading ratios by BMP type and drainage area classification.

For BMPs proposed within karst areas strict adherence to the SWM Ordinance's maximum loading ratios of 3:1 for impervious drainage area and 5:1 for total drainage area must be met for all BMP types and drainage area categories.

TABLE 4.1-6 DRAINAGE AREA CATEGORIES

Category	TSS EMC Range (mg/L)	Associated Land Use Classification
A	0 - 12 mg/L	Rooftops
B	22 - 109 mg/L	Residential, commercial, or institutional parking; residential driveways/playgrounds; and other on-site impervious areas
C	110+ mg/L	Industrial parking and all streets

TABLE 4.1-7. BMP MAXIMUM ALLOWABLE LOADING RATIOS[1]

BMP Type	Category A Drainage Areas[2]	Category B Drainage Areas[3]	Category C Drainage Areas[4]
Bioretention/Bioinfiltration	No maximum	16	5 or use Loading Ratio Adjustment Method (whichever is greater)
Green Roofs	1.5	1	N/A
Porous Pavement	No maximum	4	3
Subsurface Infiltration	No maximum	8	5 or use Loading Ratio Adjustment Method (whichever is greater)
Subsurface Detention	No maximum	No maximum	No maximum

1. Does not apply for proposed BMPs within karst areas.
2. Category A land uses only.
3. Category A or B land uses only.
4. Any combination of land uses that include Category C.

If the BMP maximum allowable loading ratio does not require the Loading Ratio Adjustment Method, proceed to **Step 7**. Otherwise, follow the Loading Ratio Adjustment Method detailed below.

Loading Ratio Adjustment Method

For Category C drainage areas, the loading ratios provided in Table 4.1-7 may be used or an adjusted loading ratio may be calculated which could allow for a higher loading ratio. In this method, the loading ratios from Category B are adjusted based on the project-specific TSS EMC of the drainage area.

Step 6-A. Categorize the land uses in the drainage area.

The first step of the Loading Ratio Adjustment Method is to categorize the land uses of the contributing impervious drainage area. First, determine the area for all land uses in the drainage area. Next, determine the TSS EMC for each land use using Table 4.1-8.

If there is more than one type of land use in the drainage area, a weighted TSS EMC must be calculated, as detailed in **Step 6-B.**

If the drainage area consists of only one type of land use, the average TSS EMC will be the TSS EMC for that land use and a weighted average calculated is not required. Proceed to **Step 6-C**.

TABLE 4.1-8. TSS EMC CONCENTRATIONS BY LAND USE TYPE

Land Use	Recommended TSS EMC (mg/L)	Definition	Sources
Rooftop	21	Any rooftop area	Mean of (1) and (2)
Residential, Commercial, or Institutional Parking	65	Any residential, commercial, or institutional parking	Mean of (1), (2), and (4)
Residential Driveway, Play Courts, etc.	109	Residential or institutional on-site impervious area not used for parking	Mean of (2) and (5)
Low Traffic/ Residential Street	174	Collector and local retail and residential streets, as defined by the City of Lancaster Code 360, Chapter 265 Subdivision and Land Development	Mean of (2) and (3)
High Traffic Street	200	Major arterial streets, as defined by the City of Lancaster Code 360, Chapter 265 Subdivision and Land Development	Mean of (2), (3), and (4)
Industrial Parking	270	Any industrial parking	Mean of (1) and (4)
Medium Traffic/ Commercial Street	316	Secondary arterial streets, as defined by the City of Lancaster Code 360, Chapter 265 Subdivision and Land Development	Mean of (2) and (4)

(1) Claytor, R. and T. Schueler. 1996. Design of Stormwater Filtering Systems. Center for Watershed Protection. Ellicott City, MD.
(2) Steuer, Jeffrey, et al. Sources of contamination in an urban basin in Marquette, Michigan and an analysis of concentrations, loads, and data quality. No. 97-4242. US Geological Survey, 1997.
(3) United States Department of Transportation. Federal Highway Administration. 1990. Pollutant loadings and impacts from highway stormwater runoff. FWHA-RD/88-06. Washington, DC. 440 pp.
(4) Bannerman, Roger T., et al. "Sources of pollutants in Wisconsin stormwater." Water Science and Technology 28.3-5 (1993): 241-259.
(5) Philadelphia Water Department, Office of Watersheds, 2000. Technical Memorandum No. 3: A Screening Level Contaminant Loading Assessment for the Darby and Cobbs Creek Watershed.

Step 6-B. Calculate the Area Weighted Average TSS EMC for the Drainage Area

Once the TSS EMC and area have been determined for each land use type in the drainage area, calculate the area weighted TSS EMC using the following equation:

$$TSS\ EMC_{AVG}\ \left(\frac{mg}{L}\right) = \frac{\sum_{i=1}^{n} A_i \times TSS\ EMC_i}{DA}$$ *(Equation 4.1-10)*

Where,

n = The number of land use types in the BMP drainage area

A_i = Drainage area of land use type i (square feet)

$TSS\ EMC_i$ = TSS EMC of land use type i (milligrams per liter, Table 4.1-8)

DA = Impervious drainage area that drains directly to the BMP, excluding any impervious area within the drainage area that is managed by non-structural BMPs (square feet)

NOTE: *If the average TSS EMC of the drainage area is less than or equal to 109 mg/L, the Category B maximum allowable loading ratio from Table 4.1-7* **must** *be used. Loading ratios higher than that of Category B are not permitted.*

Step 6-C. Calculate the Maximum Allowable Loading Ratio

Using the average TSS EMC calculated in Equation 4.1-10, the maximum allowable loading ratio of the BMP shall be calculated as follows:

$$Allowable\ LR = LR_0 \times \frac{TSS\ EMC_0}{TSS\ EMC_{AVG}}$$ *(Equation 4.1-11)*

Where,

LR_0 = The Category B maximum allowable loading ratio for the BMP type (Table 4.1-7.)

$TSS\ EMC_0$ = 109 milligrams per liter, the maximum pollutant load for Category B (Table 4.1-6.)

$TSS\ EMC_{AVG}$ = Area weighted average TSS EMC for the drainage area (mg/L, Equation 4.1-10)

NOTE: The calculated maximum allowable loading ratio shall be rounded to the nearest whole number.

Step 6 Example Calculation

This example uses the Loading Ratio Adjustment Method to calculate the maximum allowable loading ratio for a subsurface infiltration system that is not within karst geology.

Step 6-A. Categorize the Land Uses in the Drainage Area

In this example, the subsurface infiltration BMP has three types of land uses within its drainage area, as shown in Table 4.1-9. The TSS EMCs for the land uses were obtained from Table 4.1-8.

TABLE 4.1-9. EXAMPLE FOR WEIGHTED TSS EMC CALCULATION

Land Use	Area (SF)	TSS EMC (mg/L)
Rooftops	500	21
Residential, commercial, or institutional parking	5,000	65
Medium Traffic/Commercial Street	7,500	316

Step 6-B. Calculate the Area Weighted Average TSS EMC for the Drainage Area.

Using Equation 4.1-10 and Table 4.1-9, the area weighted average TSS EMC for the entire drainage area to the subsurface infiltration BMP is calculated as follows.

$$TSS\ EMC_{AVG}\left(\frac{mg}{L}\right) = \frac{\sum_{i=1}^{n} A_i \times TSS\ EMC_i}{DA}$$

$$Area\ Weighted\ TSS\ EMC\left(\frac{mg}{L}\right) = \frac{500\ sf * 21\frac{mg}{L} + 5000\ sf * 65\frac{mg}{L} + 7500\ sf * 316\frac{mg}{L}}{500\ sf + 5000\ sf + 7500 sf} = 208\frac{mg}{L}$$

Step 6-C. Calculate the maximum allowable loading ratio.

Using the area weighted average TSS EMC calculated above, the maximum allowable loading ratio may be calculated using Equation 4.1-11 and the maximum allowable loading ratio from Table 4.1-7.

$$Allowable\ LR = LR_0 \times \frac{TSS\ EMC_0}{TSS\ EMC_{AVG}}$$

Given:

LR_0 = 8 for subsurface infiltration BMPs (Table 4.1-7)
$TSS\ EMC_0$ = 109 mg/L
$TSS\ EMC_{AVG}$ = 208 mg/L

$$Allowable\ LR = 8 \times \frac{109\frac{mg}{L}}{208\left(\frac{mg}{L}\right)} = 4.192 \approx 4$$

Because the maximum allowable loading ratio calculated with the Loading Ratio Adjustment Method is less than 5 (see Table 4.1-7), a **loading ratio of 5** may be used in the design of this BMP.

Step 7. Calculate Structural BMP Storage Volumes

The SWM Ordinance requires documentation showing that the retention volume is adequately managed by proposed BMP(s) (refer to Section 2.3.1). Multiple structural BMPs can be used to manage the retention volume.

Calculation Requirements

- Storage above the BMP overflow elevation cannot be included in the calculation of retention volume storage.
- For detention/slow-release systems, storage below the outlet elevation cannot be included in the calculation of retention volume storage.
- Storage calculations for each individual BMP must be provided.

Step 7-A. Calculate Surface Storage Volume

The surface storage capacity of a structural BMP is calculated using the following equation.

$$V_{SURF} = \frac{(A_{TP} + A_{BP})}{2} \times D_P$$

(Equation 4.1-12)

Where,

V_{SURF} = *Total surface volume managed (cubic feet)*

A_{TP} = *Top of ponding area (square feet)*

A_{BP} = *Bottom of ponding area (square feet)*

D_P = *Depth of ponding (feet)*

More complex geometries for surface storage may require calculating Equation 4.1-12 multiple times.

Step 7-B. Calculate Subsurface Storage Volume

The subsurface storage capacity of a structural BMP will depend on the storage media and storage structures that form the BMP. The storage capacity of these features varies and in turn depends on the volume of voids present within the specific feature (Equation 4.1-13). To determine the storage capacity, specific void volumes, which are typically presented as percentages or ratios, are applied to the volume occupied by the media or structure. Typical void ratios are shown in Table 4.1-10.

TABLE 4.1-10. VOID RATIOS		
Void Ratio	Storage Type*	Notes
0.40	Stone aggregate	
0.20	Soil	Mulch and compost can be included in the soil storage calculation.
0.30	Sand	
0.92	Pipe	
Varies	Proprietary storage system	Refer to the manufacturer for the void ratio.

*Must meet required material specifications of this manual.

$$V_{SUB} = \sum_{i=1}^{n} A_{SUB_i} \times d_i \times \varphi_i$$

(Equation 4.1-13)

Where,

V_{SUB} = *Subsurface storage volume (cubic feet)*

A_{SUBi} = *Subsurface footprint of storage layer i (square feet)*

d_i = *Depth of storage layer i (feet)*

φ_i = *Void ratio of storage layer i (see Table 4.1-10)*

n = *Number of storage layers*

i = *Storage layer i*

Step 7-C. Calculate Total Storage Volume

The total volume managed by the BMP must be greater than or equal to the retention volume:

$$V_T = V_{SURF} + V_{SUB}$$

(Equation 4.1-14)

The total volume managed by all the structural BMPs must be greater than or equal to the structural BMP retention volume:

$$V_{RS} \leq \sum_{i=1}^{n} V_{T\,i}$$

(Equation 4.1-15)

Where,

V_{RS} = *Retention volume required to be managed by structural BMPs (cubic feet)*

V_{Ti} = *Total surface and subsurface volume managed by structural BMP i (cubic feet)*

n = *Total number of structural BMPs*

i = *Structural BMP i*

If the BMP(s) cannot manage the required retention volume, the BMP(s) must be resized. BMP re-sizing may result in changes to the loading ratio. Loading ratios must be checked for all re-designed structural BMPs to ensure requirements are still met.

Step 8. Calculate Structural BMP Drawdown Time

The storage volume of structural BMPs must completely drain over a period of time not less than 24 hours and not more than 72 hours from the end of the design storm. Any water stored at the surface must drawdown within 24 hours from the end of the design storm. See Section 2.3.1. C for specific exemptions of drawdown requirements.

Infiltrating Systems

Drawdown time for infiltrating systems can be calculated using the equation below.

$$t = \frac{\left(\frac{V_s}{A_i}\right)}{i} \times 12$$

(Equation 4.1-16)

Where,

t = *Drawdown time (hours)*

V_s = *Static storage volume (cubic feet)*

A_i = *Infiltration footprint at one-third of the ponding depth from the bottom of ponding (square feet)*

i = *Tested infiltration rate (inches per hour)*

Slow Release Systems

Drawdown time for extended detention or slow-release systems can be calculated using the equation 4.1-17.

$$t = \frac{2V_s}{C_d A_o \sqrt{2gh}} \times \frac{1}{3600}$$

(Equation 4.1-17)

Where,

t = *Drawdown time (hours)*

Vs = *Static storage volume (cubic feet)*

h = *Maximum hydraulic head (feet)*

C_d = *Discharge coefficient = 0.62*

A_o = *Area of orifice (square feet)*

g = *Gravitational constant (feet per second squared)*

Step 9. Calculate Maximum Release Rate for Slow-Release Structural BMPs

Documentation of stormwater release rate is required for BMPs designed as slow-release BMPs rather than infiltration BMPs. A system's maximum release rate can be calculated using the maximum head over the discharge point (as described below) or by modeling. Contact the City Engineer to determine the allowable maximum slow-release rate. The maximum slow release rate will vary based on project location, sewershed, and capacity of receiving infrastructure.

BMP stormwater slow-release rates can be calculated using the orifice equation, as shown below. The maximum head over the discharge point, typically an orifice, shall be used as the hydraulic head.

$$Q_{allowable} \leq Q_{max} = C_d A_o \sqrt{2gh}$$

(Equation 4.1-18)

Where,

$Q_{allowable}$ = *Allowable maximum release rate (cubic feet per second)*

Q_{max} = *Maximum release rate (cubic feet per second)*

C_d = *Discharge coefficient = 0.62*

A_o = *Area of orifice (square feet)*

g = *Gravitational constant (feet per second squared)*

h = *Hydraulic head (feet)*

Step 10. Confirm Postdevelopment Runoff Does Not Exceed Predevelopment Runoff

In addition to the retention of the first one inch of runoff, the SWM Ordinance §260-303 volume control requires modeling showing that the postdevelopment total runoff volume does not exceed the predevelopment total runoff volume for storms equal to or less than the two-year, 24-hour storm event.

Refer to SWM Ordinance §260-303(A)(2) for modeling parameters and refer to the rate control section for calculation requirements.

Step 11. Calculate Annual Runoff Reduction

The following methodology is used to calculate the annual runoff reduction provided by the implementation non-structural and structural BMPs:

Step 11-A. Calculate the Total Annual Impervious Area Runoff

$$RT_{ANNUAL} = DA \times AR \times ARR \times \frac{7.4805}{10^6}$$

(Equation 4.1-19)

Where,

RT_{ANNUAL} = Total annual impervious area runoff (million gallons per year)

DA = Impervious drainage area managed (square feet)

AR = Average annual rainfall (inches per year) = 42.04 inches per year

ARR = Average annual rainfall on impervious areas that become runoff (%) = 85%

Step 11-B. Calculate the Annual Percent Runoff Reduction

The following equation calculates the average percent annual runoff reduced based on the runoff depth managed:

$$RR_{AVG} = -0.195 \times R^4 + 1.0588 \times R^3 - 2.1835 \times R^2 + 2.1692 \times R + 0.0106$$

(Equation 4.1-20)

Where,

RR_{AVG} = Average annual runoff reduction (%)

R = Runoff depth managed (inches) <= 1 inch

Annual runoff reduction is calculated using the following equation:

$$RR_{Annual} = DA_{MANAGED} \times RT_{ANNUAL} \times RR_{AVG}$$

(Equation 4.1-21)

Where,

RR_{Annual} = Total annual impervious area runoff reduction (million gallons per year)

$DA_{MANAGED}$ = Percent of total impervious area managed (%)

RT_{ANNUAL} = Total annual impervious area runoff (million gallons per year, Equation 4.1-19)

RR_{AVG} = Average annual impervious area runoff reduction (%, Equation 4.1-20)

Step 12. Calculate Annual Pollutant Load Reduction

Pollutant load reductions are calculated for reporting purposes only and do not have associated requirements in the SWM Ordinance. Calculate the annual pollutant load reductions for total suspended soils (TSS), total phosphorous (P) and total nitrogen (TN) using the following equations:

$$RedCSO_{ANNUAL} = RR_{ANNUAL} \times CSS_{CAPTURE} \times RedCSO_{EFFICIENCY}$$ *(Equation 4.1-22)*

Where,

$RedCSO_{ANNUAL}$ = Estimated total annual CSO reduction from impervious area runoff (million gallons per year)

RR_{ANNUAL} = Total annual impervious area runoff reduction (million gallons per year, Equation 4.1-21)

$CSS_{CAPTURE}$ = Percentage of capture in the CSS = 100%

$RedCSO_{EFFICIENCY}$ = CSO reduction efficiency, the ratio of stormwater capture to CSO reduction in the CSS = 63.9%

$$PR_{Annual} = ReductionCSO_{ANNUAL} \times \frac{[CSO\ Discharge]}{453592.37} \times 10^6 \times 3.785412$$ *(Equation 4.1-23)*

Where,

PR_{ANNUAL} = Total annual pollutant reduction (pounds per year)

$RedCSO_{ANNUAL}$ = Estimated total annual CSO reduction annual impervious area runoff (million gallons per year, Equation 4.1-22)

[CSO Discharge] = Average CSO discharge concentration of pollutant (milligrams per liter, Table 4.1-11)

TABLE 4.1-11. AVERAGE POLLUTANT CONCENTRATIONS IN CSO DISCHARGE

Pollutant	Average CSO Discharge Concentration (mg/L)[1]
Total Suspended Solids (TSS)	94
Total Phosphorus (TP)	0.7
Total Nitrogen (TN)	3.6

[1]TN and TP based on USEPA's CSO Report to Congress (2004); TSS from City of Lancaster monitoring data.

4.2 RATE CONTROL CALCULATIONS

Introduction

The general design calculation methodology for structural BMPs is summarized in this section to ensure accordance with the SWM Ordinance. Refer to Section 2.3.2 for a summary of the SWM Ordinance rate control regulatory requirements.

Table 4.2-1. provides an overview of the rate control requirement calculation methodology. Detailed equations are presented in the subsequent sections.

Rate control is required for regulated activity that does not meet the definition of small project or very small project.

TABLE 4.2-1. RATE CONTROL CALCULATION METHODOLOGY

Step #	Description
Step 1	Determine a point of discharge within the sewershed for comparison of the pre- and postdevelopment conditions.
Step 2	Develop drainage area maps within limits of the project.
Step 3	Develop the pre- and postdevelopment runoff to the point of discharge using an acceptable computation methodology.
Step 4	Design the BMPs to meet the rate control requirements.

Step 1. Determine a point of discharge within the sewershed for comparison of the pre- and postdevelopment conditions

Select a common point of discharge for comparison of predevelopment and postdevelopment conditions. It is recommended using a single point of discharge unless project site discharges to multiple sewers, waterbodies, outfalls.

Step 2. Develop drainage area maps within limits of the project

Delineate drainage areas for each point of discharge. Include all areas within the project limits, areas which flow through project site, and any project areas that bypass BMPs.

Step 3. Determine the total pre- and postdevelopment runoff to the point of discharge

The pre- and postdevelopment drainage areas and conditions shall be determined and used in an acceptable computation methodology per Table III-1 of SWM § 260-305B, reproduced as Table 4.2-2.

TABLE 4.2-2. ACCEPTABLE COMPUTATION METHODOLOGIES FOR STORMWATER MANAGEMENT PLANS		
METHOD	METHOD DEVELOPED BY	APPLICABILITY
TR-20 (or commercial computer package based on TR-20)	USDA NRCS	Applicable where use of full hydrology computer model is desirable or necessary
Win TR-55 (or commercial computer package based on TR-55)	USDA NRCS	Applicable for land development plans within limitations described in TR-55
HEC-1/HEC-HMS	U.S. Army Corps of Engineers	Applicable where use of full hydrologic computer model is desirable or necessary
Rational Method (or commercial computer package based on Rational Method)	Emil Kuichling (1889)	For pipe routing calculations development sites less than 200 acres, Tc < 60 minutes or as approved by the City of Lancaster
EFH2	USDA NRCS	Applicable in rural and undeveloped areas subject to the program limits
Other methods	Varies	Other methodologies approved by the City of Lancaster

NRCS Curve Number Method

The NRCS Curve Number Method is the preferred method used to estimate site stormwater runoff from a given storm. Additional methods may be used with discretion as detailed above.

The NRCS Curve Number Method is widely used to produce estimates of runoff volume for both pervious and impervious cover. It empirically accounts for the initial abstraction and infiltration of rainfall events based on ground cover type characteristics.

Care must be taken to select appropriate curve number values since this calculation method is very sensitive to changes in these values. To obtain conservative results, separate calculations for pervious and impervious area runoff must be used. Weighted curve number values averaged for pervious and impervious areas are not acceptable. The resulting flows can be routed, if necessary, and then summed.

Criteria and assumptions to be used in the determination of stormwater runoff and design of management facilities are as follows:

Runoff curve numbers (CN) shall be based on the information contained in the SWM Ordinance (Appendix E). If the required land use is not listed in this appendix, runoff curve numbers shall be chosen from other published documentation and is subject to review and approval by the City of Lancaster.

Peak Rate and CN Adjustment to Reflect Volume Control

To account for the impacts on peak rate reduction through the application of volume reducing measures on a project site, an adjustment may be made to the CN assigned to disturbed areas managed by a BMP. The CN value is adjusted to reflect both the volume captured in various BMPs as well as any infiltration that occurs over a defined time period during a large storm.

CN adjustment, part of the Runoff Reduction Method (Battiata, et al. 2010), combines the NRCS runoff equations 2-1 through 2-4 (renumbered below) in "Urban Hydrology for Small Watersheds" (USDA 1986) to develop an adjusted CN that accounts for the reduced runoff volume from implementing volume reduction BMPs. This modification of the standard computational procedure starts with a combination of Equations 4.2-1 and 4.2-2 in order to show runoff depth in terms of rainfall and potential retention, producing Equation 4.2-3. In addition, the potential retention, S, is related to soil and cover conditions of the watershed through the designation of a runoff CN as shown in Equation 4.2-4.

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$ *(Equation 4.2-1)*

$$I_a = 0.2S$$ *(Equation 4.2-2)*

$$Q = \frac{(P - 0.2S)^2}{(P + 0.8S)}$$ *(Equation 4.2-3)*

$$S = \frac{1000}{CN} - 10$$ *(Equation 4.2-4)*

Where:

Q = Runoff (inches)

P = Rainfall (inches)

S = Potential maximum retention after runoff begins (inches)

I_a = Initial abstraction (inches)

CN= Runoff curve number

In the CN adjustment method, the runoff depth (Q) is reduced to reflect the volume captured or infiltrated. The retention storage depth retained onsite (equivalent to the storage provided on the site through various structural BMPs and infiltration) is reflected in terms of R and is subtracted from the total runoff depth, Q, in inches. A new modified S value (S_{mod}) is then calculated using Equation 4.2-5. The S_{mod} value can be determined by reorganizing the modified Equation 4.2-5 to solve directly for S_{mod}.

$$Q - R = \frac{(P - 0.2S_{mod})^2}{(P + 0.8S_{mod})}$$ *(Equation 4.2-5)*

Where:

R = Runoff depth retention (inches)

S_{mod} = Potential maximum retention after runoff begins (inches) reflecting volume retention or infiltration

Solve for S_{mod} based on known Q, R, and P values. Using the value found by solving for S_{mod}, a new adjusted CN (CN_{adj}) may be calculated (Equation 4.2-6).

$$CN_{adj} = \frac{1000}{S_{mod} + 10}$$ *(Equation 4.2-6)*

Time of Concentration (Tc) shall be calculated based on the methodology recommended in the respective model used, except that Tc for channel and pipe flow shall be computed using Manning's Equation.

- **Sheet flow:** The maximum length for each reach of sheet or overland flow before shallow concentrated or open channel flow develops is 150 feet. Flow lengths greater than 100 feet shall be justified based on the actual conditions at each development site. Sheet flow may be determined using Manning's kinematic solution as detailed in TR-55, Urban Hydrology for Small Watersheds, with roughness values for sheet flow as shown in TR-55.
- **Shallow concentrated flow:** Travel time for shallow concentrated flow shall be determined using Figure 3-1 and Equation 3-1 from TR-55.
- **Open channel flows:** At points where sheet and shallow concentrated flows concentrate in field depressions, swales, gutters, curbs, or pipe collection systems, the travel times to the downstream end of the development site between these design points shall be based upon Manning's Equation and/or acceptable engineering design standards. This is subject to review and approval by the City of Lancaster.

Step 4: Select and Design BMPs

Design BMPs to meet the rate control requirements as described in Section 2.3.2.

A shift in hydrograph peak time of up to five minutes and a rate variation of up to 5% at a given time may be allowable to account for the timing effect of BMPs used to manage the peak rate and runoff volume.

Any portion of the volume control storage may be used as rate control storage if:

- The volume control storage is designed according to the infiltration standards.
- The volume control storage is available within 24 hours from the end of the design storm based on the design infiltration rate.

4.3 STORMWATER CONVEYANCE CALCULATIONS

Stormwater designs must control peak discharge rates and demonstrate that all pipes, inlets, and other stormwater conveyance structures can convey the 25-year, 24-hour storm event for all on-site runoff and the 50-year, 24-hour storm event for all off-site runoff (SWM Ordinance §260-302.L). Systems must provide safe conveyance of the 100-year, 24-hour storm event to appropriate peak rate control BMPs in the design.

Conveyance structures, such as pipes, swales, and inlets that are designed to transport runoff from project sites less than 25 acres may be sized for capacity using the Rational Method. Rational Method coefficients are provided in the SWM Ordinance (Appendix E). The Rational Method has been used extensively to estimate peak runoff rates from relatively small (25 acres or less), highly impervious drainage areas using the following equation:

$$Q_p = C \times i \times A \quad \text{(Equation 4.3-1)}$$

Where:

Q_p = *Peak rate of runoff (cfs)*

C = *Rational method runoff coefficient*

i = *Average rainfall intensity (inches/hour) for a storm with duration equal to the time of concentration of the area*

A = *Drainage area (ac)*

Average rainfall intensity in inches per hour (for the duration equal to the time of concentration) can be obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 interactive application.

The Rational Method may not be used to analyze peak rate mitigation nor may it be used to calculate detention pond volumes.

Inflow Conveyance

Design Flow

The drainage area and contributing pervious and impervious areas shall be delineated for each inlet. Required flows for each inlet shall be determined using the Rational Method equation (Equation 4.3-1).

Runoff coefficients for use with Equation 4.3-1 shall comply with Table 4.3-1.

TABLE 4.3-1. RATIONAL METHOD RUNOFF COEFFICIENTS

Surface Cover	Runoff Coefficient "C"
Pervious	0.35
Impervious	0.95

Inlet calculation methodology is based on the U.S. Department of Transportation Federal Highway Administration Hydraulic Engineering Circular No. 22 (FHWA HEC-22). Refer to Section 4 of the FHWA HEC-22 for additional detail for the equations in this section.

Inlets: On Grade Condition

Grate Inlet

The capacity of a grate inlet on grade is determined by the efficiency of the grate and the total gutter flow. The following equation, from Section 4 of the FHWA HEC-22, shall be used to determine the capacity of grate inlets on grade. Refer to FHWA HEC-22 for the methodology to calculate the variables listed below:

$$Q = E\,Q_T = Q_T\,[R_f E_o + R_s(1 - E_o)]$$

(Equation 4.3-2)

Where,

Q = Inlet capacity (cubic feet per second)

E = Grate efficiency

Q_T = Total gutter flow (cfs)

R_f = Frontal flow ratio

E_o = Ratio of frontal flow to total gutter flow for uniform cross slope

R_s = Side flow ratio

For grate inlets on grade with composite cross slopes or depressed gutters, Equation 4.3-3 shall use E'_o instead of E_o, where:

$$E'_o = E_o\left(\frac{A_w'}{A_w}\right)$$

(Equation 4.3-3)

Where,

E'_o = Adjusted frontal flow ratio for composite cross sections

A_w' = Gutter flow area in a width equal to grate width (square feet)

A_w = Flow area in depressed gutter width (square feet)

Curb Opening Inlet

Curb-opening inlet lengths on grade shall be determined using the methods described in the FHWA HEC-22. The coefficients a, b, and c shall be used in the curb opening length equation instead of those presented in the FHWA HEC-22. The support for these modified coefficients is provided in the urban drainage and flood control district (*UDFCD) Technical Memorandum: Hydraulic Efficiency of Street Inlets Common to UDFCD Region.*

Curb-opening inlet on grade without depressed gutter/composite cross slope:

$$L_T = N\,Q_S{}^a\,S_L{}^b\left(\frac{1}{n\,S_x}\right)^c$$

(Equation 4.3-4)

Curb-opening inlet on grade with depressed gutter/composite cross slope:

$$L_T = N\, Q_S{}^a\, S_L{}^b \left(\frac{1}{n\, S_e}\right)^c$$

(Equation 4.3-5)

Where,

L_T	=	*Curb opening length to intercept flow (feet)*
N	=	*Reduction factor*
Qs	=	*Peak runoff rate (cubic feet per second)*
S_L	=	*Roadway longitudinal slope (foot/foot)*
n	=	*Manning's n-value*
S_x	=	*Cross slope (foot/foot)*
S_e	=	*Equivalent transverse cross slope (foot/foot)*
a	=	*0.51*
b	=	*0.06*
c	=	*0.46*

Combination Inlet

Combination inlets shall be considered the same as a grate inlet, except in the condition that a section of curb-opening is extended beyond the extents of the grate. In this scenario, the length of opening that extends beyond the grate may be considered a curb-opening inlet that provides additional capacity.

Inlets: In Sag Condition (Sumped Condition)

Grate Inlet

Grate inlets in sag condition operate as a weir or orifice, depending on the depth over the inlet. Grate inlets in sag condition shall provide adequate capacity by comparing the function of the inlet as a weir and as an orifice, with the lesser of the two considered the controlling capacity. The weir and orifice equations are provided in Equation 4.3-6.

Inlet Weir Flow

$$Q = 3.0\, P\, h^{1.5}$$

(Equation 4.3-6)

Where,

Q = Inlet capacity (cubic feet per second)

P = Inlet perimeter (feet)

h = Average head over inlet (feet)

Grate inlets installed adjacent to solid curbs shall not include the length of grate against the curb in the total inlet perimeter.

Inlet Orifice Flow

$$Q = 0.67\,A\sqrt{2gh}$$

(Equation 4.3-7)

Where,

Q = Inlet capacity (cubic feet per second)

A = Open grate area (square feet)

g = 32.2 (feet per second squared)

h = Average head over inlet (feet)

The controlling grate inlet capacity shall be reduced by 50% to simulate clogged conditions. The clogged condition capacity shall be compared to the required conveyance flow rate.

Curb Opening Inlet

The capacity of a curb-opening inlet in a sag condition operates as a weir during flow depths up to 1.4 times the opening height. Flow depths that exceed 1.4 times the opening height cause the inlet to function as an orifice.

The following equation shall be used to determine the weir capacity of curb-opening inlets in sag condition:

$$Q = 3.0\,L\,d^{1.5}$$

(Equation 4.3-8)

Where,

Q = Inlet capacity (cubic feet per second)

L = Length of curb opening (feet)

d = Flow depth at curb based on roadway cross slope and spread of flow (feet)

For curb-opening inlets in sag condition with a depressed gutter, the following equation shall be used to determine the weir capacity of the inlet:

$$Q = 2.3\,(L + 1.8\,W)\,d^{1.5}$$

(Equation 4.3-9)

Where,

Q = Inlet capacity (cubic feet per second)

L = Length of curb opening (feet)

W = Lateral width of gutter depression (feet)

d = Flow depth at curb based on roadway cross slope and spread of flow (feet)

The following equation shall be used to determine the orifice capacity of curb-opening inlets in sag condition:

$$Q = 0.67\, h\, L \sqrt{2gd}$$ *(Equation 4.3-10)*

Where,

Q = Inlet capacity (cubic feet per second)

h = Height of the curb-opening orifice (feet)

L = Length of curb opening (feet)

g = 32.2 (feet per second/second)

d = Effective head on the center of the curb-opening (feet)

For curb-opening inlets that do not have openings along the vertical plane, Equation 4.3-10 may be used with:

h = Curb-opening orifice width (feet)

Combination Inlet

Combination inlets shall be considered the same as a grate inlet. Except in the condition that a section of curb-opening is extended beyond the extents of the grate. In this scenario, the length of opening that extends beyond the grate may be considered a curb-opening inlet that provides additional capacity.

Pipes

Stormwater conveyance piping shall provide adequate capacity for required flows. Adequate capacity of conveyance piping shall be determined using the Manning's equation:

$$Q = \left(\frac{1.49}{n}\right) A\, R^{\frac{2}{3}} \sqrt{S}$$ *(Equation 4.3-11)*

Where,

Q = Pipe capacity (cubic feet per second)

n = Manning's n-value

A = Cross-sectional area of the pipe (square feet)

R = Hydraulic radius

S = Pipe slope (feet/feet)

Manning's n-value for use with Equation 4.3-11 shall comply with Table 4.3-2.

TABLE 4.3-2. MANNING'S N-VALUE FOR VARIOUS PIPE MATERIALS

Pipe Material	Manning's N-Value
RCP, VCP, CIP	0.013
HDPE, PVC	0.011

Open Channel

Stormwater conveyance channels such as trench drains and swales shall provide adequate capacity for required flows. Adequate capacity of conveyance channels shall be determined using the Manning's equation (Equation 4.3-11). Manning's n-value for use with open channels shall comply with PennDOT Publication 584, Table 8.1.

4.4 EROSION AND SEDIMENT CONTROL GUIDANCE

Sufficient erosion and sediment control are required to promote the long-term function of a BMP. Erosion controls such as energy dissipators reduce erosive velocities from concentrated flows that can cause erosion and thereby undermine the surface stability of a BMP. Sediment controls, such as stilling basins, concentrate fine particulates from the inflow that may otherwise settle in pore spaces of media and liners, and reduce performance of a BMP. Below is guidance for the sizing of erosion and sediment controls. These erosion and sediment controls are often referred to as pretreatment features.

TABLE 4.4-1. MAXIMUM ALLOWABLE ENTRANCE VELOCITIES

Surface Material	Maximum Allowable Entrance Velocity (ft/s)
Fine Gravel	5.0
Coarse Gravel	6.0
Seed Mixture/Grasses	2.5

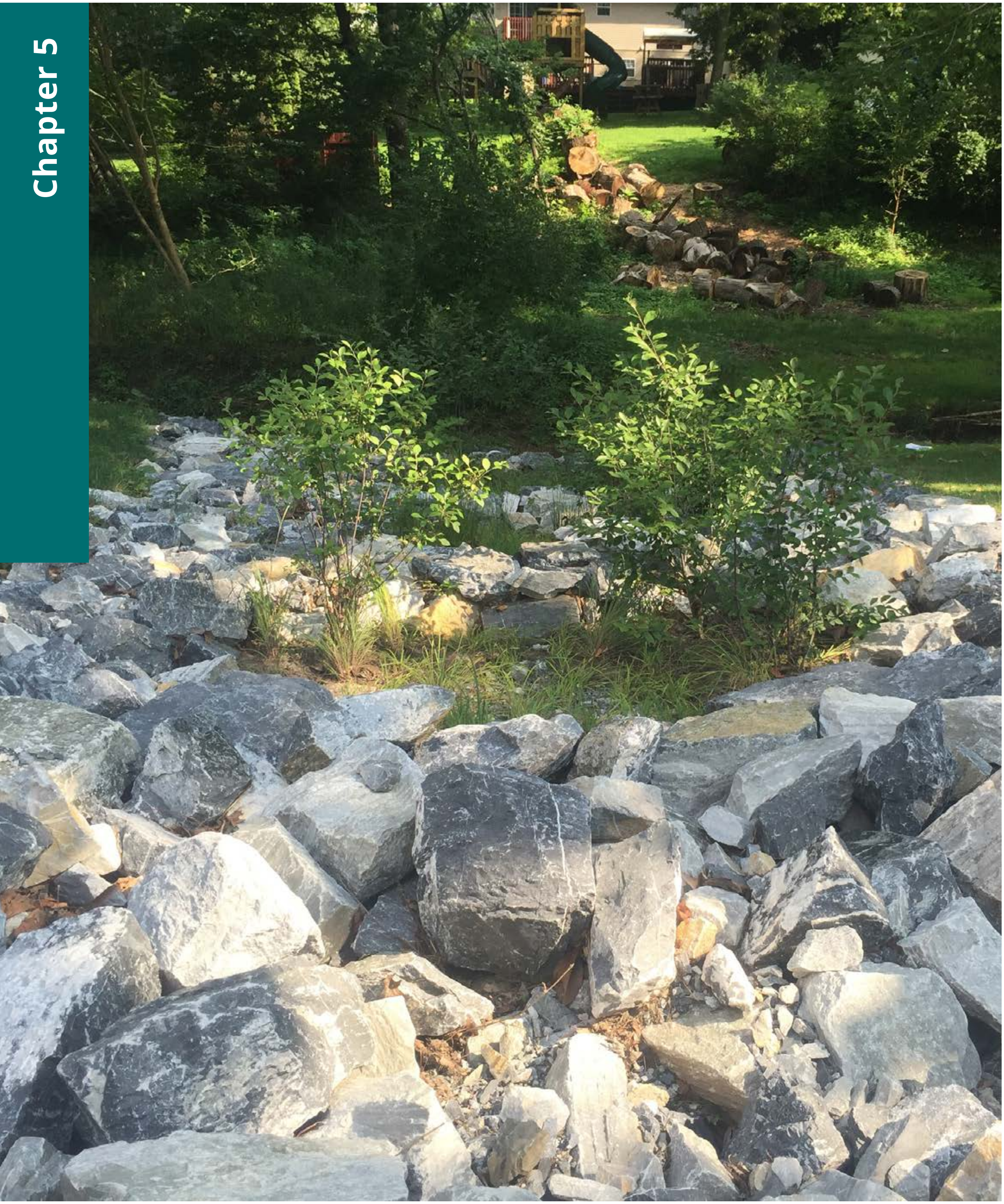
Values based on Columbus SWDM Table 2-17.

Erosion Control

The extent of erosion controls required will depend on the entrance velocity at the inflow point. The designer shall consider the site-specific entrance velocity when designing erosion controls dependent on the surface material. Allowable entrance velocities come from the Columbus Stormwater Drainage Manual and are shown in Table 4.4-1.

Sediment Control

Sediment control can be integrated into the design of inlet structures as described in Chapter 5. Surface level sediment control, such as stilling basins, will depend on the space available on the site. When feasible, stilling basins, also known as forebays, must be sized to store **5% of the total managed stormwater.**



5. DESIGN GUIDELINES

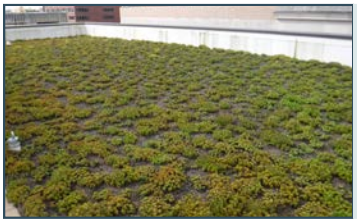
This chapter provides design standards on preferred structural BMP types that can be used to meet the City of Lancaster SWM Ordinance requirements. Figure 5.1-1 lists and briefly describes the six preferred types of structural BMPs. This chapter first provides general design guidance that apply to all BMP types, followed by more detailed guidance for each BMP type. Within the general guidance and individual BMP sections, content is divided into six component categories (e.g., pretreatment systems, conveyance, storage, vegetation, outlet control, and maintenance and monitoring) that are common among BMP types.

Bioretention/Bioinfiltration (see Section 5.2)

Bioretention/bioinfiltration systems are vegetated depressions that use surface ponding, plants, stormwater soil, and subsurface storage media to manage and treat stormwater runoff.

Porous Pavement (see Section 5.3)

Porous pavement BMPs are hardscape surfaces that allow stormwater to infiltrate through the surface. The water is stored in a subsurface storage system and then infiltrates into the soil below or is slowly released into the sewer.



Green Roofs (see Section 5.4)

Green roof BMPs are vegetated rooftop facilities that manage stormwater through evapotranspiration, retention, detention, and slow-release to the sewer.

Subsurface Infiltration and Detention (see Section 5.5)

Subsurface infiltration and detention BMPs are underground facilities that provide stormwater runoff storage through stone, pipes, or other structures. The stormwater then infiltrates into the soil below or is slowly released into the sewer.

Cisterns (see Section 5.6)

Cistern BMPs are underground or above ground tanks that allow for stormwater runoff storage for reuse.

Naturalized Basins (see Section 5.7)

Naturalized basins BMPs are vegetative basins that manage stormwater runoff through storage and infiltration. These BMPs are designed to support native wildlife populations.

Figure 5.1-1. Overview of GI Structural BMPs

5.1 GENERAL GI DESIGN STANDARDS

The following guidance must be applied to all structural BMP designs, unless otherwise noted or amended in their respective sections, or granted explicit approval by the City Engineer.

BMP Siting and Design

General

A. All BMP systems and earth disturbance activities require E&S control measures and compaction prevention measures during construction. See SWM Ordinance §260-301.K.

B. Placement

1. All new BMP systems are to be located at least 5 feet from the established property line in order to protect existing or future buildings and structures.
2. All infiltrating BMP systems must be located at least 10 feet from existing buildings and structures. All slow-release systems must be located at least 5 feet away from existing buildings and structures. Structures include but are not limited to retaining walls and foundations.
3. All infiltrating systems must be lined with an impermeable barrier within the 1:1 zone of influence of structures and sewers.
4. The bottom elevation of BMPs must not be within 2 feet of bedrock or the seasonal high groundwater.
5. All utilities that conflict with a BMP location must be properly protected (e.g., utility sleeve) and/or supported (e.g., concrete cradle). All utility conflicts must be identified and reviewed with the City Engineer.
6. Native soil surrounding the trench must be investigated for contamination and stability before system excavation and installation.

C. Performance

1. BMPs must comply with all regulation within the SWM Ordinance. Refer to Chapter 2 for details on volume, rate, and erosion and sediment control. Refer to Chapter 4 for guidance on calculations to meet these requirements.

D. Safety

1. All associated site work access must meet applicable Americans with Disabilities Act (ADA) standards as approved by the City Engineer.
2. The fall depth, the distance from adjacent walking surfaces to the BMP surface, shall not exceed 16 inches, unless safety measures are implemented and approval is provided by the City Engineer. Precautionary safety measures include but are not limited to curbing, hedge rows, fencing, and/or designated walking areas.

E. Infiltration

1. Infiltration systems are not permitted in areas with karst geology or within areas of environmental contamination. Areas of karst geology will be identified by the City Engineer. Slow-release systems may be implemented in these locations if the systems are lined with impermeable liner and approved by the city engineer.
2. Infiltration rates shall be determined by testing procedures as outlined in Appendix A.

3. Acceptable infiltration rates for infiltrating BMPs shall be greater than 0.1 inch per hour and less than 10 inches per hour.

4. Systems with tested infiltration rates below 0.1 inch per hour shall be designed for slow-release and require approval from the City Engineer.

5. Systems with tested infiltration rates greater than 10 inches per hour will require a 2 foot layer of an engineered soil amendment placed below the final bottom elevation of the system to reduce infiltration rates within the acceptable range. The infiltration rate of the amended soils must be tested during construction per Appendix A.

Pretreatment

Pretreatment of the stormwater runoff removes sediment as well as trash and/or debris that is generated in urban environments. Sediment, trash, and debris worsen the overall water quality and can cause clogging and poor performance of the BMPs. Screening for these materials increases the operational lifespan and decreases the maintenance requirements of a system. Some common pretreatment methods include sumped inlets, geotextile filter bags, sediment/grit chambers, or media filters. Forebays, filter strips, and swales can promote sedimentation prior to entering the BMP. Energy dissipators can help prevent erosion by reducing the energy of high-velocity stormwater entering the BMP.

F. All BMPs require pretreatment of the stormwater runoff.

G. Sites with high sediment loading must incorporate more extensive pretreatment methods to prevent storage layer from clogging.

H. All hydraulic control structures must have sumps.

I. All structures connected to a combined sewer must have a gas trap.

J. All exterior orifices and outlet control structures must include a screen or trash rack to prevent debris from clogging conveyance piping.

Conveyance

Conveyance features control the stormwater flow entering a BMP. Typical conveyance features include concrete inlet structures, curb cuts, and distribution piping.

K. Refer to Chapter 4 for design storm requirements and calculation guidance for sizing conveyance features.

L. Pipes shall have a minimum cover of 2 feet.

M. Distribution and underdrains pipes shall have a slope of 0% within the BMP.

Storage

Storage components are the features of a BMP that allow for stormwater volume storage. Stormwater storage can occur on the surface of a BMP through ponding and within the void spaces of subsurface elements such as stormwater soil, clean-washed stone, piping, or proprietary storage devices.

N. The total static storage provided by the BMP shall meet volume control requirements. BMPs can be incorporated in series with other BMPs to meet these requirements. Refer to Chapter 4 for storage volume calculation guidance.

O. Subsurface storage media shall meet the following requirements:

1. The subsurface storage media shall have a minimum depth of 12 inches.
2. The subsurface storage media shall have a level bottom.
3. Subsurface stone storage media shall be wrapped in geotextile on the sides and bottom.
4. All infiltrating systems shall have a minimum 6 inch sand layer installed under the stone storage media.
5. For non-infiltrating systems, a minimum 6 inch sand layer may be installed under the stone storage media in lieu of the geotextile on the bottom of the system.
6. Proprietary stormwater structures must be designed and installed per manufacturer's specifications.

P. Maximum allowable surface ponding depth for BMPs is 12 inches unless otherwise approved by the City Engineer.

Q. Anti-seep collars shall be provided on all pipes entering or exiting subsurface storage media.

Vegetation

Vegetation reduces the volume of stormwater entering the CSS via evapotranspiration. Vegetation can further provide benefits, such as erosion control, aesthetic enhancement, habitat creation, reduction of urban heat island effect, and improved air quality of the surrounding neighborhood.

R. Plant Materials

1. Plants must conform to the indicated botanical names and standards of size, culture and quality for the highest grades and standards as adopted by the American National Standards Institute (ANSI) Z60.1 - American Standard for Nursery Stock, current edition.
2. All plants must be nursery grown at certified, reputable nurseries in the same hardiness zone (see Winter Hardiness and Heat Zones, Section 5.1.T.2) as the location of the project. Plants must be of local provenance, preferably within 100 miles of the site to ensure the use of ecotypes that are adapted to local conditions.
3. All plants must meet specified sizes and be provided as balled and burlapped (B&B), container grown, or plugs grown in trays. Balled and burlapped plants must be freshly dug, unless otherwise approved by the Engineer. Heeled in plants or plants from cold storage are not acceptable. All plants must be sound, healthy, well branched, and free of disease or pests. Plants must be free of physical damage such as bark abrasions, disfiguring knots, sunscald, or unhealed cuts over 3/4 inch. All single stem trees must have a straight trunk; branching height must be 1/3 to 1/2 of tree height, with no multiple leaders.
4. Balled and burlapped plants must have a solid root ball of earth held securely in place by burlap and stout rope. Burlap and rope must be biodegradable, not synthetic material. Loose, broken, or manufactured root balls are not acceptable.
5. Container grown materials must be healthy, vigorous, well rooted and established in the container in which they are growing. Root systems must reach the sides of the containers to maintain a firm root ball, but not have excessive root growth encircling the inside of the container. Field-potted materials must be potted for delivery as they are dug from the field.

S. Plant Sizes and Spacing

1. Nursery plants are available in a range of sizes, depending on the species and type of stock (woody or herbaceous). Smaller plants are less expensive on a unit basis, but a closer spacing with a larger number of plants is required for adequate coverage. Depending on growth rate, several growing seasons may be needed to produce a more finished landscape appearance.

2. Shade and flowering trees, which are the largest plants, are usually acquired B&B. It is important to keep in mind the root ball size when specifying B&B trees to ensure the root ball will fit properly within the system dimensions. Shrubs can also be acquired B&B, although container-grown plants are less expensive and equally effective.

3. Herbaceous plants can be specified as container grown or plugs, which are grown in trays of 32, 50 or 72 count. Trays with a smaller number of plugs generally have bigger, deeper cells to propagate wildflower and grass species with taproots or deep fibrous root systems. These larger plugs also have faster establishment. Projects may benefit from a mix of plant sizes to balance costs, functional requirements, and aesthetics.

4. Another consideration in specifying plant size is the ponding depth of a system. Plants at installation must be tall enough that they are not completely submerged during the design storm event.

5. Plant spacing depends on the size of the plant at installation, as well as the expected size at maturity. Plants that are large at maturity require greater spacing at installation. Alternatively, a dense planting at the outset can be thinned later as needed if rapid early coverage is desired.

T. Plant Species Selection

1. All plant species must be selected from the approved planting list in Appendix D, unless approved otherwise by the City, and be appropriately chosen per site conditions and other considerations, as described below. Trees must be selected and installed in accordance with the Lancaster Tree Ordinance §273 and the City of Lancaster Tree Manual.

2. Winter Hardiness and Heat Zone

a) The 2012 USDA Plant Hardiness Zone Map is the standard used to determine which plants are most likely to overwinter successfully and generally thrive at a location. The map is based on the average annual minimum winter temperature, divided into 10°F zones. Lancaster is located within Hardiness Zone 6A. Plants selected for BMPs must be known to thrive in the specific hardiness zone of a project site.

b) Plants are also affected by summer temperatures. Pennsylvania summers can be very hot, and heat tolerance must be considered in plant selection as well. The American Horticultural Society (AHS) has developed a Plant Heat Zone Map, divided into 12 zones that indicate the average number of days each year that a given region experiences "heat days"—temperatures over 86°F (30°C). That is the point at which plants begin suffering physiological damage from heat. The zones range from Zone 1 (less than one heat day) to Zone 12 (more than 210 heat days). AHS Plant Heat Zone ratings assume that adequate water is supplied to the roots of the plant. Although some plants are naturally more drought tolerant than others, no plant can survive becoming completely desiccated.

c) Not all catalogs, websites and garden centers currently indicate a plant's Heat Zone, although many sources indicate heat and drought tolerance more generally. Where information is available, two ratings are shown for a given plant, such as 5-10, 11-1. The first pair of numbers is the cold Hardiness Zone. This plant will survive winter temperatures in zones 5 to 10. The second pair of numbers is the Heat Zone. A rating of 11-1 indicates that the plant is heat tolerant in zones 11 through 1.

U. Microclimate

1. Climate at the site level may vary from the larger scale Winter Hardiness or Heat Zone as a result of existing and proposed vegetation and structures within or adjacent to the system. Microclimatic variations in shade, soil moisture, air temperature, wind exposure, and other environmental conditions can occur throughout the day or across seasons. These variations can expand the potential species diversity of the system, but it is important to consider the potential impacts on plant establishment and growth over time and select appropriate species accordingly.

V. Species Diversity and Resilience

1. The number of different species used in a BMP depends on multiple considerations such as environmental conditions, functional and cultural goals, system size, and proximity to other green spaces (parks, greenways, etc.). In general, higher species diversity confers greater resilience against disease, pests, extreme weather events, and other stressors. However, species diversity must be balanced with the availability of maintenance staff and budgets. Too many different species can be challenging to maintain successfully.
2. Tree planting diversity goals according to the Lancaster Tree Manual are as provided in Table 5.1-1.

TABLE 5.1-1. LANCASTER TREE MANUAL TREE PLANTING DIVERSITY GOALS

Number of Trees Required	Number of Tree Varieties/Species
1-5	1-2
6-15	2-3
16-25	3-5
26-50	5-7
51-100	7-10
101+	11+

3. No single species shall make up more than 10% of a planting or population.
4. No single genus shall make up more than 20% of a planting or population.
5. Maple (*Acer*) may not comprise more than 5% of any given planting project.
6. Asian Longhorn Beetle host species may not exceed 25% of any given planting project.
7. For off right-of-way projects, it is recommended that at least 20% of species be evergreen.

W. Habitat

1. Plant selection for BMPs must include consideration of habitat for wildlife to the extent feasible. For example, by selecting flowering plants with lengthy or overlapping bloom periods, designers can create systems that provide pollen and nectar for bees and butterflies from early spring through the fall. Foliage from native species supports invertebrate grazers such as caterpillars, which in turn sustain migratory songbirds and their young. Summer and fall fruits, nuts, and seeds support migratory and overwintering songbirds.

X. Native and Naturalized, Noninvasive Species

1. Native species are generally the most optimal in terms of habitat and ecological value, given the longstanding adaptive and often highly specific relationships that have evolved between plants and animals. It is preferred that native species comprise at least 50% of the plant material for a project. However, some native species may not be tolerant of harsh urban conditions. Careful use of naturalized, noninvasive introduced species can effectively supplement and enhance designed plant communities. Note, however, that invasive ornamental grasses and other invasive plants available in the nursery trade are not permitted to be used in any system (see the PA Department of Conservation and Natural Resources Invasive Plants website for more information).

Y. Plant Communities

1. In nature, plants form communities, which are essentially groups of compatible plants that interact with each other and the site. Compatible species must be able to grow and thrive under the same environmental conditions and stresses. Plants in communities typically occupy different parts of the system, both physically and in terms of resource use. Selecting species to form designed communities must include an understanding of factors such as vertical layering from the ground plane to canopy.
2. Plant species in a community also compete for space and resources. Aggressive, rapidly growing species will overwhelm slower-growing species, so consideration must be given to selecting species that are able to maintain a balance to avoid the system becoming dominated by just one or two species.

Z. Growth Habit

1. Height – Each species has a typical range that is reached at maturity if site conditions support the growth requirements of the plant. In right-of-way systems, selection of plants must account for the depth from the adjacent sidewalk or roadway to the surface of the stormwater planting media. In deeper systems, taller species shall be used to be visible at maturity above the pavement grade. In addition, plant heights at both installation and maturity shall be considered in terms of pedestrian and vehicular circulation and sightlines – especially at intersections. A clear zone between 4 and 7 feet must be maintained. When determining tree species, potential conflicts with overhead utilities must be taken into account. Proximity to buildings and other structures must also be considered.
2. Spread – The ultimate spread, or width, of a plant at maturity determines the spacing and number of plants needed in a system. Plants that spread through rhizomes or other methods may establish more quickly and aggressively.

AA. Soil Volume

1. Trees require sufficient soil volume for root development and healthy growth. A number of studies have examined the relationship between tree growth and soil volume. For broad canopy trees, a general rule of thumb is that 2 cubic feet of soil is needed for every one square foot of canopy projection (diameter spread). Note that trees are able to share soil volume, so individual soil volume may be slightly lower.

AB. Light Requirements

1. Plants have different requirements and tolerances for sunlight and shade that must be considered when developing a planting design for BMPs. Sites may be exposed to full, intense sunlight all day or be shaded or partially shaded by adjacent trees and buildings. Even the plant

palette selected for the BMP can create areas of shade for lower growing plants. The depth of a sidewalk planter or bumpout can also affect sun exposure, with the concrete walls of the system casting shade similar to a building. A sun–shade analysis for proposed conditions must be completed for each site to determine which species are best suited for the expected light exposure in the system.

AC. Hydrologic Zones

1. Plant species vary in their tolerance of different moisture conditions. Some species are able to withstand long periods of inundation, while others will perform poorly because of extended periods of ponding and/or saturated soil. Similarly, drought tolerance varies among species. Plant selection for BMPs must take into consideration species characteristics in relation to the hydrology of engineered systems, which is a function of the designed maximum ponding depth, infiltration rate, drawdown time, stormwater soil mix, and steepness of side slopes.

AD. Salinity Tolerance

1. Stormwater BMPs adjacent to pavements treated with deicing chemicals expose plants to potential salt damage. Salt carried by runoff may accumulate in the soil from melted snow, or it may be dispersed in an aerosol spray by fast-moving traffic and strong winds along wet, salted roads. Rock salt (sodium chloride), the most commonly used deicer, disrupts soil chemistry, structure, and microbial communities, which makes soil unsuitable for proper root growth and development. Salt spray in contact with plant tissues causes damaging desiccation. Therefore, plants with high salt tolerance must be used in the right-of-way. Note that a plant's tolerance to soil salt may differ from its tolerance to salt spray.

AE. Seasonal Interest

1. Stormwater BMPs provide an opportunity to create attractive neighborhood amenities through the selection of plant species that exhibit characteristics with year-round and seasonal interest. Flowers, fruits, foliage, and bark have various colors and textures that become more or less pronounced throughout the growing season and during winter dormancy. Evergreen species also contribute to winter interest.

AF. Maintenance Access

1. Vegetated BMPs require maintenance of various system components, such as cleanouts and inlets, as well as the plants themselves. Maintenance equipment may include vactor trucks, watering hoses, and wheelbarrows, along with personnel. Planting design must consider the ease with which staff with equipment can access the system. Hardy species that will tolerate maintenance activities while not impeding them shall be used at entry locations.

Outlet Control

Outlet controls are features that manage how stored stormwater runoff is released from the BMP. These controls can be used to limit peak release rates from the BMP as well as provide safe conveyance of larger storm events. Common outlet structures include inlets, domed risers, orifices, and weirs.

AG. All outlet control structures must include pretreatment measures to filter out debris.

AH. All BMPs shall have a perforated underdrain and must meet the following requirements.

1. Underdrains shall not be less than 4 inches in diameter.

2. Underdrains shall have a minimum of 4 inches of vertical separation between the pipe and the boundary of the subsurface storage.
3. Underdrains shall be fitted with a solid cap for infiltrating systems.
4. Underdrains shall have an orifice with a minimum orifice diameter of ½ inch for slow-release systems.
5. Underdrains shall have a minimum length of 20 feet, where feasible.
6. Underdrains shall be used to connect subsurface storage media between any multi-tier systems or between check dams.

AI. BMPs must be designed to prevent preferential flow paths of stormwater stored within the subsurface storage area. The stormwater must be infiltrated or slowly-released through a flow control device, such as an orifice.

Maintenance and Monitoring

BMPs require routine maintenance to maximize their operational lifespan and ensure continual performance. Incorporating access to allow for maintenance is an important aspect of BMP design. Regular monitoring of the systems allows BMP designs to be improved upon with each successive iteration. The data collected can be a useful design tool and can indicate when an established maintenance schedule may be insufficient.

AJ. All surface and subsurface components require unobstructed and safe access for inspection and maintenance and monitoring.

AK. All Occupational Safety and Health Administration (OSHA) standards must be met including but not limited to confined space entry and fall protection.

AL. Consideration for maintenance vacuum truck access for maintenance of conveyance, storage, and outlet control components must be taken into consideration from the initial concept design. The standard vacuum truck dimensions are 8 feet wide by 35 feet long with 12 feet vertical clearance.

1. Vehicular access routes must allow for a total load of 68,000 pounds based on a standard vacuum truck that is fully loaded.
2. Vehicular access routes must be at least 10 feet wide with a maximum slope of 10%.
3. Soil stabilization or structural paths using permeable grass pavers may be necessary in some cases.

AM. All pipes shall have a maximum pipe bend of 45 degrees.

AN. Every run of pipe shall be accessible at either end of the pipe, at minimum. Access points may include cleanouts and an inlet connections.

AO. Cleanouts, manholes, and other access features shall be provided to allow unobstructed and safe access to BMPs for routine maintenance and inspection of piping and storage systems, and meet the following requirements:

1. Unobstructed and safe access must be provided to all access features for inspection and maintenance.
2. Cleanouts shall be included, at minimum, every 75 feet and at the end of all pipes.

3. Cleanouts shall be located upstream of complicated bends and shall be evenly spaced during straight pipe runs.
4. All intermediate (mid-run) cleanouts shall be oriented downstream to direct all closed-circuit television (CCTV) inspections towards an inlet or access structure.
5. All pipes shall be connected to a downstream sumped structure to which they can be flushed. These structures shall have access for vacuum cleaning.
6. Whenever possible, cleanouts shall not be located in driveways or in the travel lanes.

AP. Observation wells and other monitoring features shall be provided for all storage systems and shall meet the following requirements:

1. A minimum of one observation well shall be provided for each BMP, including BMPs that are fully lined with an impermeable liner.
2. For any subsurface system, an initial observation well needs to be located within 50 feet of the primary inlet. All elements of the system then need to be within 100 feet of this initial observation well, or any subsequent additional observation wells, so that all elements of the system can be observed.
3. An observation well shall be located near the center of each storage system to monitor the level and duration of water stored within the system (drawdown time).
4. For multi-tiered systems and systems with check dams, an observation well shall be placed in each storage area.
5. The observation well shall extend to the bottom of the system.
6. Adequate inspection and maintenance access to observation wells shall be provided.

Material Standards

Piping

AQ. Distribution and underdrain piping within the BMP shall be corrugated high-density polyethylene (HDPE) or polypropylene (PP) pipe and shall have an annular corrugated exterior and smooth inner wall (dual wall pipe); piping shall be all manufactured by the same company and shall meet or exceed the following specifications as applicable: American Association of State Highway and Transportation Officials (AASHTO) M-252, AASHTO M-294, American Society for Testing and Materials (ASTM) F2306, or ASTM F2881.

AR. Polyvinyl chloride pipe shall be Schedule 80 or SDR-17 as a minimum pipe wall thickness.

AS. Backfilling over the pipe shall be to ASTM D2321 or the pipe manufacturer's specifications, whichever is greater. Cover shall be compacted to at least 95% of its maximum dry density as determined by ASTM Test D1557, Method D.

AT. Joints shall be watertight according to the requirements of ASTM D3212. Gaskets shall be made of polyisoprene meeting the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.

AU. Fittings shall be PVC or HDPE and shall meet or exceed the following specifications as applicable: AASHTO M-252, AASHTO M-294, ASTM F2306, and/or ASTM D3034. Fittings shall have bell and spigot connections that utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of ASTM D3212.

AV. Perforated pipe shall have AASHTO Class II perforations. Class II perforations shall be located in the outside valleys of the corrugations, be circular and/or slotted, and evenly spaced around the circumference and length of the pipe. The opening area shall be no less than 0.945 square inches per linear foot (pipe diameters 4 through 10 inches).

AW. Piping outside of the BMP shall comply with plumbing regulations set out in Chapter 215 of the City of Lancaster's code.

Subsurface Storage Aggregate

AX. Subsurface storage aggregate shall consist of uniformly graded, crushed, clean-washed stone meeting AASHTO No. 3 or No. 57 requirements.

AY. Aggregate shall not surpass 0.5% wash loss under ASTM C 117 or AASHTO T-11 testing.

AZ. Aggregate durability index shall meet 35 or greater under ASTM D 3744 testing.

BA. Aggregate abrasion loss shall not exceed 10% per 100 revolutions and 50% for 500 revolutions under ASTM C 131.

BB. At least 95% by mass (weight) of aggregate shall have 1 fractured face and 90% shall have 2 fractured faces under ASTM D5821 testing.

BC. Sand, if used, shall have a grain size between 0.02 to 0.04 inches and meet AASHTO M-6 or ASTM C-33 standards.

Maintenance and Monitoring Structures

BD. Cleanouts shall be made of rigid material with a smooth interior having a minimum inner diameter of 4 inches. Cleanouts shall be PVC structures in all vertical sections, with adapters to horizontal dual wall corrugated HDPE pipe. Covers and frames shall be ductile iron and lockable.

1. Frames and lids are to be lockable by means of stainless steel bolts.
2. Locking bolts shall be stainless steel machine head bolts with countersunk hex key. Bolts shall be installed clean and free of grit or debris and coated using white lithium grease or equivalent metal-to-metal lubricant and rust protector prior to initial installation.

BE. Observation wells shall be minimum inner diameter of 4 inches of rigid Schedule 40 PVC pipe in upper section, with solid cap. Covers and frames shall be ductile iron and lockable See detailed product information below.

1. Slotted sections shall be 4 inch PVC slotted well with 0.01 slots and attached plug.
2. Covers for observation wells shall be lockable ductile iron with gray iron frames. Bolts shall be machine head stainless steel with hex key insert as appropriate. Bolts shall be installed clean and free of grit or debris and coated using white lithium grease or equivalent metal-to-metal lubricant and rust protector prior to initial installation.
3. Protective casing for observation wells in unpaved areas that experience surface ponding shall have built-in aluminum mounting casing.

4. Aggregate fill around observation wells shall be consistent with surrounding aggregate. In the case of a free-standing well which is not located within a given stormwater structure, the aggregate utilized shall be AASHTO #57.

Geotextile Fabric and Impermeable Liners

BF. Geotextile shall be non-woven, consist of polypropylene fibers and meet the following specifications. Heat-set and heat-calendared geotextiles are not permitted.

TABLE 5.1-2. ASTM TESTING REQUIREMENTS FOR GEOTEXTILE FABRIC		
TEST MEASUREMENT	VALUE	TESTING STANDARD
Minimum flow rate	110 gal/min/ft^2 (min.)	ASTM D 4491 99A
Grab tensile strength	150 lb (min.)	ASTM D 4632 91
Mullen Burst strength	300 psi (min.)	ASTM D 3786 87
Puncture strength	90 lb (min.)	ASTM D 4833 00
Apparent opening size	No. 60-70 US Sieve	ASTM D 4751 99A

BG. Impermeable liners shall conform to PennDOT Specifications (Publication 408, Section 736).

Construction Standards

BH. Prior to beginning earthwork operations, all utility mark out, necessary clearing and grubbing, removal of obstructions and pavements, installation of required erosion and sediment control facilities shall be completed. The contractor shall be responsible for the condition of the trenches and filled areas.

BI. Clearly mark area of proposed work on site before work begins. Soil disturbance and compaction must be avoided during construction. If the system designed for infiltration, the area of the proposed footprint shall be properly marked as a zone of exclusion for heavy equipment to avoid compaction prior to excavation.

BJ. Erosion and Sediment Control

1. Rock construction entrances may not be located on top of areas of proposed infiltration practices.

BK. Earthwork

1. Excavation shall be performed during a period of dry weather and shall be accomplished by methods which preserve the undisturbed state of subgrade soils. The existing subgrade shall not be compacted or subject to excessive construction equipment prior to placement of BMP components. If it is essential that equipment be used in the excavated area of infiltration facilities, all equipment must be approved by the City or authorized representative. Use of equipment with narrow tracks or tires, rubber tires with large lugs, or high-pressure tires that will cause excessive compaction shall not be permitted within the excavation.
2. The bottom surface of any excavation for an infiltration system shall be uncompacted yet stable. The top 3 to 6 inches of remaining subgrade soils shall be scarified prior to installation of the system, unless otherwise directed by the City Engineer or authorized representative.

3. Subgrade of BMPs shall be level: Plus or minus 1/2 inch is acceptable as level. Subgrade elevation must be as shown in drawings.
4. Volume, elevations, and grades shall be verified after excavation and prior to any backfill.
5. Prior to backfill, double ring infiltrometer testing shall be conducted in one location for each system footprint that is not fully lined with an impermeable liner. Test holes shall be located within the limits of the proposed trench excavation and results of the testing shall be submitted to the City Engineer or an authorized representative.

BL. Geotextile and aggregate shall be placed in excavated area immediately after approval of subgrade preparation to avoid accumulation of sediment or debris. Geotextile shall be placed in accordance to the manufacturer's specifications. Overlap between strips of geotextile shall be a minimum of 16 inches and the geotextile shall be secured at least four feet outside of the bed area. Once soil contiguous to the bed on-site has been fully stabilized, excess geotextile may be cut back to the edge of bed. If required, impermeable liner shall be placed and continuous contact with native soils shall be ensured.

BM. Aggregate course shall be installed in lifts of 6 to 8 inches. Each layer shall be compacted with equipment, keeping equipment movement over storage bed native soils to a minimum. Aggregate shall be installed to grades indicated on the drawings.

BN. If vaults, pipe, grid system, or other storage units are to be used, they must be placed in accordance with manufactures or design engineer's specifications. Stone or pea gravel base for storage units shall be installed as noted above.

5.2 BIORETENTION/BIOINFILTRATION

Bioretention and bioinfiltration BMPs are vegetated depressions that use surface ponding, plants, stormwater soil, and subsurface storage media to mitigate stormwater runoff. Bioretention and bioinfiltration BMPs reduce stormwater pollution by filtering runoff through the various layers of the BMP, including a vegetated soil medium, and reduce stormwater volume through evapotranspiration. Bioretention BMPs slowly release the collected stormwater to the sewer system whereas bioinfiltration BMPs permanently remove stormwater through infiltration into the native subsoil. Infiltration systems are preferred as they reduce the volume of the stormwater entering the sewer and provide groundwater recharge. These BMPs can also be designed to mitigate peak runoff rates.

Bioretention and bioinfiltration BMPs can be implemented in a variety of applications such as in private parking lots as a basin or within the right-of-way as a stormwater planter or bumpout. They can also be used in series with other BMP types.

Figure 5.2-1. Typical Bioretention/Bioinfiltration System

Examples of typical bioretention/bioinfiltration layouts are provided in Appendix B.

Key Advantages

- Flexible layout that is easy to incorporate into landscaped areas
- Reduces stormwater volume and peak runoff rates
- Provides additional stormwater management through evapotranspiration
- Improves air quality and reduces the carbon footprint
- Reduces urban heat island effect
- Provides wildlife habitat
- Can improve aesthetic appeal and property values of the surrounding neighborhood
- Creates opportunities for community engagement at schools, libraries, or other highly visible locations

Key Limitations

- May need to be used in combination with other BMPs to meet volume control and rate control requirements
- May be limited by surface-level space constraints
- May be difficult to maintain vegetation in high traffic volume areas or high sediment loading environments.

Key Design Considerations

- On steep or moderately sloped sites, a multi-tiered system can be constructed to reduce excavation and maintain natural contours. These systems shall include berms, check dams, and upstream forebays for pretreatment and/or retention areas.
- Energy dissipation should be considered at inlet locations to minimize scour.
- Sites with space constraints should incorporate planter boxes or tree pits for bioretention/bioinfiltration instead of a basin design.
- Bioretention/bioinfiltration BMPs shall be integrated with other site considerations and features such as streetscape elements and site usage, as opposed to stand-alone and/or drop-in features.
- Bioretention/bioinfiltration BMPs within the ROW shall have raised curbs and/or fencing for pedestrian safety.

5.2.1 Components and Design Standards

The following section provides an overview of typical components and design standards for bioretention/bioinfiltration BMPs. Refer to Section 5.1 for General GI Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements.

Pretreatment

A. Refer to the pretreatment subsection of Section 5.1 General GI Design Standards.

Conveyance

B. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

Storage

C. Refer to the storage subsection of Section 5.1 General GI Design Standards.

D. Bioretention/bioinfiltration BMP basins shall have a maximum side slope of 3(H):1(V), although 4(H):1(V) is preferred. Steeper slopes may be considered with permission by the City Engineer.

E. Bioretention/bioinfiltration BMPs shall have a minimum stormwater soil depth of 18 inches for herbaceous plants, 24 inches for shrubs and 36 inches for trees.

F. Bioretention/bioinfiltration BMPs shall have a minimum mulch depth of 3 inches on the surface.

Vegetation

G. Refer to the vegetation subsection of Section 5.1 General GI Design Standards.

H. Vegetation shall be selected based on the location within the following four zones (see Appendix D for lists of appropriate species):

1. In-flow or Entry Zone – This zone is typically a high stress area for plants that is characterized by rapid inflow of a large volume of water, with the highest concentration of sediment and pollutants. This area usually requires the most maintenance. Consequently, plants selected for this zone must be able to tolerate these stressors. Deep-rooted grass species are generally suited for this zone and are able to stabilize the soil and prevent erosion.
2. Lowest Zone – This zone is the deepest part of the BMP and experiences the greatest amount of ponding and fluctuating water levels. Depending on system design, plants may be exposed to as much as 18 inches of inundation, as well as periods of drying.
3. Middle Zone – This zone is at the upper limit of ponding, experiences some water level fluctuation and is slightly drier than the Lowest Zone.
4. Highest Zone – This zone comprises the upper slopes of the system above the ordinary ponding elevation and is the driest part of the BMP, with possible extended periods of drought.

Outlet Control

I. Refer to the outlet control subsection of Section 5.1 General GI Design Standards.

Maintenance and Monitoring

J. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

5.2.2 Plan Layout Schematics and Details

The Bioretention/Bioinfiltration Typical Application Layout (BB-1) shows examples of potential layouts and applications of bioretention/bioinfiltration BMPs. There are other site-specific applications for bioretention BMPs and these examples are not exhaustive. Standard details BB-2 through BB-4 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Bioretention/Bioinfiltration Typical Layouts and Standard Detail Sheets:

- BB-1: Bioretention/Bioinfiltration Typical Application Layout
- BB-2: Typical Stormwater Bumpout
- BB-3: Typical Stormwater Planter
- BB-4: Typical Rain Garden

5.2.3 Material Standards

This section provides material standards for the inlet control, storage media, and outlet control of bioretention/bioinfiltration BMPs. Refer to the materials subsection of Section 5.1 General GI Design Standards for additional requirements.

Subsurface Storage

A. Refer to the materials subsection of Section 5.1 General GI Design Standards.

Stormwater Soil

B. Stormwater soil shall consist of uniformly mixed individual soil components (topsoil, sand, and compost) that meet the criteria described below.

Topsoil

Topsoil is soil harvested from fields or development sites comprising loose, friable mineral particles resulting from natural soil formation from the A, E and upper B horizons, or "solum" where most plant roots grow. Topsoil that has been stripped from the project site may be used as stormwater soil providing it meets the specifications. Topsoil shall be free of construction and trash debris, rocks, hydrocarbons, petroleum materials, herbicides, or other harmful contaminants that would negatively impact plant growth.

Topsoil shall comply with the following parameters:

- USDA soil texture class: loam or sandy loam
- Organic matter (ASTM F1647, Method A): 1.5% minimum (by dry weight)
- pH (1 soil : 1 water): 5.0–7.0

Sand

Sands used in the manufacture of stormwater soils shall be clean, sharp, hard, durable natural quartz sands free of limestone (calcareous sand), shale and slate particles and free of harmful contaminants that would negatively impact plant growth. Round or fine sand, including masonry sand, shall not be used.

Compost (Organic Amendment)

Compost shall be as defined by the "US Composting Council Landscape Architecture / Design Specifications for Compost Use, Planting Bed Establishment with Compost." Compost shall be a well decomposed, stable, weed-free organic matter source derived from agricultural or food waste; leaf litter and yard trimmings; and/or municipal source-separated solid waste. The product shall contain no substances toxic to plants and shall be reasonably free (< 1% by dry weight) of synthetic foreign matter. The compost shall have no objectionable odors and shall not resemble the raw material from which it was derived.

Laboratory analysis shall be no more than 90 days old at time of application. Compost shall comply with the following parameters:

- pH: 6.0–8.0.
- Soluble salt content (electrical conductivity, 1 soil : 2 water): maximum 5 dS/m (mmhos/cm).
- Compost derived from stabilized mushroom soil compost may possess a maximum EC of 10 dS/m (1:2), if the maturity testing is a minimum of 95% and ammonia (NH_4) content is a maximum of 250 ppm.

- Moisture content, wet weight basis: 30 – 60%.
- Organic matter content, dry weight basis: 30 – 65%.
- Particle size, dry weight basis: 98% passing through 1/2 inch screen.
- Stability carbon dioxide evolution rate: mg CO2-C/ g OM/ day ≤ 3.
- Maturity, seed emergence and seedling vigor, % relative to positive control: minimum 80%.
- Physical contaminants (inerts), dry weight basis: <0.5%.
- Chemical contaminants, mg/kg (ppm): meet or exceed US EPA Class A standard, 40CFR § 503.13, Table 3 levels.
- Biological contaminants select pathogens fecal coliform bacteria, or salmonella, meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) level requirements.

C. Stormwater soil shall meet the requirements set out in Table 5.2.3-1 and meet USDA soil texture classifications as sandy loam or loamy sand. Particle size distribution shall follow ASTM F-1632.

TABLE 5.2.3-1. STORMWATER SOIL PARTICLE DISTRIBUTION

Particle Type	Size Range	% Volume
Gravel	2.0 – 12.7 mm	≤12
Coarse – Medium Sand	0.25 – 2.0 mm	≥65
Fine – Very Fine Sand	0.07 – 0.25 mm	≤17
Silt	0.002 – 0.07 mm	≤20
Clay	≤ 0.002 mm	5 – 15

D. Organic matter shall be 4-7% of mixture by dry weight as measured by ignition using ASTM F1647, Method A. Compost used to achieve the specified organic matter content shall not be added at more than 30% by volume.

E. Stormwater soil shall not contain clods of soil greater than 3 inches in diameter.

F. Hydraulic conductivity (ASTM F1815) shall be 2.0 – 6.0 inches/hour at 75% Proctor.

G. pH shall be between 6.0 and 7.2.

H. Soluble salt content shall not exceed 1.60 mmho/cm when measured as a 1:2 soil-water ratio. Sodium (Na) salinity shall not exceed 700 ppm.

I. Cation Exchange Capacity shall not be less than 12 meq/100 g.

Mulch

J. Mulch shall be double-shredded hardwood bark, aged 6 months to 1 year. Particle size shall be 2 inches or less in any dimension with less than 30% composed of fines. Mulch shall be free of wood chips, stones or other undesirable matter. Mulch shall be dark brown in color. Postconsumer materials and dyes are not permitted.

5.2.4 Construction Considerations

A. Refer to the construction subsection of Section 5.1 General GI Design Standards for general requirements and subsurface stone storage requirements.

B. Do not mix, deliver, place, grade, plant or seed stormwater soil when frozen or wet, such as after a heavy rain.

C. For systems with subsurface storage, confirm that the top elevation of the stone bed is at the proper elevation before installing stormwater soil.

D. Place stormwater soil in the BMP using equipment operating on stable ground adjacent to the system. Do not use rubber-tired or heavy equipment within the perimeter of the BMP system at any time. For larger systems that are not fully accessible from outside the perimeter, use wide-track or balloon tire machines rated with a ground pressure of 4 psi or less.

E. Place stormwater soil in 12 inch lifts until the specified depth is achieved. Scarify the surface area of each lift by raking immediately prior to placing the next lift. Overfill by 10% to 15% or as needed to allow for settlement of the soil. To encourage settling of stormwater soil, saturate the entire footprint of the BMP area after each lift of soil is placed.

F. Where possible place trees first and fill stormwater soil around the root ball.

G. Perform final grading of the stormwater facility after a 24 hour settling period.

H. Place mulch and hand grade to confirmed, final elevations.

I. Phase work so that equipment to deliver or grade soil does not have to operate over previously installed stormwater soil.

5.3 POROUS PAVEMENT

Porous pavement is an alternative to traditional pavement that allows rain and snowmelt to drain through the pavement surface into a subsurface storage bed. This subsurface layer provides storage for stormwater runoff while allowing infiltration into the native soil below. Porous pavement can be used in combination with other BMPs to meet stormwater management requirements.

Types of porous pavement surfaces may include, but are not be limited to: porous asphalt, porous concrete, permeable pavers, reinforced turf, and synthetic turf. There are many different types of structural surfaces that allow water to flow through void spaces in the surface. Any of these alternatives serve as a form of conveyance and filtration for the storage bed below.

Figure 5.3-1. Typical Porous Pavement System

Porous pavement can be designed to be structurally comparable to traditional pavement in order to support vehicular traffic loading. Applications of porous pavement may include roadway travel lanes, parking lanes, parking lots, sidewalks, and recreation surfaces (e.g., athletic courts/fields, running tracks, playgrounds, etc.). Examples of typical porous pavement layouts are provided in Appendix B.

Key Advantages

- Can be used in place of traditional paving materials.
- Allows for a highly customizable footprint.
- Can be used in combination with other BMP types.
- Can improve drainage and reduce standing water and ice buildup associated with traditional pavement surfaces.
- Provides secondary benefits such reduction of urban heat island effect, quieter vehicular traffic, and reduction of road glare compared to standard asphalt.

Key Limitations

- Can be more expensive compared to other BMP types.
- Curing of cast in place porous concrete is highly subject to environmental conditions and must be performed by a highly experienced installer.

- Not recommended in high traffic areas or heavy industrial areas where heavy debris and sediment loads may quickly clog porous surfaces.
- Not typically suitable on steep slopes.
- Requires regular maintenance with specialized equipment.
- Not recommended for areas where gasoline or other hazardous materials may be stored or handled.

Key Design Considerations

- Design of paving sections must consider anticipated structural loading.
- Maintenance access for routine cleaning by regenerative air sweeping equipment must be considered.
- Porous pavement that receives run-on from adjacent drainage areas may require more frequent maintenance.
- Installations located under the canopy of deciduous tree may require more frequent maintenance.

5.3.1 Components and Design Standards

The following section provides an overview of typical components and design standards for porous pavement BMPs. Refer to Section 5.1 for General Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements.

Pretreatment

Porous pavement surfaces provide filtration of large particles at the surface. The small voids in the pavement surface provide a barrier to limit sediment, trash, debris and pollutants from entering the subsurface storage layer. Pretreatment is required for any stormwater that directly enters the subsurface storage layer.

A. Refer to the pretreatment subsection of Section 5.1 General GI Design Standards.

Conveyance

Porous pavement controls the inflow of stormwater to the subsurface storage area via voids in the pavement material surface. Overflow inlets are often included as a redundant capture method downstream of the porous pavement.

B. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

C. Edge restraints must be used for porous pavers and must be in accordance with manufacturer's minimum specifications. Edge restraints may be used for porous asphalt and porous concrete, as necessary. If not otherwise specified, concrete curbing shall be acceptable in all applications where the curb extends below the paver bedding layer.

D. Porous pavement shall meet all surface requirements of the latest ADA requirements and accessibility guidelines.

E. Porous pavement must be certified by H-20 loading or greater for all traffic applications.

F. Porous pavement surfaces shall have a minimum surface slope of 1% to provide positive drainage in overflow events or in the event of porous surface clogging.

G. Porous pavement shall not exceed a surface slope of 5% in any direction. Slopes in excess of 5% will be considered with approval from the City Engineer.

H. The design surface infiltration rate through the porous pavement surface shall be a minimum of 200 inches per hour.

Storage

Subsurface storage, typically clean-washed stone, is located directly below the porous pavement surface. This storage media temporarily holds the stormwater runoff in the void space allowing for infiltration to the native soils below. The storage media layer will vary in depth to meet the volume storage requirements and may also incorporate pipes, arches, or other structures with larger void space if required.

I. Refer to the storage subsection of Section 5.1 General GI Design Standards.

J. If the stone storage media is composed of #57 stone, a choker course is not required. If the stone storage media is comprised of #3 stone, a #57 stone choker course is required.

K. If required, the choker course shall have a minimum depth of 2 inches or as specified by the manufacturer.

L. Check dams, if proposed, shall meet the following requirements:

1. Check dams shall be installed as needed to accommodate significant grade changes and limit the overall system depth while maintaining a flat bottom storage bed.
2. At least 6 inches between the top of the check dam and the top of the storage media shall be provided.
3. Allowable check dam types include:
    - Compacted earthen berms,
    - Concrete,
    - PVC, and
    - Plastic lumber.
4. Compacted earthen berm check dams shall be constructed with a maximum 1:1 side slopes and have a minimum top width of 18 inches.

Vegetation

Porous pavement does not typically include vegetation components, with the exception of reinforced turf applications. However, porous pavement can be used in series with vegetated BMPs such as bioretention/bioinfiltration BMPs.

Outlet Control

M. Refer to the outlet control subsection of Section 5.1 General GI Design Standards.

Maintenance and Monitoring

N. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

O. Porous pavement BMPs must allow for routine maintenance access by regenerative air sweeping equipment. A minimum width of 8 feet is recommended.

5.3.2 Plan Layout Schematics and Details

The Porous Pavement Typical Application Layout (PP-1) shows examples of potential layouts and applications of porous pavement BMPs. There are other site-specific applications for porous pavement BMPs and these examples are not exhaustive. Standard details PP-2 through PP-5 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Porous Pavement Typical Layouts and Standard Detail Sheets:

- PP-1: Porous Pavement Typical Application Layout
- PP-2: Typical Porous Pavement Parking Lane
- PP-3: Typical Porous Sidewalk
- PP-4: Typical Porous Asphalt Parking Lot
- PP-5: Terraced Porous Pavement

5.3.3 Material Standards

This section provides material standards for the inlet control, storage media, and outlet control of porous pavement. Material standards for porous asphalt and porous concrete are derived from PennDOT Publication 408. Porous asphalt and concrete shall meet all material standards in PennDOT Publication 408, Sections 420 and 520 respectively regardless of inclusion in this document. Refer to the materials subsection of Section 5.1 General GI Design Standards for general requirements and subsurface stone storage requirements.

Porous Asphalt

A. Porous asphalt mix design shall result in pavement that can infiltrate 200 inches per hour. Testing shall be in accordance with ASTM C 1701.

B. Bituminous surface shall be made of a bituminous mix of 5.75% to 6.75% by weight dry aggregate. Wearing course shall be 5.5% to 7.0% bitumen content by dry weight. Binder course shall be 3.0% to 5.0% bitumen content by dry weight. Bituminous material shall be asphalt cement, Class PG 70-72 or PG 76-22 for wearing coarse. Bituminous material shall be asphalt cement, Class PG 64-22 for binder course.

C. Asphalt binder course drawdown shall not exceed 0.3% under testing AASHTO T 305.

D. Asphalt aggregate shall be clean and open-graded.

E. At least 85% by mass (weight) of aggregate shall have 2 fractured faces under ASTM D5821 testing.

F. Flat and elongated pieces shall not exceed the maximum percentages specified in AASHTO M 323, Table 5.

G. Hydrated lime, if required, shall conform to ASTM D 3625 and be blended with dry aggregate at a rate of 1.0% by weight. Other anti-stripping agents may be used if approved by Engineer.

H. Asphalt aggregate shall be 100% crushed material with gradations conforming to the tables below:

Porous Concrete

I. Porous concrete shall be produced and provided by a National Ready Mixed Concrete Association (NRMCA) certified plant with concrete meeting all specifications of American Concrete Institute (ACI) 522.1-08 Section 1.6.1.1

J. Porous concrete mix shall result in concrete with an infiltration rate of 200 inches per hour. Testing shall be in accordance with ASTM C 1701.

K. Porous concrete shall use either Portland Cement conforming to AASHTO M 85 and AASHTO M 240.

L. Hydrated Lime shall conform to ASTM C 977. Hydration stabilizing admixtures shall conform to PennDOT Section 711.3 and be both water reducing and retarding admixture.

M. Aggregate shall be either AASHTO No. 8, Type A coarse aggregate.

N. Water to cement ratio shall be between 0.32 and 0.40.

O. Concrete void space shall be between 15% and 21% conforming with ASTM C 1688 during mixing and ASTM C 1754-12 after hardening.

Permeable Pavers and Grid Systems

P. Pavers shall be interlocking concrete pavers with aggregate joints, or pervious concrete pavers with mortared joints.

Q. All pavers shall be certified for H-20 loading or greater for all traffic applications (including sidewalk installation within the City right-of-way).

R. All pavers shall comply with ASTM C936 as a minimum for materials, ASTM C140 for compressive strength, and ASTM C979 for coloring and pigmentation.

5.3.4 Construction Considerations

A. Refer to the construction subsection of Section 5.1 General GI Design Standards for general requirements and subsurface stone storage requirements.

Porous Asphalt

B. Choker course aggregate shall be installed and compacted evenly over surface of subsurface stone storage. Choker base course shall be sufficient to allow placement of asphalt, but no thicker than 1 inch in depth.

C. Vehicles with smooth, clean dump beds shall be used to transport the asphalt mix to the site.

D. Porous asphalt mix shall not be stored for more than 90 minutes before placement. Asphalt shall be covered to control cooling.

E. Porous bituminous surface course shall be laid in 1 lift directly over base course.

F. Surface course shall not be compacted until it is cool enough to resist a 10-ton roller. Porosity and permeability may be reduced if more than 2 passes are performed with the roller.

G. 48 hours of cooling shall be allowed before allowing vehicular traffic on the surface.

H. Porous asphalt pavement shall not be used for equipment or material storage.

I. After hardening, hydrologic performance of the pavement surface will be tested by applying clean water to a single location at the surface at a rate of at least 5 gallons per minute. The water applied to the surface shall readily infiltrate without creating puddles or runoff.

TABLE 5.3.3-1. BINDER COURSE GRADATION	
U.S. Standard Sieve Size	% Passing by Weight
1"(25.0 mm)	100%
3/4" (19.0 mm)	85-100%
1/2" (12.5 mm)	35-68%
No. 4 (4.75 mm)	10-25%
No. 8 (2.36 mm)	5-15%
No. 200 (75 μm)	0-4%

TABLE 5.3.3-2. WEARING COURSE GRADATION	
U.S. Standard Sieve Size	% Passing by Weight
3/4" (19.0 mm)	100%
1/2" (12.5 mm)	95-100%
3/8" (9.5 mm)	70-100%
No. 4 (4.75 mm)	20-40%
No. 8 (2.36 mm)	10-20%
No. 200 (75 μm)	0-4%

Porous Concrete

J. Base material shall be wetted immediately before placement of concrete begins.

K. Concrete shall not be placed in cold weather. Cold weather will be identified as 3 days with an average daily outdoor temperature below 40°F in accordance to ACI 306.1.

L. The process of curing must begin within 20 minutes of placement. Surface shall be covered with 6-mil thick polyethylene sheet.

Porous Pavers

M. Gaps at the edge of paved areas shall be filled with cut units. Cut units subject to vehicular traffic shall not exceed 1/3 of unit size.

N. Pavers shall be compacted with at least 2 passes of the plate compactor. Compaction shall not occur within 6 feet of unrestrained edges.

O. Additional aggregate shall be added to the opening of joints as needed after each compaction. Excess aggregate shall be swept before compaction begins again.

5.4 GREEN ROOFS

Green roofs, also known as vegetated roofs, rooftop gardens, or eco-roofs, manage runoff that would otherwise be generated by impervious rooftops. Green roofs manage stormwater above ground level, which differs from the ground level stormwater management of other BMP types. The runoff is captured, stored, and treated, all within the confines of the roof.

Green roofs are composed of multiple layers, including vegetation, growing media, geotextile, storage media, and an impermeable liner. Rainfall is stored within these layers until the stormwater undergoes evapotranspiration or is slow-released.

Figure 5.4-1. Typical Green Roof System

Green roofs are divided into two general categories: extensive and intensive.

- Extensive roofs have a thickness less than 6 inches, resulting in less management capacity compared to intensive roofs. They are typically planted with succulents, grasses, and other drought-resistant species. Extensive roofs tend to be lightweight, require less added structural support, and are more appropriate for retrofit projects than intensive roofs.
- Intensive roofs have a thickness greater than 6 inches, resulting in a greater management capacity compared to extensive roofs. They can sustain a more diverse set of plant types and species, but typically require more maintenance, additional structural support, and higher initial investment.

Green roofs can be utilized on most building types as long as the building is structurally capable of supporting the weight. Green roofs can be implemented on existing buildings as a retrofit or on new buildings. Examples of typical green roof layouts are provided in Appendix B.

Key Advantages

- Manages stormwater while maximizing usable space.
- Avoids ground-level conflicts with other infrastructure.
- Increases aesthetic and market value of buildings.
- Does not usually require new sewer connections and instead utilizes existing infrastructure.
- Does not require excavation for installation.
- Can reduce heating and cooling costs by stabilizing temperature fluctuations.

- Reduces urban heat island effect through evaporative cooling measures.
- Extends the service life of the roof by protecting the underlying liner from physical damage, temperature extremes, and ultraviolet (UV) radiation degradation.
- Improves surrounding air quality by filtering out small airborne particulates.
- Supports small wildlife communities, such as birds and beneficial insects.
- Reduces the net carbon footprint of the building over its lifecycle.
- Can be utilized for highly-visible community engagement activities; such as a recreational space, educational space, or as a rooftop garden/farm.

Key Limitations

- Higher initial investment than traditional roofing.
- May need to be combined in series with other BMP types to fulfill stormwater requirements.
- May not be suitable for some retrofit projects depending on the structural capabilities of building.

Key Design Considerations

- Ideal for sites with ground-level space constraints.
- Ideal for sites with buildings that occupy a large percentage of the total parcel area.
- Coordination with architectural and structural engineers early in the design process is essential. Green roofs will affect the operation of other building systems, such as heating ventilation, and air conditioning (HVAC) systems, and shall be integrated with these systems for potential cost savings.
- Green roofs are most effective on flat roofs.
- The effectiveness of the green roof system depends on the level of evapotranspiration that occurs. This effectiveness can be increased by considering the following strategies:
    - Include low-transmissivity drainage layers. Limiting the amount of sand within the drainage layers will limit the hydraulic conductivity of the layer and thereby promote water retention;
    - Lengthen flow path to outflow drains;
    - Introduce new rainfall interception layers;
    - Select plants with dense roots; and
    - Select growth medium with high water capacity.

5.4.1 Components and Design Standards

The following section provides an overview of typical components and design standards for green roofs. Refer to Section 5.1 for General Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements.

General

A. Structural Loading

1. Green roofs must be analyzed for structural loading by a licensed structural engineer. The wet weight of the green roof must be considered, and the potential maximum loads must adhere to the American Society of Testing and Materials E2397.

B. Surface Slope

1. Green roofs shall not exceed a surface slope of 1:6 in any direction without incorporating additional slope stabilization measures.

2. Green roofs with a surface slope greater than 2% shall include battens to secure drainage layers and prevent erosion while vegetation is being established.

C. Proper waterproofing and root barrier layers must be included to meet all building code requirements.

1. The bottom and sides of the system must include an impermeable liner. If the impermeable liner is not resistant to root penetration, an additional root barrier layer shall be incorporated to protect the impermeable liner.

Pretreatment

Green roofs receive direct rainfall and may be designed to receive runoff from adjacent roofs. The sediment and debris content of runoff managed by green roofs is typically low and therefore pretreatment of the runoff is typically not required.

Conveyance

D. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

E. Any diverted flow from adjacent impervious areas shall be evenly dispersed across the green roof surface through sheet flow or a level spreader.

Storage

Stormwater storage typically occurs within the following layers:

- Growing medium – holds the stormwater runoff in the void space and provides medium for vegetation
- Geotextile – prevents sediment and soil migration between the growing medium and underlying drainage layer
- Drainage layer – provides conveyance of stormwater beneath the growing medium
- Root barrier/impermeable liner – protects the underlying roof from moisture and root intrusion
- Roofing system – provides structure and support

F. A filter or separation geotextile that allows root penetration shall be placed between the storage media and growing media to prevent migration of the growing media into the storage media.

G. For extensive roofs:

1. The growing media shall have a minimum allowable thickness of 3 inches.

2. The drainage layer shall have a minimum depth of 4 inches below the growing media.

H. For intensive roofs:

1. The growing media shall have a minimum allowable thickness of 6 inches.
2. The drainage layer shall have a minimum depth of 4 inches below the growing media.

Vegetation

Vegetation shall consist of a diversity of species to increase viability and mitigate extreme weather conditions.

Approximately 50% of the total number of plants shall be comprised of four or more different species of native sedum. Approximately 70% of the total number of plants shall be evergreen plants in order to protect from erosion during winter months. Other plants shall include shrubs, herbs, meadow grasses, or meadow flowers, depending on the desired appearance and type of green roof.

Other types of plants can also be considered as long as they are resistant to drought and the growing media is adequate for healthy growth. Planting shall take place between April 1st – June 15th and/or between September 15th – November 15th. The plantings shall be permitted to establish for one full season before adjacent drainage areas are diverted to the green roof. Depending on site characteristics and climate, irrigation systems may need to be incorporated within intensive green roof BMPs for maximum plant preservation during dry periods.

I. Refer to the vegetation subsection of Section 5.1 General GI Design Standards.

J. Vegetation, once fully established, must cover the area of the growing media.

Outlet Control

Unlike most other BMP types, the stormwater within the storage media will not infiltrate into the ground. Instead, runoff leaves the system via evapotranspiration and slow-release to another BMP or the sewer via an overflow structure, such as a riser, gutter, or roof drain.

K. Drains, scuppers, and risers must include a grate or lid and pretreatment measures to prevent clogging by debris.

Maintenance and Monitoring

L. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

M. Green roof systems must be sited to allow for safe and routine access for maintenance and monitoring. Typical roof access will be sufficient in most cases.

N. Gravel or stone walking paths shall be included at regular intervals around the systems to provide access to system structures for maintenance personnel to be able to move about the system unimpeded and to protect plants from damage.

O. Access to maintenance of adjacent building systems, such as HVAC or electrical equipment, shall be considered when siting vegetation footprints.

P. Green roofs must comply with OSHA Fall Protection Safety Standards (1926.501) and the ANSI and American Society of Sanitary Engineering (ASSE) consensus-based fall protection standards.

5.4.2 Plan Layout Schematics and Details

The Green Roofs Typical Application Layout (GR-1) shows examples of potential layouts and applications of green roof BMPs. There are other site-specific applications for green roof BMPs and these examples are not exhaustive. Standard details shown on GR-2 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Green Roofs Typical Layouts and Standard Detail Sheets:

- GR-1: Green Roofs Typical Application Layout
- GR-2: Typical Extensive and Intensive Green Roofs

5.4.3 Material Standards

Growing Medium

A. Growing medium shall meet the following criteria:

TABLE 5.4.3-1. MEDIUM TESTING REQUIREMENTS

Test Measurement	Acceptable Range	Testing Method
Moisture Content	≥ 35 %	ASTM E2399
Porosity at water capacity	≥ 6 %	ASTM E2399
Water permeability	≥ 0.25 in/min (15 in/hr)	ASTM E2399
Soluble Salts	≤ 2 mmhos/cm	DPTA
Total Organic Matter	≥ 10 %, ≤ 3 %	MSA
pH	≥ 8.0, ≤ 6.5	MSA

B. Medium shall be able to withstand freezing and thawing.

C. Medium shall meet German FLL (see Appendix F for acronym) guidelines for grain-size distribution.

D. Medium must have a saturated permeability of at least 6 inches per hour (ASTM E2399).

Geotextile

E. Geotextile shall meet the following criteria:

TABLE 5.4.3-2. GEOTEXTILE TESTING REQUIREMENTS

Test Measurement	Acceptable Range	Testing Standard
Flow Rate	≥ 95 gal/min/ft2	ASTM D4491-99A
Grab Tensile Strength	≥ 120 lb	ASTM D4632
Mullen Burst Strength	≥ 225 psi	ASTM D3786 -7
UV Resistance (after 500 hrs)	≥ 70%	ASTM D4355

F. Heat set geotextiles shall not be used.

Drainage Layer

G. Synthetic drainage layers are acceptable if the depth of the drainage layer is less than 5 inches.

H. Granular drainage layers are required whenever the drainage depth is 5 inches or greater.

I. Granular drainage layers shall meet the following criteria:

TABLE 5.4.3-3. DRAINAGE LAYER REQUIREMENTS

Test Measurement	Acceptable Range	Testing Standard
Abrasion Resistance	≤ 25% loss	ASTM C 131 96
Porosity	≥ 25%	ASTM C 29
Soundness	≤ 5% loss	ASTM C 88
Particles passing ½" Sieve	≥ 75%	ASTM C 136

J. Thickness of the granular layer shall be 2 inches at minimum. Granular drainage layer may be used in conjunction with a synthetic layer.

Impermeable Liner and Root Barrier

K. The following materials are permitted and shall meet the corresponding standard:

1. PVC liners shall meet ASTM D4434.
2. EDPM liners shall meet ASTM D4637.
3. Thermoplastic polyolefin (TPO) liners shall meet ASTM D6878.

L. Liner shall have waterproof seals at all seams, corners, and other protrusions.

M. Liner shall abide by most recent building codes of the City of Lancaster including, but not limited to, those outlined in Chapters 109 and 116 of the City of Lancaster code.

Vegetation

N. Extensive green roof vegetation shall be at least half sedums using at least four different species of sedum.

O. All selected plantings must be able to withstand extreme weather, such as high winds, heat, or cold.

P. Roof planting shall be self-sustaining and tolerant of drought conditions.

Q. Roof planting shall avoid *Sedum sarmentosum*, otherwise known as Star sedum, Gold moss, or Graveyard moss.

5.4.4 Construction Considerations

Installation Procedure

A. Install impermeable liners and root barrier/impermeable liner protection layer. Inspect for any irregularities with both liner and layer upon installation.

B. Install drainage layer, beginning with granular layer if both granular and synthetic layers are to be used.

C. Install and test irrigation system if specified for use by manufacturer.

D. Install layer separation geotextile and growing medium.

Planting Guidance

E. Sedum can be propagated by using fresh cuttings in the autumn or spring.

F. Perennial plants shall be installed as plugs or container plants in the period between April and November. Newly installed plants will be irrigated as required.

G. Perennial plants may be established from seeds outside of the summer period (June, July, and August).

H. Full establishment of vegetation may take up to 2 growing seasons. High wind environments may require wind scour blanket or hydromulch to prevent erosion during the establishment period. Permanent placement of these anti-erosion practices may be necessary in some cases.

5.5 SUBSURFACE INFILTRATION AND DETENTION

A subsurface infiltration and detention system is an underground storage trench that captures and temporarily stores stormwater below an impervious or vegetated surface. Subsurface infiltration and detention systems typically store stormwater runoff until it infiltrates into the native soil below and/or slowly released through an outlet control structure to the sewer system or a downstream BMP. The subsurface storage media may consist of clean-washed, open-graded stone aggregate, perforated pipes set in a stone bed, or other proprietary stormwater storage products. Subsurface infiltration and detention systems can be implemented in series with other BMPs to achieve volume and rate control requirements.

Figure 5.5-1. Typical Subsurface Infiltration and Detention System

Subsurface infiltration and detentions system designs vary by site and space constraints but are versatile and can be suitable in many different locations. They are typically well-suited for expansive level areas where surface BMPs are not feasible due to program requirements, such as playgrounds, paved areas where porous pavement is not suitable, athletic fields, or turf areas. Examples of typical subsurface infiltration and detention layouts are provided in Appendix B.

Key Advantages

- Flexible layout that is easy to incorporate beneath sites.
- Can manage stormwater in areas with limited surface or rooftop space.
- Effective at reducing runoff rates and volumes.

Key Limitations

- May have higher installation costs than surface BMPs.
- Systems can easily clog if stormwater is not pretreated, loading is high, and maintenance is not consistent.
- No aesthetic or environmental benefits compared to surface BMPs.
- Limited water quality benefits for slow release systems.

Key Design Considerations

- Pipes, arches, crates, and other proprietary structures may be used for increased void space.
- Landscape features or surface BMPs can be implemented on top of the subsurface infiltration and detention system, provided that appropriate separation and barriers are incorporated.

5.5.1 Components and Design Standards

The following section provides an overview of typical components and design standards for porous pavement BMPs. Refer to Section 5.1 for General Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements.

Pretreatment

A. Refer to the pretreatment subsection of Section 5.1 General GI Design Standards.

Conveyance

B. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

Storage

C. Refer to the storage subsection of Section 5.1 General GI Design Standards.

D. Manufacturer's guidelines must be followed if using proprietary storage structures such as arches, crates, or chambers.

Vegetation

Vegetation typically consists of trees planted in series that are hydraulically connected to the subsurface storage (e.g., tree trenches).

E. Refer to the vegetation subsection of Section 5.1 General GI Design Standards.

Outlet Control

F. Refer to the outlet control subsection of Section 5.1 General GI Design Standards.

Maintenance and Monitoring

G. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

H. Requires regularly scheduled inspections as maintenance problems are not immediately apparent.

5.5.2 Plan Layout Schematics and Details

The Subsurface Infiltration and Detention Typical Application Layout (SS-1) shows examples of potential layouts and applications of Subsurface Infiltration and Detention BMPs. There are other site-specific applications for subsurface infiltration and detention BMPs and these examples are not exhaustive. Standard details SS-2 through SS-4 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Subsurface Infiltration and Detention Typical Layouts and Standard Detail Sheets:

- SS-1: Subsurface Infiltration and Detention Typical Application Layout
- SS-2: Typical Stone Trench
- SS-3: Subsurface Infiltration Planter
- SS-4: Subsurface Inflitration with Modular Storage Units

5.5.3 Material Standards

A. Refer to the materials subsection of Section 5.1 General GI Design Standards.

5.5.4 Construction Considerations

A. Refer to the construction subsection of Section 5.1 General GI Design Standards.

5.6 CISTERNS

Cistern BMPs are stormwater storage tanks with the purpose of collecting stormwater for volume control and rate control. Cistern BMPs can be used in the application of rainwater harvesting if water supply and demand calculations demonstrate all stored stormwater will be removed from the tank before the next storm event. This will allow storage capacity for the next storm event.

Figure 5.6.1. Typical Cistern System

Cistern BMPs are customizable. While there are many prefabricated designs to choose from, cisterns can take many shapes and configurations depending on the design requirements. Cistern BMPs can be sited in a variety of locations. Surface tanks are located above the ground, typically adjacent to buildings or on top of roofs. Subsurface tanks are located beneath the ground, often underneath paved or vegetated surfaces. Interior tanks are located within a building, typically in a basement or within another dedicated mechanical space, while exterior tanks are located exterior to a building.

This manual does not seek to establish regulations on water quality or treatment procedures for any re-use applications. Third party professional guidance by a qualified individual is recommended to make sure all cistern components comply with all city, state, and federal water quality regulations.

Examples of typical cistern layouts are provided in Appendix B.

Key Advantages

- Can be utilized in small, constrained spaces.
- Allows for flexible, customizable design options and configurations.
- Reduces potable water demand/usage when runoff is re-purposed for grey or landscaping applications.
- Promotes sustainability and provides community engagement options when used on public projects or at highly visible sites.

Key Limitations

- Any collected stormwater designated for re-use is limited by city, state, and federal code restrictions.
- Cisterns may require additional downstream BMPs to meet volume control or rate control requirements.

- Cistern BMPs do not typically contribute aesthetic value of buildings and/or sites to the same extent as surface vegetation BMPs.

Key Design Considerations

- Cistern conveyance typically consists of gutters, downspouts, and pipes. Minimizing the length of conveyance systems is important. Cisterns shall be gravity-fed where feasible. Pumps can be used if necessary.
- Cistern pretreatment requirements vary by any potential re-use of the stormwater. Sediment filtration is often sufficient. Additional pretreatment such as disinfection for microorganisms may be required for indoor re-use.
- Cisterns may need to be located underground (below the frost line) or indoors if freezing conditions are of concern.
- Underground cisterns may require clearance if they are located beneath parking areas or other loading surfaces.
- For re-use applications, the drainage area to each storage tank needs to consider year-round water demands.

5.6.1 Components and Design Standards

The following section provides an overview of typical components and design standards for cistern BMPs. Refer to Section 5.1 for General Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements. The design of internal distribution, treatment, and pumping systems is beyond the scope of this manual.

General

A. Cistern foundations must be designed by an appropriate design professional. Cisterns, especially above-ground cisterns, must be placed on a structurally sound foundation to prevent damage from settling.

B. All cistern systems must comply with City Plumbing Codes for allowable indoor uses and pipe labeling, and state and federal codes for treatment and management of reuse water.

C. Drainage area to the cistern shall be sized to meet drain down time requirements as well as any intended re-use of the stored stormwater. Refer to Chapter 4 for methodology.

Pretreatment

Cisterns utilize various types of pretreatment methods, depending on the end-use of the harvested water and the composition of the contributing drainage area. Primary types of pretreatment methods utilized for cistern BMPs are described below.

- Gutter screens remove trash and debris from roof gutters and downspouts before runoff is conveyed into the storage tanks.
- First flush diverters (or roof washer) reroute the first pulse of stormwater away from the cistern to a first flush chamber or onto a surface BMP. The first flush of stormwater runoff carries the majority of sediment and pollutants (sand, dust, pollen, hydrocarbons) that has collected on the impervious areas since the previous rain event. First-flush diverters prevent contaminants, sediment, and small debris from entering the cistern.

D. The inflow conveyance system shall include, at minimum, a screen to prevent leaves, debris, and small animals from entering the cistern.

E. First-flush diverters shall be sized to capture approximately the first 1 to 3 gallons of stormwater per 100 square feet of drainage area in the first-flush chamber. Diverted stormwater shall not be excluded from management and treatment requirements but shall be diverted to an alternative BMP.

Conveyance

Cisterns typically collect water from impervious roof area via gutters or overflow drains. The runoff is gravity-fed from the collection point, through the gutters, downspouts, and conveyance piping, into the storage tank.

F. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

G. For underground cisterns, a pump, pressure tank, and backflow preventer are required.

Storage

Cistern BMPs store water within a tank. Multiple cistern tanks can be utilized in series or parallel to meet design requirements. Tanks shall be sited as close to the end-use location as possible to minimize the distribution system piping and requirements. Below ground tanks must be designed to account for buoyancy effects assuming an empty condition.

H. Refer to the storage subsection of Section 5.1 General GI Design Standards.

I. Only the volume of water that is utilized or slow-released within 72 hours can be used to meet the volume control requirement. Any remaining volume must be managed by other BMPs for compliance.

J. Supply and demand calculations must be provided for cistern storage volume used for compliance with the SWM Ordinance.

K. Cisterns located exterior to buildings require drainage of stored volume prior to freezing events.

Vegetation

Cistern BMPs do not include vegetation, but they can be used in series with vegetated BMPs such as bioretention/bioinfiltration BMPs.

Outlet Control

L. Stormwater volume used for compliance must be designed to be slowly-released to the sewer or be directed to another BMP.

M. The overflow shall be near the top of the storage unit.

Maintenance and Monitoring

N. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

O. Access:

1. First-flush systems shall have accessible cleanouts.

2. Inspection and maintenance access features, such as panels, ports, and manholes, shall have sufficient space for inspection and maintenance of the storage area, and be secured with a lock to prevent unwanted entry.
3. Ladder access must be provided for vaults greater than 4 feet in height.
4. Observation ports are sufficient to monitor tank volume. However, volume gauges/sensors at accessible locations allow tank levels to be monitored without entering the tank itself.
5. Cistern drainage access points must be readily accessible.

5.6.2 Plan Layout Schematics and Details

The Cistern Typical Application Layout (CI-1) shows examples of potential layouts and applications of Cistern BMPs. There are other site-specific applications for Cisterns BMPs and these examples are not exhaustive. Standard details CI-2 through CI-4 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Cistern Typical Layouts and Standard Detail Sheets:

- CI-1: Cistern Typical Application Layout
- CI-2: Typical Interior Cistern Detail
- CI-3: Typical Exterior Tank
- CI-4: Typical Subsurface Tank

5.6.3 Material Standards

A. Refer to the materials subsection of Section 5.1 General GI Design Standards.

B. Cisterns shall be constructed of fiberglass, concrete, plastic, or other watertight storage vessel.

C. Galvanized steel, wood, and other materials prone to environmental decay or corrosion are prohibited.

D. Cisterns shall be opaque or protected from direct sunlight to inhibit algae growth.

E. Subsurface cisterns shall be either poured concrete or approved prefabricated plastic tanks.

F. All premanufactured products shall have a watertight rating for the life of the cistern.

G. Service ways, when used, shall have lockable manhole covers. Multiple service ways must exist to accommodate repairs, cleaning, and inspection.

5.6.4 Construction Considerations

A. Refer to the construction subsection of Section 5.1 General GI Design Standards.

B. Cisterns shall be installed according to the manufacturer's specifications.

C. Temporary flow diversions shall be installed before construction begins.

5.7 NATURALIZED BASINS

Naturalized basins are depressions or basins planted with native species that manage stormwater runoff. Unlike conventional detention basins that are covered with mowed lawn, or urban bioretention systems with rigid geometry and hard edges, naturalized basins are designed to appear as naturally occurring features in a landscape.

Three types of naturalized basins are described in this section. Regardless of the specific design attributes, all naturalized basins function both to manage stormwater and provide ecosystem services, e.g., wildlife habitat.

Dry Detention Basin Retrofit

The term "naturalized basin" has been commonly used in reference to conventional detention basins in which the turf lawn is replaced by a native meadow plant community. Other functional aspects of the system remain the same, and the system still acts to temporarily store and then infiltrate runoff from a design storm event. Depending on site conditions, it may also be possible to convert a conventional detention basin into a wet pond system (see below).

Wet Pond

A wet pond (also called a retention pond) is a basin with a permanent pool or ponded area that provides water quality treatment and temporary storage capacity for stormwater runoff above the permanent pool.

Wet ponds require a connection with shallow groundwater or an adequate source of inflow to maintain a permanent pool. They are best suited to low-lying areas that serve as collection points for stormwater runoff, although it is also possible to convey runoff into ponds via subsurface piping from other BMPs. Almost any drainage area where soils are impermeable enough to support permanent ponding can be feasible for a wet pond.

Stormwater Wetland

A constructed stormwater wetland, like a wet pond, has areas of long-term or persistent soil saturation as well as permanently ponded water. The configuration of a wetland (e.g., microtopography, extent of ponding, flow path, and plant zones) is more complex than a wet pond, and several variations on the design are possible:

- Shallow wetlands with a large surface area that provide water quality improvement through displacement of the permanent pool.
- Extended detention shallow wetlands that use extended detention for water quality and peak rate control.
- Pocket wetlands that serve smaller drainage areas.
- Pond and wetland systems that combine a wet pond and a constructed wetland.

Although constructed wetlands provide habitat and aesthetic value, they are unlikely to have the full range of ecological functions as a naturally occurring wetland and are designed mainly for water quality improvement and rate control.

Both wet ponds and constructed wetlands improve the quality of stormwater runoff through settling, filtration, chemical and biological decomposition, uptake and volatilization, and adsorption. Pollutant removal—including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens—varies in effectiveness by season as vegetation undergoes dormancy and ambient temperatures rise and fall.

Figure 5.7.1. Typical Naturalized Basin System

Examples of typical naturalized basin layouts are provided in Appendix B.

Key Advantages

- Can be effective at meeting rate control requirements.
- Although not typically considered volume-reducing BMPs, wet ponds and constructed wetlands can achieve some volume reduction through evapotranspiration, especially for small storms.
- Can support native wildlife populations while improving air and water quality.
- Can reduce urban heat island effects.
- Can easily be converted from existing dry detention basins.
- More aesthetically pleasing than traditional detention basins and other non-vegetated BMP types.
- Can create opportunities for education and community engagement when sited near schools, libraries, or other public spaces.

Key Limitations

- Require a large dedicated ground surface area.
- May include areas of deep water, which will require enhanced safety measures to protect the public.
- May reduce the storage volume available if converted from an existing dry detention basin.
- May attract geese and other wildlife that pose a nuisance to surrounding areas.

Key Design Considerations

- To ensure proper function and persistence of ponded areas, adequate contributing drainage area is required (typically 10 acres minimum; 5 acres for a pocket wetland). A detailed analysis, including a water budget, may be required to demonstrate adequate base or groundwater flow. All inputs and outputs to the system must be considered, including runoff, flooding, groundwater inflow, evapotranspiration, and groundwater outflow.
- Structural design of berms must be considered. Dam permitting may be required dependent on depth and storage volume.
- Underlying soils must be relatively impermeable or an engineered liner is needed. Note that areas with soils that infiltrate well should generally not be converted to impermeable systems.
- Constructed wetlands shall be designed with a meandering flow path using berms and grading where space allows for a longer travel time. Longer residence time in the system improves water quality treatment.
- The discharge from wet ponds can have undesirable thermal effects on downstream water bodies supporting cold water fish species. Designers shall mitigate warm water impacts by planting shade trees around the perimeter, designing the system as a series of pools that can allow cooling to occur before discharge, and positioning the outlet structure in the deep pool to allow for withdrawal of colder bottom water.
- The depth to the water table must be included in siting and design of systems to avoid adverse hydraulic impacts, such as exacerbating a seasonally or year-round high water table and causing unwanted surficial ponding nearby or off site.
- Goose deterrent/antigrazing measures may be needed to protect new plant installations during the establishment period.
- Wildlife blinds, observation platforms, and boardwalks can be incorporated into systems for additional recreational and educational value and to promote community engagement.

5.7.1 Components and Design Standards

The following section provides an overview of typical components and design standards for naturalized basin BMPs. Refer to Section 5.1 for General Design Standards and Appendix B for City of Lancaster Standard Details for additional requirements.

General

A. Wet basin systems shall be designed with a length-to-width ratio of at least 2:1 to the extent possible.

B. Basin side slopes on the inside shall be 4:1 to 5:1 (H:V) or flatter wherever possible, and 10:1 maximum for aquatic safety benches. External side slopes shall be no steeper than 3:1.

C. The minimum allowable freeboard designed to provide the rate control requirement is 1 foot unless otherwise approved by the City Engineer.

D. The minimum allowable basin width is 10 feet.

E. The minimum allowable sediment forebay length is 10 feet.

F. Two aquatic safety benches, each 4 to 6 feet wide, must be incorporated into all areas deeper than 4 feet. The first bench shall be located 1 to 1.5 feet above the normal water surface elevation and the second shall be 2 to 2.5 feet below the water surface.

G. Any proposed deviations from these details must meet all requirements of this manual and must be approved by the City Engineer.

Pretreatment

H. Refer to the pretreatment subsection of Section 5.1 General GI Design Standards.

I. Wet ponds and stormwater wetlands must have a forebay at all major inflow points to capture sediment and reduce erosion from inflow. Forebays shall comprise 10% to 15% of the total permanent pool volume and shall be 4 to 6 feet deep, or at least as deep as the other open water areas.

J. The bottom of the forebay can be a hardened material to facilitate sediment removal.

K. Permanent vertical markers shall be installed to indicate the depth of sediment accumulation.

L. Inflow channels must be fully stabilized.

M. Inflow pipes can discharge at the surface or be partially submerged.

Conveyance

N. Refer to the conveyance subsection of Section 5.1 General GI Design Standards.

Storage

Naturalized basins store stormwater runoff in two ways: permanent storage and temporary storage. Permanent storage consists of the inflow and retention of the minimum water required to support the ecosystem. Temporary storage consists of the volume of runoff able to be managed by the system. This water will undergo evapotranspiration or slow release and/or bypass. Only the temporary storage volume will be considered for stormwater credit.

O. Refer to the storage subsection of Section 5.1 General GI Design Standards.

Outlet Control

P. Refer to the outlet subsection of Section 5.1 General GI Design Standards.

Q. Outlet control structures are typically multistage devices with pipes, orifices, or weirs for flow control. Orifices, if used, shall be at least 2.5 inches in diameter and protected from clogging using a reverse side slope. The outlet pipe shall have an anti-seep collar through the embankment.

R. Outlet control structures shall be placed in open water areas 4 to 6 feet deep to prevent clogging and to allow the system to be drained for maintenance.

S. Trash racks/overflow grates are required for outlet structures but must not obstruct outflow or act as the hydraulic control for the system.

T. Online facilities shall have an emergency spillway that can pass the 100-year storm safely with 1 foot of freeboard.

Vegetation

U. Vegetation is an essential part of naturalized basins, helping to enhance pollutant removal, limit erosion, provide habitat, support soil microbes, shade and cool water, and contribute to extended water circulation and flow path.

V. Wet basin systems have a range of hydrologic zones with varying levels of inundation and extent of soil saturation, as well as drier upland areas. Plants selected for these systems must be adapted for the particular hydrologic conditions of a given zone. Typically, these systems have a zone of deep, persistent ponding (pool zone) surrounded by areas of shallower water (marsh zone). Shallow water zones transition to a semiwet zone that may experience a low level of seasonal inundation or saturated soil.

W. The pool zone usually has a standing water depth between 2 and 6 feet (8 feet maximum), which supports floating and submerged (depending on water clarity) vegetation but is too deep for most emergent species. The depth of the pool shall be shallow enough to prevent thermal stratification but deep enough to minimize algal blooms and resuspension of previously deposited materials by storms and strong winds.

X. The marsh zone has shallower standing water depths than the pool zone, usually just up to 18 inches. This zone may be further characterized as high marsh (0–6 inches deep) or low marsh (6 – 18 inches deep), with specific emergent vegetation typical of each area. In constructed wetlands, the marsh zone shall comprise at least 60% of the water surface area.

Y. Plants in the semiwet zone or shoreline fringe (0–12 inches above water surface elevation) are species adapted to the more variable hydrology in this zone, which is the interface between wetland and upland.

Z. A 25-foot-wide vegetative buffer from the maximum water surface elevation is recommended for ecological and aesthetic value. Perimeter vegetation at least 24 inches tall will help to deter Canada geese.

Maintenance and Monitoring

AA. Refer to the maintenance and monitoring subsection of Section 5.1 General GI Design Standards.

AB. Regular, effective maintenance is essential to ensure naturalized basins meet design performance requirements. All system components that receive and/or trap floatable trash, debris and sediment must be inspected for clogging and excessive accumulation and be accessible for cleaning using vactor trucks or other vehicles. Soil stabilization or structural paths using permeable grass pavers may be necessary to provide vehicular access.

AC. Cleanout structures must be included at regular intervals along distribution and conveyance pipes.

AD. Even with regular annual maintenance, these systems accumulate sediment, and a full cleanout cycle shall be considered as part of the overall maintenance plan. Depending on watershed conditions, the cleanout cycle for a wet basin system can average about 10 years.

AE. Water levels and flow volumes must be measured at regular intervals. Water samples shall also be analyzed to track and correct for changes to the ecosystem equilibrium.

AF. When establishing or restoring vegetation, inspections shall be performed biweekly. Once established, inspections of health, density, and diversity of plant species shall be performed at least twice annually during both growing and nongrowing seasons. Vegetative cover must be maintained at 85% minimum, with less than 10% cover by invasive species.

5.7.2 Plan Layout Schematics and Details

The Naturalized Basin Typical Plan Layout (NB-1) shows examples of potential layouts and applications of Naturalized Basin BMPs. There are other site-specific applications for naturalized basin BMPs and these examples are not exhaustive. Standard details NB-2 through NB-4 provide requirements for various application types and BMP components. Layout and details are listed below and can be found in Appendix B.

Naturalized Basin Typical Layouts and Standard Detail Sheets:

- NB-1: Naturalized Basin Typical Application Layout
- NB-2: Typical Naturalized Basin Detail

5.7.3 Material Standards

Subsoil

A. Underlying subsoils must have limited permeability to retain a permanent pool. Sites with hydrologic soil group (HSG) class "C" and "D" soils are acceptable without modification.

B. For sites with HSG class "A" and "B" underlying soils, a clay or synthetic liner necessary to reduce permeability. However, the design of an infiltrating systems is preferable to artificially creating an impermeable soil condition unless infiltration is not desirable because of other site conditions. Refer to Appendix B.

Planting Soil

C. Organic soils shall be used in the emergent planting zones of wet ponds and constructed wetlands. If natural topsoil from the site is to be used to create an aquatic planting substrate, it must have at least 8% organic carbon content by weight in the A-horizon for sandy soils and 12% for other soil types.

D. Equal portions of organic and mineral materials are required for any imported planting medium.

E. Imported soil materials must be free of seeds or plant parts from invasive species (see DCNR Invasive Species website).

F. Planting soil depth must be at least 12 inches.

Vegetation

G. Plant species must be suitable for the specific hydrologic zones of the system. Refer to Appendix D for a list of approved vegetation.

H. Native species must be used to the maximum extent feasible.

I. Live plants (containers, plugs) shall be used to achieve the required vegetative coverage. For large systems, the use of native seed mix as the primary method to achieve required vegetative cover may be approved by the City Arborist or Engineer.

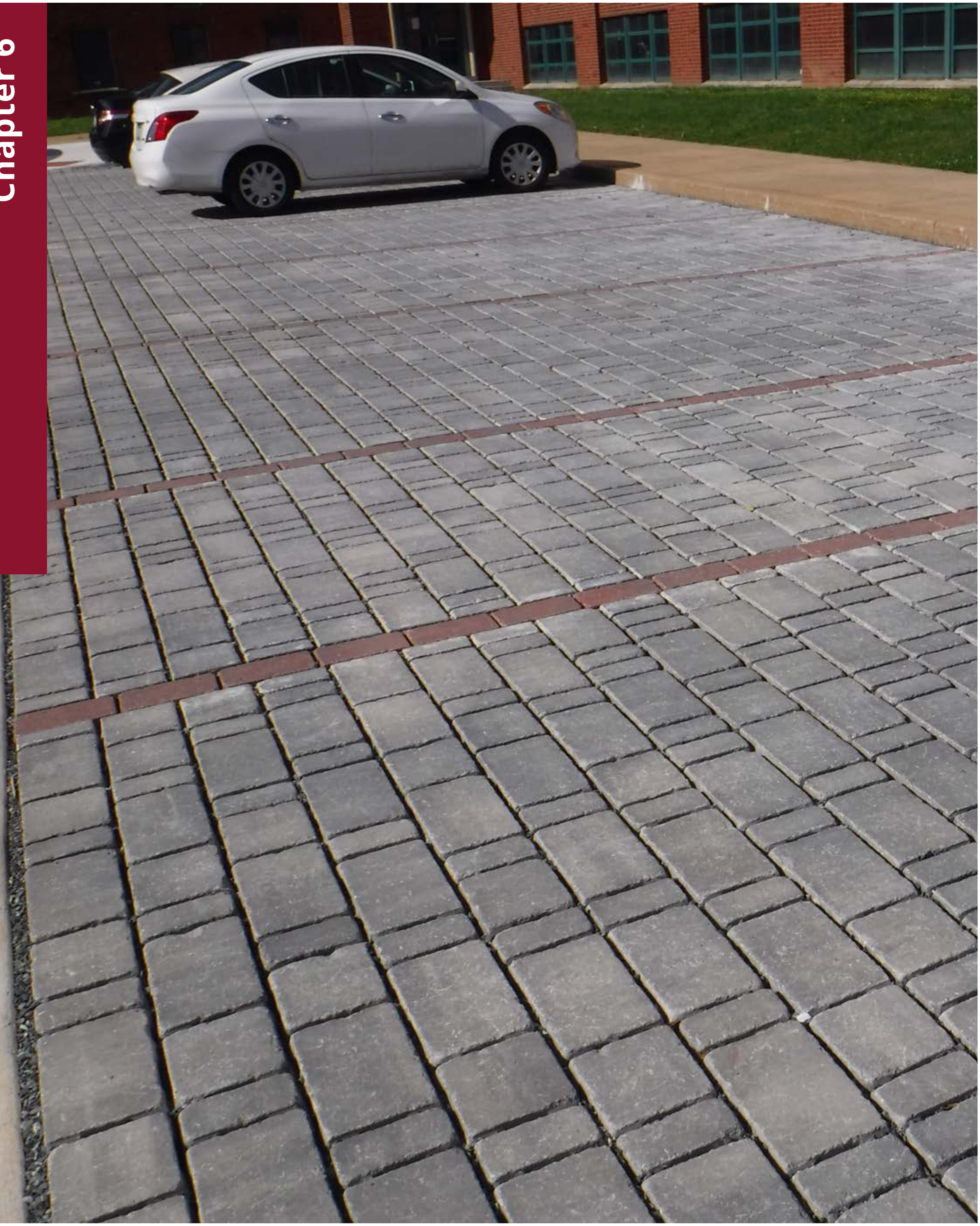
5.7.4 Construction Considerations

A. The BMP area must be isolated from the contributing drainage area prior to the start of construction and all inflow must be diverted until the system is completed and stabilized.

B. The area to be used for a wet pond or stormwater wetland shall be excavated to the required depth to achieve the designed bottom elevation, including planting soil and an impermeable liner, if specified.

C. The underlying subsoil must be free of hard clods, stiff clay, hardpan, ash, slag, construction debris, petroleum hydrocarbons, and other contaminants or undesirable materials.

D. Planting material must be properly packed and handled during all phases of work, including transport and on-site installation, to prevent injury and/or desiccation of plants. Plants must be kept from freezing and kept moist, cool and covered to be protected from precipitation, wind, and other weather.



6. CONSTRUCTION GUIDANCE AND DOCUMENTATION

Proper execution of site development and BMP construction is necessary to ensure minimal impacts on the surrounding environment and to ensure BMP components are installed properly and will function as designed. This chapter provides general construction guidance including construction and testing requirements, commonly observed construction problems, post-construction documentation requirements as well as example construction notes and an example construction sequence. Construction guidance specific to a BMP type can be found in Chapter 5.

6.1 CONSTRUCTION INSPECTION AND TESTING REQUIREMENTS

Construction inspection and testing is required to ensure all BMP components installed meet the requirements specified in the project documents.

A. Materials

Material inspection and testing certifications must be submitted for each batch of product used. Products include but are not limited to: concrete, stormwater soil, subsurface storage stone, and sand. All material submittals must be in accordance with this manual and the City of Lancaster Code.

B. Installation

The inclusion of "witness hold points" is necessary to ensure all BMP components are installed per design. A witness hold point is a step in the construction sequence that requires approval from the City before any subsequent construction activities can commence. The following are required witness hold points for typical BMP construction activities.

1. Field survey to confirm any control elevations that would impact the elevations of the BMP.
2. Installation of drainage structures, piping, or sewer connections.
3. Excavation to the bottom elevation.
4. Bottom and top elevation of sand.
5. Installation of geotextile or impermeable liner.
6. Bottom and top elevation of stone.
7. Bottom and top elevation of soil.
8. Subgrade preparation for pavement and curb installation.
9. Installation of pavement and curb.
10. Installation of plants.
11. Placement of mulch.

6.2 COMMONLY OBSERVED CONSTRUCTION ISSUES

It is important to understand what types of construction issues are common for site development and GI construction to help prevent these issues from arising. The following best practices are critical for effective GI construction.

A. Erosion and Sedimentation Control

1. All BMP footprints and existing conveyance structures downstream of construction activities must be protected from erosion and sedimentation.
2. E&S measures must be properly installed and maintained until the site is stabilized.
3. All inflow points must be blocked to prevent water from entering the BMP until the BMP construction is complete and any vegetation has been stabilized.

B. Protection of Infiltration Footprint

1. Compaction of the BMP footprint can reduce a BMP's capacity for stormwater management.
2. Construction equipment must not be stored on the BMP footprint.
3. Do not use heavy vehicles over the BMP footprint.

C. Clean Stone

1. It is important that any stone used for storage be clean and free of debris. The void spaces between the stone must be available for stormwater storage which cannot occur if the voids are filled with fines.

D. Pipes

1. Exercise caution during construction to ensure pipes are not damaged during construction.
2. Post-construction CCTV inspection shall be completed to ensure all installed pipes are free of debris and have no observable construction defects.

E. Planting

1. Planting must be installed per specifications, in accordance with all City Ordinances and this manual.

F. Elevation Tolerances

1. Final elevations of media layers (e.g., sand, stone, soil) and structure grates must not deviate greater than or less than 1 inch from design elevations. Any proposed elevation changes must be coordinated with the City Engineer.

6.3 CERTIFICATE OF COMPLETION AND AS-BUILT DOCUMENTATION REQUIREMENTS

The submission of the following post-construction documents are required:

A. Certificate of completion (SWM Ordinance §260-508)

1. Certification of completion from an engineer, landscape architect, surveyor or other qualified person verifying that all permanent SWM facilities have been constructed according to the plans and specifications and approved revisions.

B. As-built documentation (SWM Ordinance §260-509)

1. As-built plans must include final design specifications for all stormwater management facilities and be sealed by a registered professional engineer.
2. As-built plans must be submitted to the Office of Recorder of Deeds with a seal from a registered professional engineer.
3. SWM site plan must be submitted along with the as-built plans to the Office of Recorder of Deeds, unless it was previously submitted.

6.4 STANDARD CONSTRUCTION NOTES

The following set of general construction notes shall be used for GI plans in the City of Lancaster. These notes are neither exhaustive nor comprehensive and may be adapted to fit the needs of the project:

A. The existing utilities shown on the survey were taken from the best available information and are not guaranteed to be accurate. Field conditions may vary. It is the responsibility of the contractor to contact the local utility companies that have subsurface installations in the area of work for this contract and direct them to have their facilities marked out prior to commencing work. Field verification of utilities such as test pits may be needed (at contractor's expense) prior to commencing work.

B. The contractor shall examine and field verify all existing and given dimensions and conditions with those shown on the plans. In case of any discrepancy, contractor shall immediately notify the project engineer.

C. Unless noted otherwise, all work shall be performed in accordance with the latest edition of the PennDOT highway standard specifications and standard details.

D. Any discrepancies between the general notes, specifications, drawings, codes or standards shall be brought to the attention of the project engineer for direction prior to proceeding with construction, fabrication or procurement of materials.

E. The contractor shall be responsible for determining the means and methods of construction prior to the commencement of construction and shall notify the project engineer if conflicts are identified. Work not indicated on a part of the drawings but reasonably implied to be similar to that shown at corresponding places shall be repeated. Minor details or incidental items not shown or specified, but necessary for a complete and proper installation of any part of the work indicated shall be provided as required.

F. If, at any time, the existing field conditions do not permit the installation of the work in accordance with the details indicated on the contract documents, the contractor shall notify the project engineer immediately. Do not commence work until condition is resolved and modifications of the details given on the contract document have been reviewed and approved by the project engineer.

G. The contractor shall be held responsible for all damages caused by thier operations including any damage to sewers, manholes, basins, and connections. All damage shall be repaired or replaced by the contractor without cost to the owner. Any planted and/or seeded areas disturbed by the contractor's operations shall be fully restored including, but not limited to, soil decompaction to ensure proper infiltration rates as determined by project engineer, top dressing with compost, rototilling, replacement of turf or plants damaged by construction activities, and replacement and/or addition of topsoil.

H. In the event the contractor damages an existing utility service causing an interruption in or damage to said service, the contractor shall immediately arrange for service to be restored at the contractor's expense and may not continue his work operation until service is restored, unless otherwise directed by the project engineer.

I. The contractor shall perform work in such a manner to ensure minimum interference with current site activities, ingress and egress locations, walkways, and adjacent properties.

J. Acceptance of construction conformance to the applicable standards and codes is the responsibility of the owner. Full-time construction inspection is recommended to maintain adequate field quality control. Construction undertaken without such inspection shall be at the owner's risk.

K. Field quality control testing shall be performed by the contractor at the contractor's expense and the results are to be furnished to project engineer for review and approval.

L. Where construction crosses or is adjacent to existing utility lines (fuel, water, sewer, telecommunication, gas or electric), contractor shall dig test pits and carefully hand excavate so as to locate, mark, and protect the utility lines against disturbance or damage.

M. The contractor shall use extreme caution when excavating near overhead utility lines.

N. The contractor shall be responsible for adequately bracing and protecting all work during construction against damage, breakage, collapse, distortions and off alignments according to codes and standards of good practice.

O. The top elevation of all existing surface utility features (e.g., handholes, manholes, catch basins, valve boxes, and fill caps covers) located within the construction area shall be reset and be made flush with the proposed grade.

P. Unsuitable material, construction debris, etc. shall be properly removed and disposed of offsite in accordance with applicable state and local codes, ordinances, and laws.

Q. All regulatory and warning traffic signs shall conform with the PennDOT standard drawings and their standard sign list.

R. The contractor shall, unless otherwise stated in the contract documents, secure and pay for required inspections, permit(s), fees, licenses and inspections necessary for the proper execution of the work.

6.5 GENERAL SEQUENCE OF CONSTRUCTION

The following set of general construction notes shall be used for GI plans in the City of Lancaster. These notes are neither exhaustive nor comprehensive and may be adapted to fit the needs of the project:

A. At least seven days prior to starting any earth disturbance activities (including clearing and grubbing), schedule an onsite preconstruction meeting with the landowner, appropriate municipal officers, the city, and the Engineer.

B. At least three days prior to starting any earth disturbance activities, or expanding into an area previously unmarked, notify the Pennsylvania One Call System Inc. at 1-800-242-1776 for the location of existing underground utilities. All on-site utilities shall be verified prior to the start of excavation by the contractor. The contractor shall excavate test pits as needed to verify utility locations and depths.

C. Conduct all earth disturbance activities in accordance with the sequence provided on the construction drawings. Deviation from that sequence must be approved in writing from the City of Lancaster or the project engineer prior to implementation. Each step of the sequence shall be completed before proceeding to the next step except where noted.

D. Install E&S control measures per approved E&S plan. Approval of the installed measures must be given by the City before commencing work.

E. Before the start of site work, physically mark out the area of any BMPs. No heavy equipment shall be located within the footprint of BMPs.

F. Set up staging area if necessary. Verify location with project engineer.

G. Demolish/remove existing site features as indicated on plans.

H. Coordinate and perform utility relocations as required.

I. Install the proposed sewer and associated inlets, manholes, and laterals per contract documents and City of Lancaster Code.

J. BMP facilities must remain free of sediment. If sediment enters any portion of the BMP the contractor will be required to remove the sediment and/or make a replacement.

K. Survey the control elevation for each BMP. Any deviations from the designed control elevation will require design adjustments.

L. Install BMP conveyance systems, structures, and connections beginning with downstream connections. Temporarily seal all trench drain and inlet conveyance pipe openings to prevent stormwater flow to BMPs until vegetation establishment and/or site stabilization.

M. Contact the City of Lancaster for final inspection upon completion of all earth disturbance activities and prior to the removal of E&S control measures.

N. Open BMP inlets and/or conveyance structures to allow stormwater to flow into all BMPs after approval by project engineer.

7. OPERATIONS AND MAINTENANCE

Long-term O&M is crucial to ensuring proper functioning of green infrastructure BMPs. The City of Lancaster Green Infrastructure O&M Plan offers a comprehensive guide of inspection protocols, asset management, and maintenance tasks. The SWM Ordinance Article VI lists general O&M requirements and provides information on required agreements. This chapter includes useful resources to be referenced when complying with the O&M Plan and the SWM Ordinance regulations.

O&M tasks and frequencies for each BMP are provided in the O&M Plan. O&M tasks include but are not limited to the following:

- Identification and repair of any structural defects;
- Removal of sediment, debris, and trash from inlets structures, BMP areas, and pipes;
- Watering for new plantings during the first 2 years after the initial planting;
- Emergency watering during prolonged dry periods;
- Removal of invasive plants or weed species;
- Minor erosion repairs including slope stabilization;
- Minor replanting, reseeding, and re-grading; and
- Pruning of trees and shrubs, as appropriate, prior to winter months.

It is important to conduct routine inspection and maintenance to identify and remedy problems as they arise, before they become larger problems that may require intensive re-design or construction to address. It is also important to consider how work by others may affect the long-term function of the BMP. Further coordination may be required with landowners or utilities during the life of the BMP.

7.1 O&M MAINTENANCE REFERENCES

The O&M Plan and the SWM Ordinance Article VI shall be referenced when determining O&M requirements. Additional O&M resources for surface, subsurface, and porous pavement maintenance are listed below.

7.1.1 Surface Maintenance References

A. American National Standards Institute. ANSI A300. Information is found at: tcia.org.

B. American Society for Testing and Materials. 2018. C497 – 18b Standard Test methods for concrete Pipe, Manhole Sections, or Tile. Information is found at: astm.org

C. American Society of Agronomy. Information is found at: agronomy.org.

D. Bragg, T. and Sutherland, D. 1989. Establishing Warm-Season Grasses and Forbs Using Herbicides and Mowing. University of Nebraska-Omaha, Publication Code 68182-0040.

E. Commonwealth of Pennsylvania, Department of Transportation. 2011. Publication 408 Specifications. Information is found at: dot.state.pa.us

F. Commonwealth of Pennsylvania. 2015. The Pennsylvania Code Chaapter 102: Erosion and Sediment Control. Information is found at: pacode.com

G. Honu, Y.A.K., Gibson, D.J. Middleton, B.A. 2006. Response of Tridens Flavus (L.) A.S. Hitchc. To Soil Nutrients and Disturbance in an Early Successional Old Field. Journal of the Torrey Botanical Society.

H. National Association of State departments of Agriculture – Association of Official Seed Analysts. Information is found at: nasda.org

I. Northeast Organic Farming Association. 2017. Standard for Organic Land Care: Practices for Design and Maintenance of Ecological Landscapes, 6th edition. Information is found at: organiclandcare.net

J. Pennsylvania Department of Environmental Protection. 2012. Erosion and Sediment Pollution Control Program Manual: Technical Guidance Number 363-2134-008. Information is found at: dep.pa.gov

K. Pennsylvania General Assembly. 2012. Pennsylvania Consolidated Statutes, Title 3, Chapter 71, §§7101-7122. Information is found at: legis.state.pa.us

L. Pennsylvania State University, Center for Turfgrass Science. Information is found at: plantscience.psu.edu

M. Pennsylvania State University, college of Agricultural Sciences, Agricultural Research and Cooperative Extension. 2002. Updated 2007. Pennsylvania Wildlife (no. 12), Warm-Season Grasses and Wildlife. Information is found at: extension.psu.edu

N. Pennsylvania State University, College of Agricultural Sciences. Undated document. Soil Testing Methods. Information is found at: agsci.psu.edu

O. Soil Science Society of America. 1983. Methods of Soil Analysis Parts 1, 2, 3, & 4. Information is found at: soils.org.

P. United States Department of Labor. Occupational Safety and Health Administration (OSHA). Information is found at: osha.gov.

Q. US Composting Council. Seal of Testing Assurance. Information is found at: compostingcouncil.org

7.1.2 Subsurface Maintenance References

A. National Association of Sewer Service Companies. 2015. Pipe Assessment and Certification Program Manual. (Version 7.0.0).

B. National Association of Sewer Service Companies. 2014. Specification Guideline for Sewer Pipe Cleaning. Information is found at: nassco.org

7.1.3 Porous Pavement Maintenance References:

A. American Society for Testing and Materials. 2014. ASTM C920 Standard Specification for Elastomeric Joint Sealants.

B. American Society for Testing and Materials. 2009. ASTM C1701 Standard Test Method for Infiltration Rate of In Place Pervious Concrete.

C. Ballestero, Dr. Thomas, P.E. (University of New Hampshire Stormwater Center). Personal communication, November, 2014.

D. National Asphalt Pavement Association. 2008. Porous Asphalt Pavements for Stormwater Management, Information Series 131. Information is found at: asphaltpavement.org

E. The University of New Hampshire Stormwater Center. Undated document. Winter Maintenance Guidelines for Porous Pavements. Information is found at: unh.edu

APPENDIX A – INFILTRATION AND SOIL TESTING REQUIREMENTS

SOIL CHARACTERIZATION

Determining soil characteristics is an important part of early site development to determine the feasibility of implementing BMPs and whether or not infiltration is possible at a proposed site. Depth to groundwater or bedrock, existing geology and soil type, and contamination are all site factors that can be assessed with a proper soil characterization. The acceptable forms of soil characterization testing methods are:

- Exploratory test pits
- Hollow-stem augered boreholes (soil borings)

Test pits are often preferred to soil borings since they allow for observations of a larger view of the soils strata in the horizontal and vertical directions of the site than the relatively narrow boreholes. Requirements for each of the methods are listed below.

Exploratory Test Pits

A. Projects with 15,000 square feet or more of earth disturbance require at least two test pits per BMP.

B. Projects with less than 15,000 square feet of earth disturbance require at least one test pit per BMP.

C. At least one test pit within the BMP footprint must be excavated to a depth 4 feet below the lowest proposed elevation of the BMP system or until either bedrock or full saturation is encountered.

D. Should either bedrock or full saturation prevent test pits from reaching the required depth, soil borings and double-ring infiltrometer testing shall be used in conjunction with test pits.

E. Test pits are required for double-ring infiltrometer testing.

F. Test pits greater than 5 feet in depth must meet OSHA requirements for sloping and benching (Part 1926, Subpart P – Excavations, Standard Number 1926.652: Requirements for Protective Systems).

Soil Borings

A. Borings shall be performed with a hollow-stem augered borehole when site constraints do not allow for test pits. Examples of site constraints limiting test pits include existing utilities and/or structure present on site.

B. Soiling borings must be taken to a depth 6 feet below the lowest proposed bottom elevation of the BMP or until the auger can no longer continue the split spoon sampling.

C. Drilling and sampling must be in accordance with ASTM D6151-08.

D. Borehole inner tube diameter must be a minimum of four inches.

E. Standard Penetration Tests, if performed, must be in accordance with ASTM D1586.

INFILTRATION TESTING

Infiltration testing must be performed within a 25 foot radius of the proposed BMP infiltration footprint. At least one test must be performed within a 1 foot depth of the proposed bottom elevation of the BMP. Acceptable forms of infiltration testing are either:

- Double ring infiltrometer tests in test pit, or
- Cased borehole tests with soil borings

When possible, double ring infiltrometer tests are preferred due to their larger surface area of testing providing a more accurate estimate of the entire site conditions.

Double Ring Infiltrometer Test

A. A minimum of five tests must be performed per acre of BMP footprint (one test per 8,712 square feet), and a minimum of three tests must be performed for any site.

B. The diameter of the inner testing ring must be a minimum of 6 inches.

C. All double ring infiltrometer tests must be performed in a test pit with a maximum of two tests per pit.

D. Tests shall be spaced as evenly as possible between and within test pits.

E. All tests must have a minimum depth of water of 4 inches when filled.

F. A presoaking period of 1 hour is required before the beginning of each test. The rings shall be refilled once at the 30 minute mark during the presoak.

G. The frequency of test readings is determined by the inner-ring change in depth during the last 30 minutes of the presoak. Both rings must be refilled to the designated mark once readings are recorded.

   1. Readings shall be taken at 10 minute intervals for an inner-ring change of 2 inches or more.
   2. Readings shall be taken at 30 minute intervals for an inner-ring change less than 2 inches.

H. Testing may be terminated after a minimum of eight readings or once a stabilized infiltration rate is measured. A stabilized infiltration rate is reached when the inner-ring change in depth for four consecutive readings are all within 0.25 inches of each other.

I. All testing must be in accordance with ASTM D3385-09 unless specified otherwise above.

Cased Borehole Infiltration Testing

A. Infiltration tests cannot be completed within the same borehole as those used for soil characterization, but must be completed within a 25 foot radius of a soil borehole.

B. A minimum of eight tests must be performed per acre of BMP footprint (one test per 5,445 square feet), and a minimum of three tests must be performed for any site

C. Inner diameter of the pipe used for testing must be a minimum of 4 inches.

D. Borehole casing must be installed in accordance with ASTM D6151-018.

E. Only one test may be performed per borehole, regardless of the depth of tests proposed.

F. A presoaking period of one hour is required before the beginning of each test. Casings shall be filled with water at a low rate as not to disturb sediment with a minimum depth of 6 inches at the beginning of the presoak. Refill to the casing to the starting depth once at the 30 minute mark during the presoak.

G. The frequency of test readings is determined by the inner-ring change in depth during the last 30 minutes of the presoak. Both rings must be refilled to the designated mark once readings are recorded.

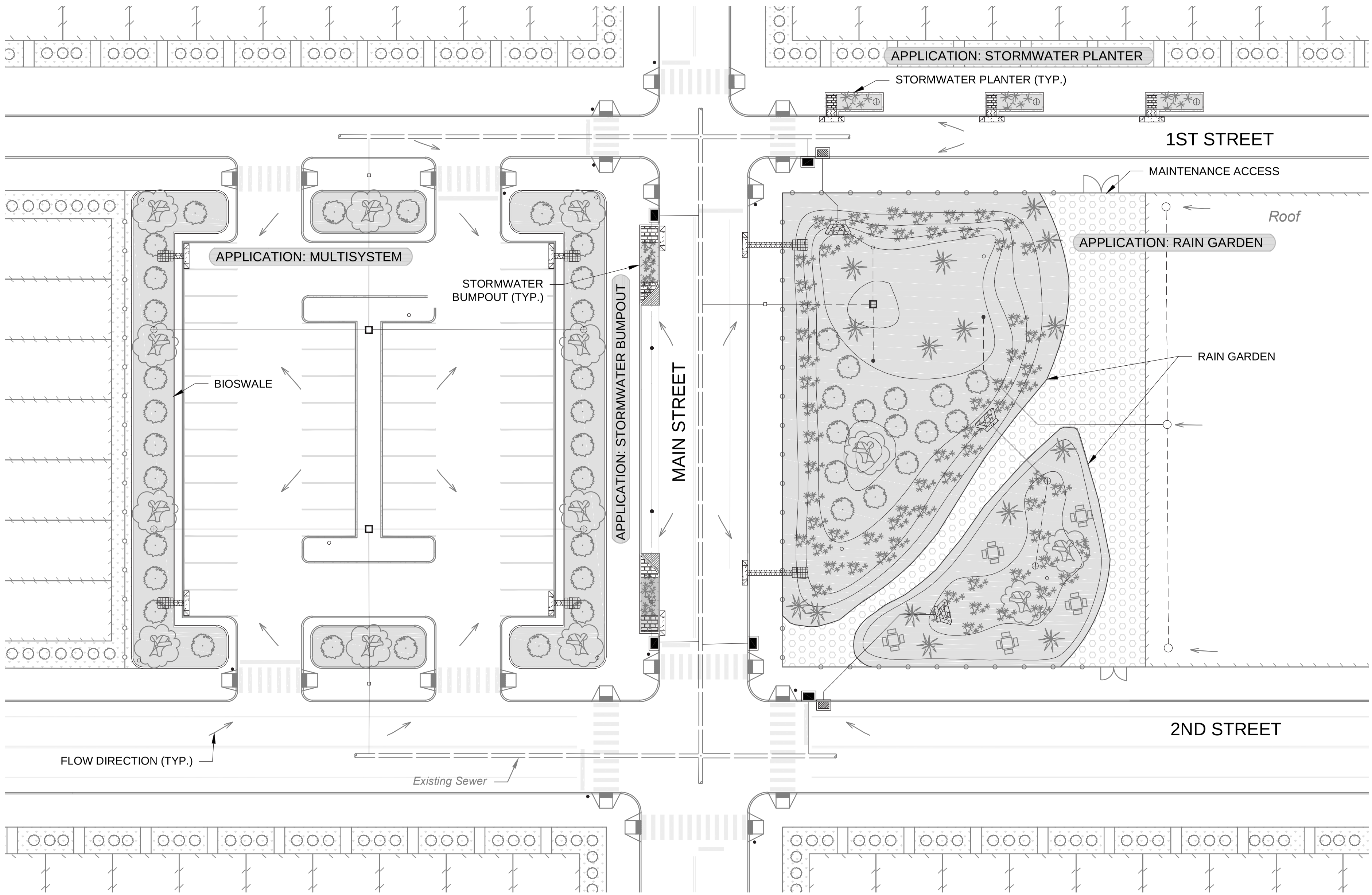
1. Readings shall be taken at 10 minute intervals for an inner-ring change of 2 inches or more.
2. Readings shall be taken at 30 minute intervals for an inner-ring change less than 2 inches.

H. Water levels shall remain a constant level of at least 12 inches from the bottom of the borehole through the duration of the test. All water added must be recorded as a volume with the time of addition.

I. Testing may be terminated after a minimum of eight readings or once a stabilized infiltration rate is measured. A stabilized infiltration rate is reached when the inner-ring change in depth for four consecutive readings are all within 0.25 inches of each other.

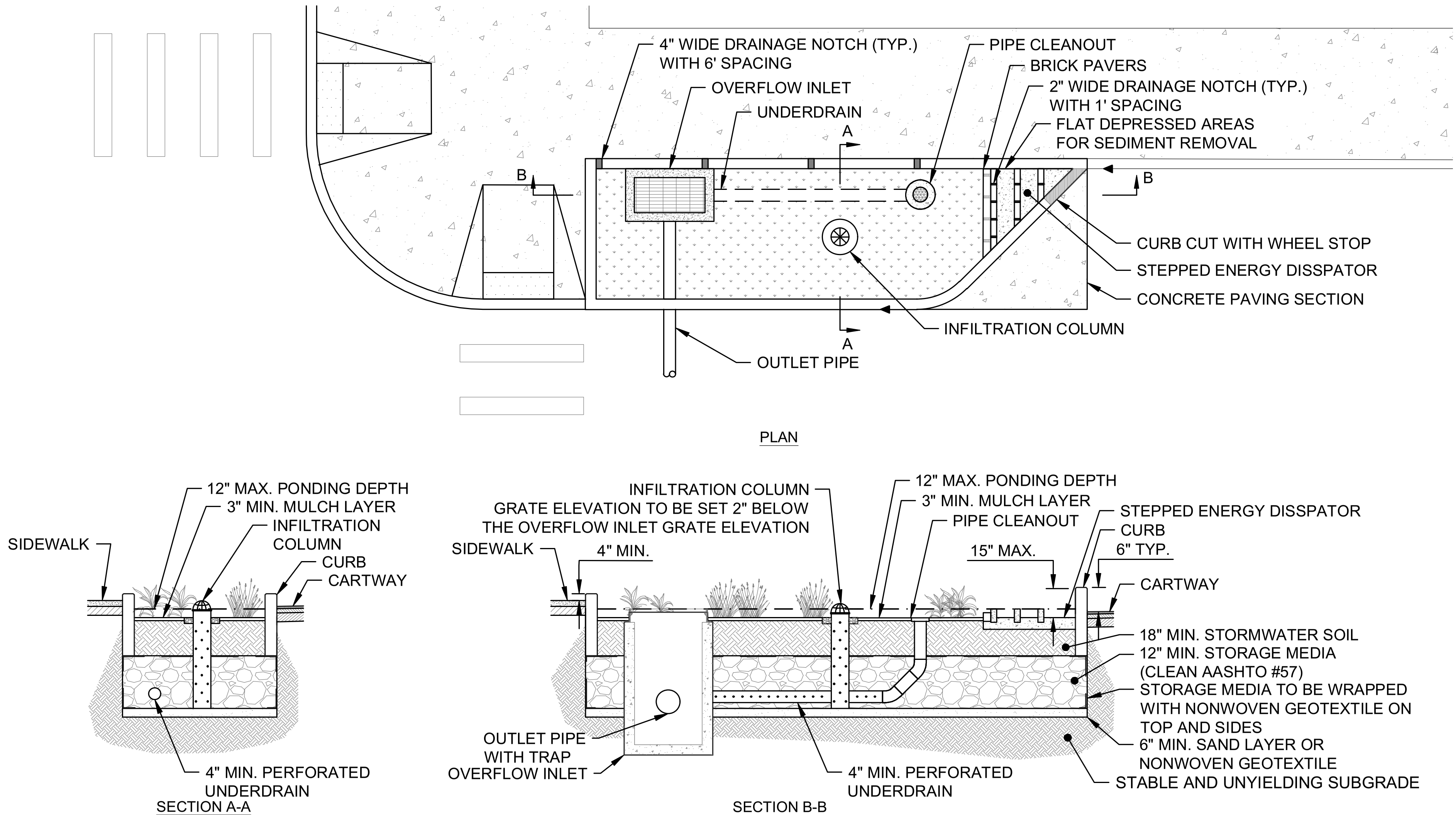
J. All testing must be in accordance with ASTM D6391-11 unless specified otherwise above.

APPENDIX B – GREEN INFRASTRUCTURE STANDARD DETAILS



THIS LAYOUT DEPICTS POSSIBILE BMP IMPLEMENTATION. REFER TO THE FOLLOWING SHEETS FOR REPRESENTITIVE TYPICAL DETAILS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	BIORETENTION/BIOINFILTRATION TYPICAL APPLICATION LAYOUT VS. DATE INITIALS REASON	SCALE: N.T.S. DRAWING NUMBER: BB - 1 SHEET 1 OF 4



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.
4. INFILTRATION COLUMN IS OPTIONAL. TO BE PROPOSED IN DESIGN IF THERE ARE CONCERNS OF STORMWATER BYPASS TO THE OVERFLOW INLET.

CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS

CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608

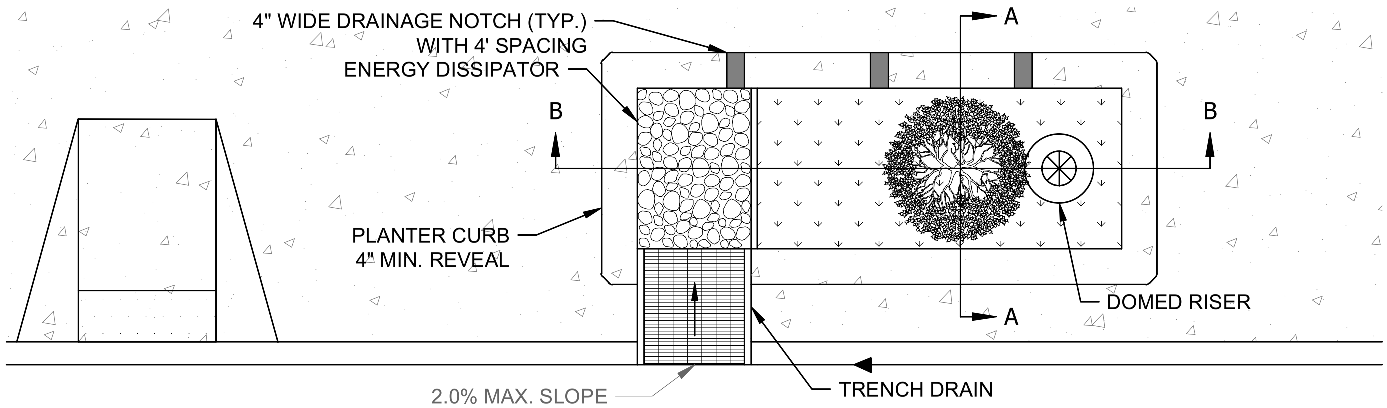
TYPICAL STORMWATER BUMPOUT

VS.	DATE	INITIALS	REASON

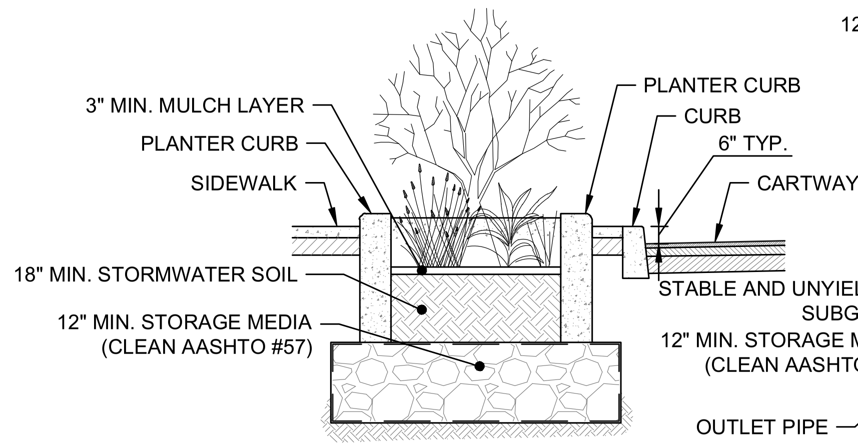
SCALE: N.T.S.

DRAWING NUMBER: BB - 2

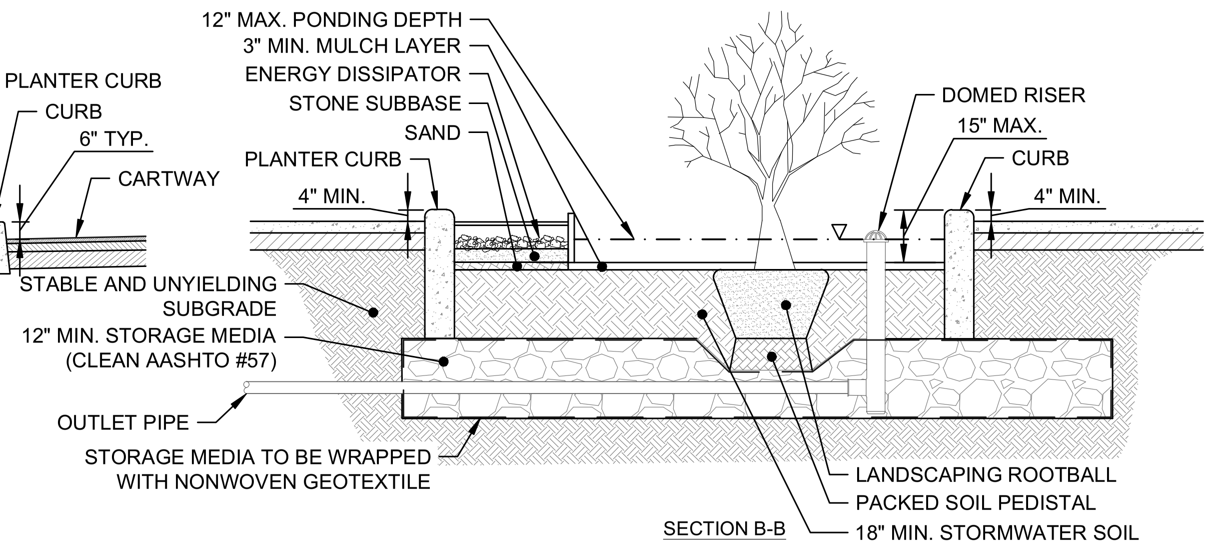
SHEET 2 OF 4



PLAN



SECTION A-A

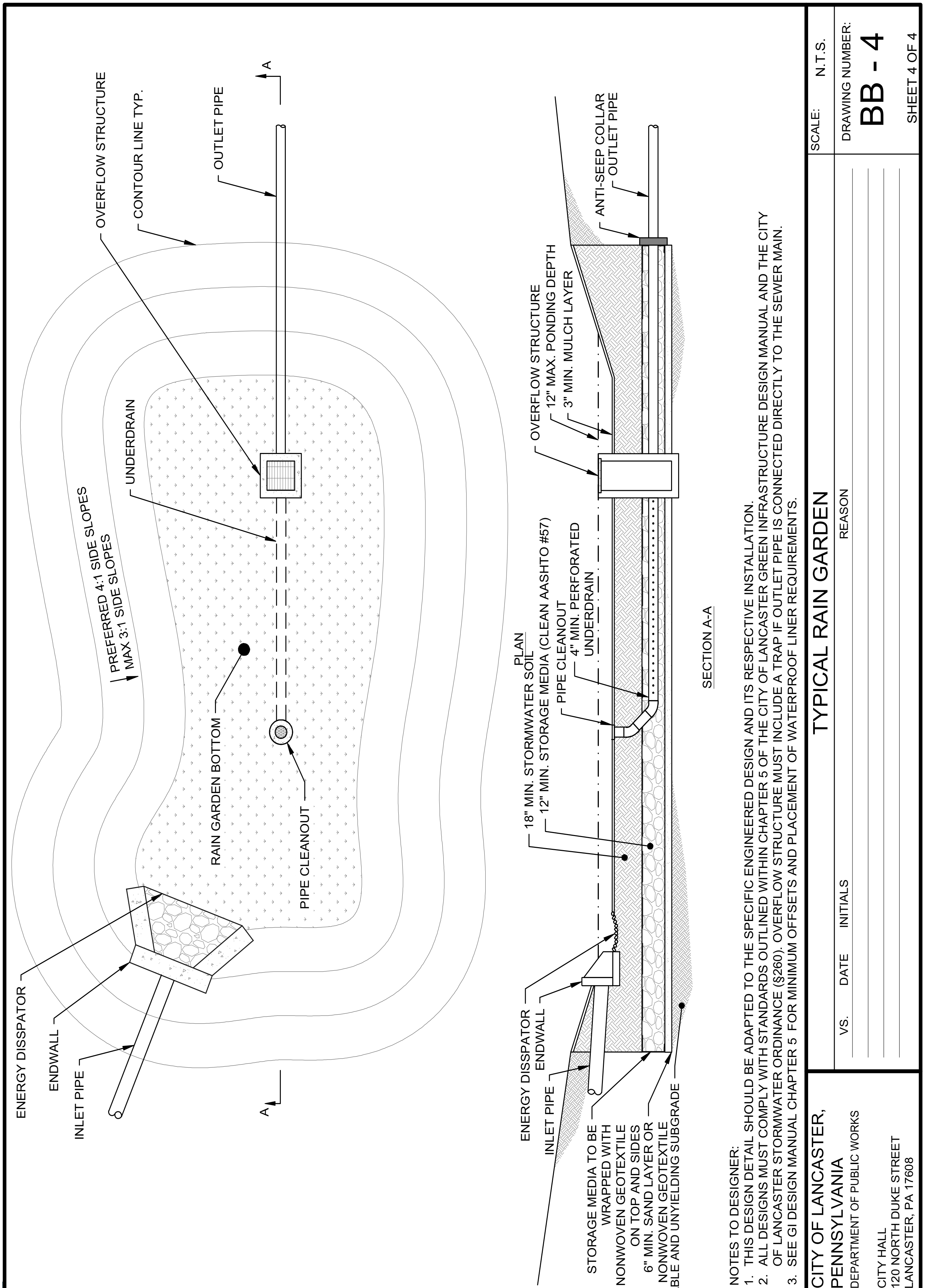


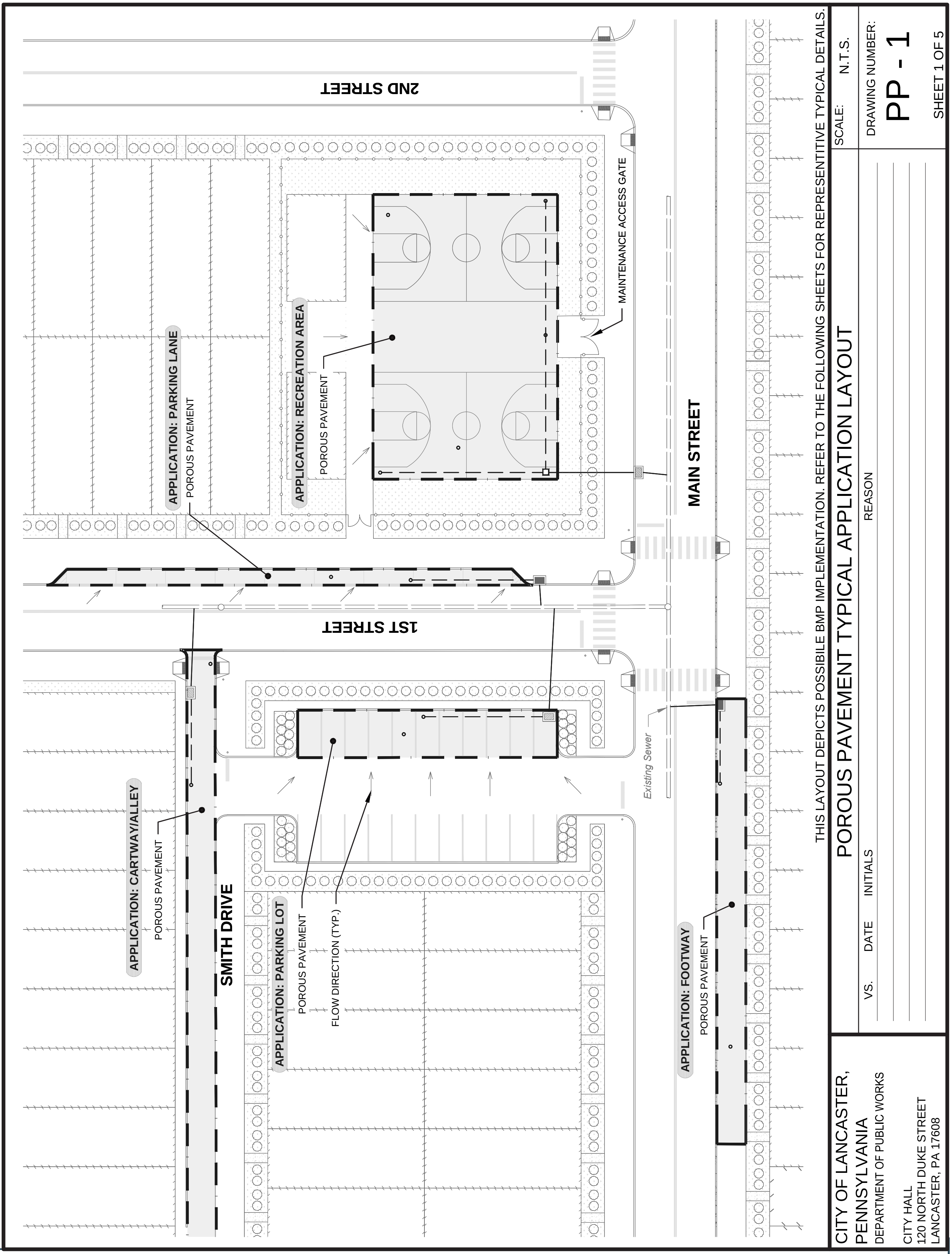
SECTION B-B

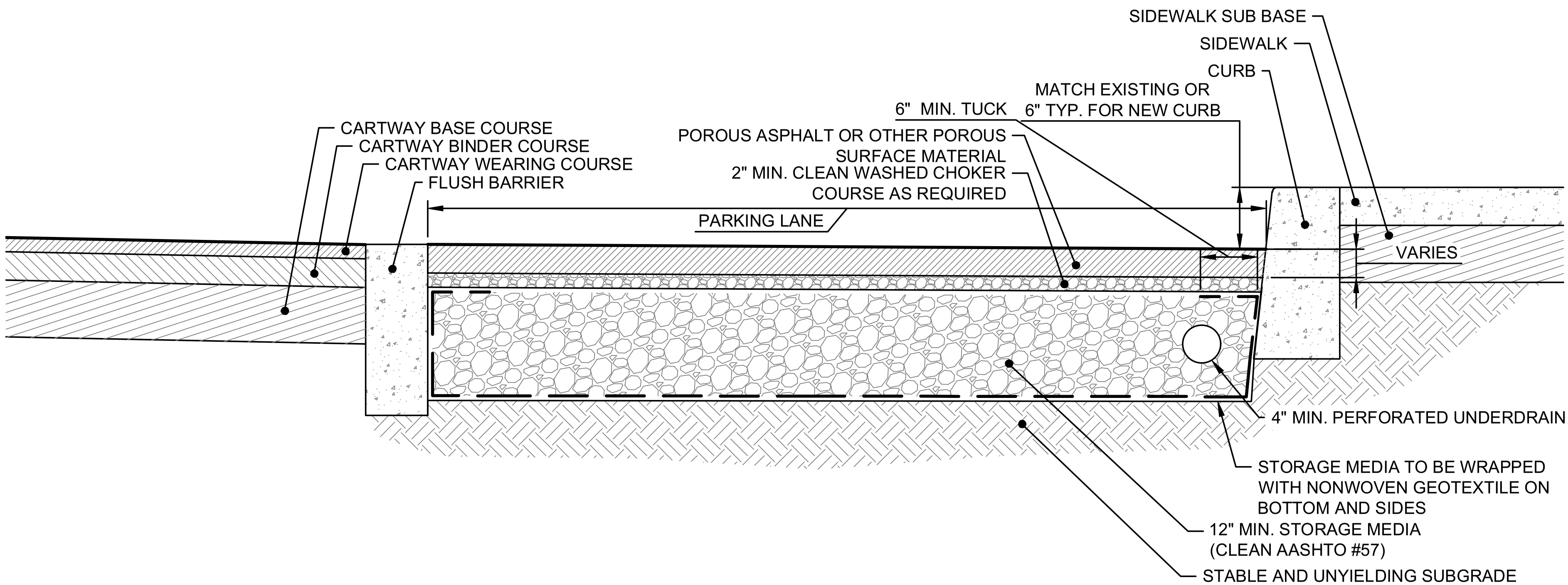
NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL STORMWATER PLANTER				SCALE: N.T.S. DRAWING NUMBER: BB - 3 SHEET 3 OF 4
	VS.	DATE	INITIALS	REASON	


OVERFLOW STRUCTURE
CONTOUR LINE TYP.
OUTLET PIPE
A
UNDERDRAIN
PREFERRED 4:1 SIDE SLOPES
MAX 3:1 SIDE SLOPES
RAIN GARDEN BOTTOM
PIPE CLEANOUT
ENERGY DISSPATOR
ENDWALL
INLET PIPE
A
PLAN
OVERFLOW STRUCTURE
12" MAX. PONDING DEPTH
3" MIN. MULCH LAYER
ANTI-SEEP COLLAR
OUTLET PIPE
18" MIN. STORMWATER SOIL
12" MIN. STORAGE MEDIA (CLEAN AASHTO #57)
PIPE CLEANOUT
4" MIN. PERFORATED UNDERDRAIN
ENERGY DISSPATOR
ENDWALL
INLET PIPE
STORAGE MEDIA TO BE WRAPPED WITH NONWOVEN GEOTEXTILE ON TOP AND SIDES
6" MIN. SAND LAYER OR NONWOVEN GEOTEXTILE
ABLE AND UNYIELDING SUBGRADE
SECTION A-A
NOTES TO DESIGNER:
1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260). OVERFLOW STRUCTURE MUST INCLUDE A TRAP IF OUTLET PIPE IS CONNECTED DIRECTLY TO THE SEWER MAIN.
3. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.
CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS
CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608
VS.
DATE
INITIALS
REASON
TYPICAL RAIN GARDEN
SCALE: N.T.S.
DRAWING NUMBER:
BB - 4
SHEET 4 OF 4

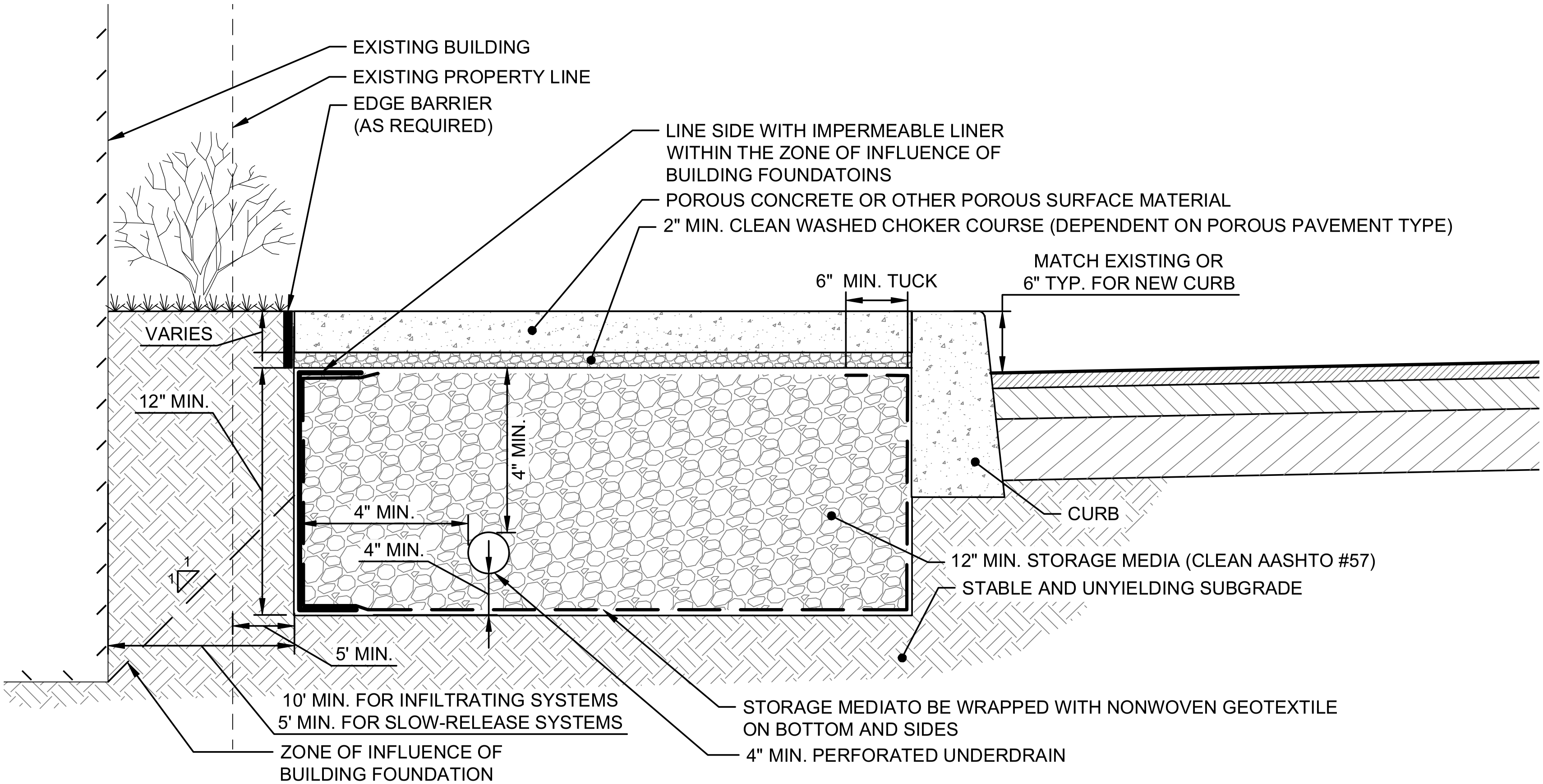

THIS LAYOUT DEPICTS POSSIBILE BMP IMPLEMENTATION. REFER TO THE FOLLOWING SHEETS FOR REPRESENTITIVE TYPICAL DETAILS.
2ND STREET
1ST STREET
MAIN STREET
SMITH DRIVE
MAINTENANCE ACCESS GATE
APPLICATION: PARKING LANE
POROUS PAVEMENT
APPLICATION: RECREATION AREA
POROUS PAVEMENT
APPLICATION: CARTWAY/ALLEY
POROUS PAVEMENT
APPLICATION: PARKING LOT
POROUS PAVEMENT
FLOW DIRECTION (TYP.)
APPLICATION: FOOTWAY
POROUS PAVEMENT
Existing Sewer
CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS
CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608
POROUS PAVEMENT TYPICAL APPLICATION LAYOUT
VS.
DATE
INITIALS
REASON
SCALE:
N.T.S.
DRAWING NUMBER:
PP - 1
SHEET 1 OF 5



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. FLUSH BARRIER TO BE CONSTRUCTED PER MANUFACTURER'S SPECIFICATIONS.
4. ALL EDGES BETWEEN NEW AND EXISTING ASPHALT PAVEMENT SHALL BE SEALED WITH HOT ASPHALT CEMENT. ALSO, JOINTS BETWEEN UTILITY FRAMES FOR MANHOLES AND INLETS OR OTHER UTILITY OWNED STRUCTURES AND PERMEABLE ASPHALT WEARING COURSE SHALL BE SEALED WITH HOT ASPHALT CEMENT FOR A DISTANCE OF 6-INCHES FROM THE EDGE OF THE FRAME. CONTRACTOR TO CONFIRM LIDS ARE OPERABLE AFTER SEALING.
5. PAVEMENT MARKINGS ON PERMEABLE PAVEMENT SURFACES SHALL BE THERMOPLASTIC PAVEMENT MARKINGS IN ACCORDANCE WITH PENNDOT PUBLICATION 408, SECTION 964.
6. PERMEABLE PAVEMENT SHALL INCLUDE CHECK DAMS AS NEEDED TO ACCOMMODATE STREET SLOPE (SEE DETAIL PP-5).
7. PERMEABLE PAVEMENT SURFACES SHALL BE GRADED AT A MINIMUM OF 1% SLOPE TO ENSURE POSITIVE DRAINAGE.
8. PERMEABLE PAVEMENT SHALL NOT BE USED IN AREAS WHERE LONGITUDINAL SLOPE IS GREATER THAN 5%. SLOPES GREATER THAN 5% WILL BE CONSIDERED WITH APPROVAL FROM CITY ENGINEER.
9. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
10. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS. TERRACED SYSTEMS MAY BE IMPLEMENTED (SEE PP-5).
11. A 6" SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
12. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
13. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

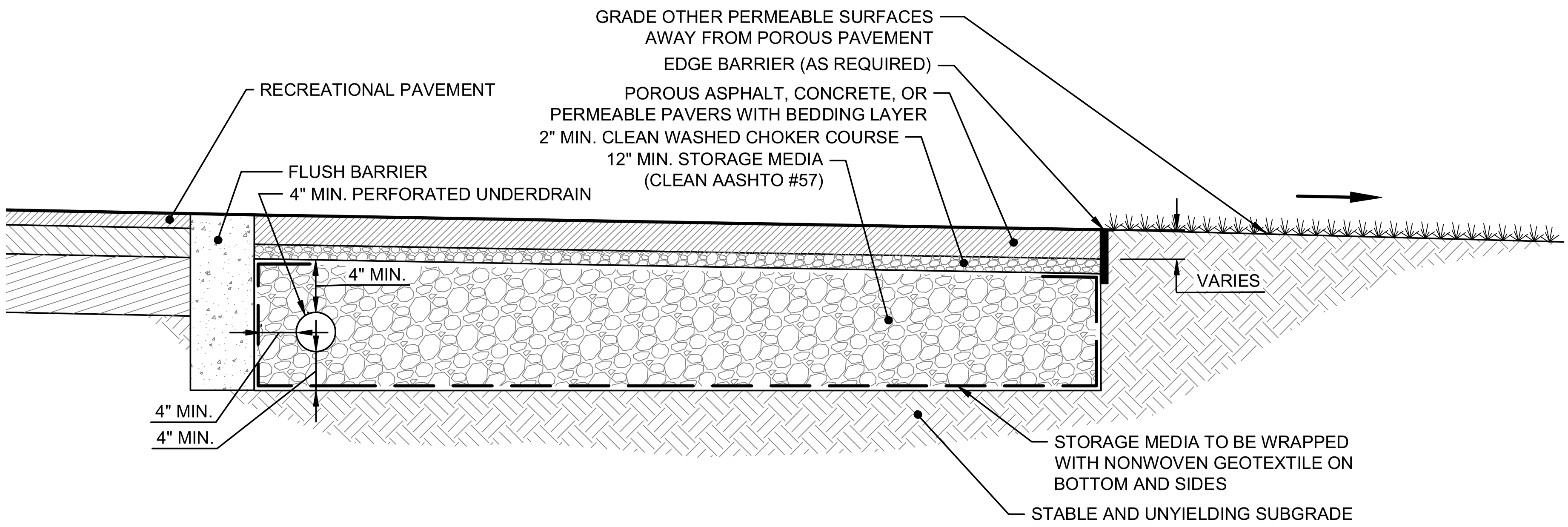
CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL POROUS PAVEMENT PARKING LANE VS. DATE INITIALS REASON	SCALE: N.T.S. DRAWING NUMBER: PP - 2 SHEET 2 OF 5



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. PERMEABLE PAVEMENT SHALL INCLUDE CHECK DAMS AS NEEDED TO ACCOMMODATE STREET SLOPE (SEE DETAIL PP-5).
4. PERMEABLE PAVEMENT SURFACES SHALL BE GRADED AT A MINIMUM OF 1% SLOPE TO ENSURE POSITIVE DRAINAGE.
5. PERMEABLE PAVEMENT SHALL NOT BE USED IN AREAS WHERE LONGITUDINAL SLOPE IS GREATER THAN 5%. SLOPES GREATER THAN 5% WILL BE CONSIDERED WITH APPROVAL FROM CITY ENGINEER.
6. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
7. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS. TERRACED SYSTEMS MAY BE IMPLEMENTED (SEE PP-5).
8. A 6" SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
9. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
10. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

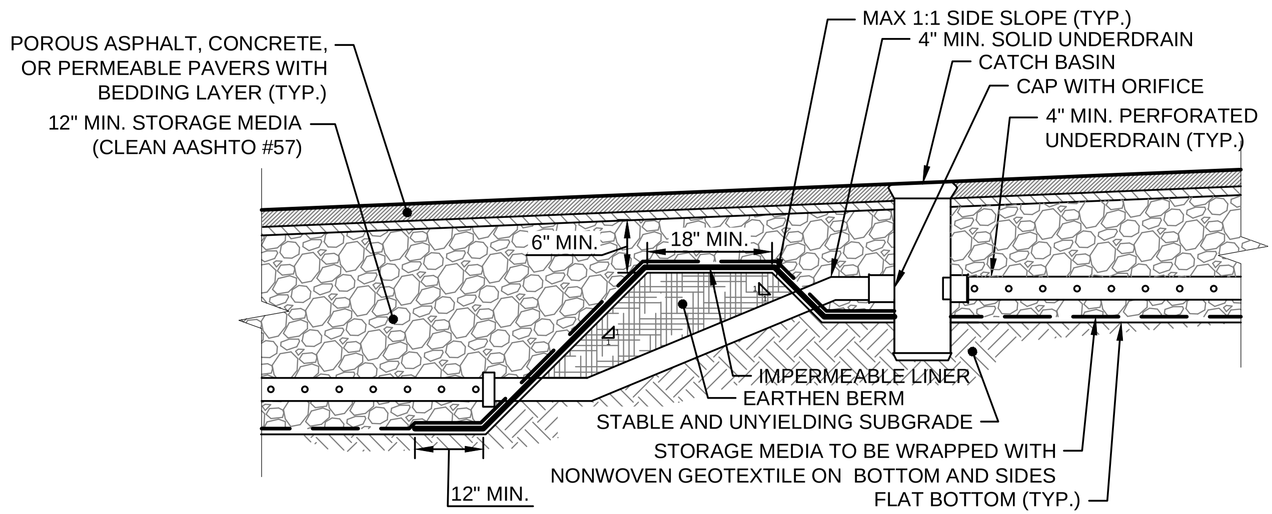
CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL POROUS SIDEWALK VS. DATE INITIALS REASON	SCALE: N.T.S. DRAWING NUMBER: PP - 3 SHEET 3 OF 5



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. ALL EDGES BETWEEN NEW AND EXISTING ASPHALT PAVEMENT SHALL BE SEALED WITH HOT ASPHALT CEMENT. ALSO, JOINTS BETWEEN UTILITY FRAMES FOR MANHOLES AND INLETS OR OTHER UTILITY OWNED STRUCTURES AND PERMEABLE ASPHALT WEARING COURSE SHALL BE SEALED WITH HOT ASPHALT CEMENT FOR A DISTANCE OF 6-INCHES FROM THE EDGE OF THE FRAME. CONTRACTOR TO CONFIRM LIDS ARE OPERABLE AFTER SEALING.
4. PAVEMENT MARKINGS ON PERMEABLE PAVEMENT SURFACES SHALL BE THERMOPLASTIC PAVEMENT MARKINGS IN ACCORDANCE WITH PENNDOT PUBLICATION 408, SECTION 964.
5. PERMEABLE PAVEMENT SHALL INCLUDE CHECK DAMS AS NEEDED TO ACCOMMODATE STREET SLOPE (SEE DETAIL PP-5).
6. PERMEABLE PAVEMENT SURFACES SHALL BE GRADED AT A MINIMUM OF 1% SLOPE TO INSURE POSITIVE DRAINAGE.
7. PERMEABLE PAVEMENT SHALL NOT BE USED IN AREAS WHERE LONGITUDINAL SLOPE IS GREATER THAN 5%. SLOPES GREATER THAN 5% WILL BE CONSIDERED WITH APPROVAL FROM CITY ENGINEER.
8. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
9. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS. TERRACED SYSTEMS MAY BE IMPLEMENTED (SEE PP-5).
10. A 6” SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
11. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
12. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

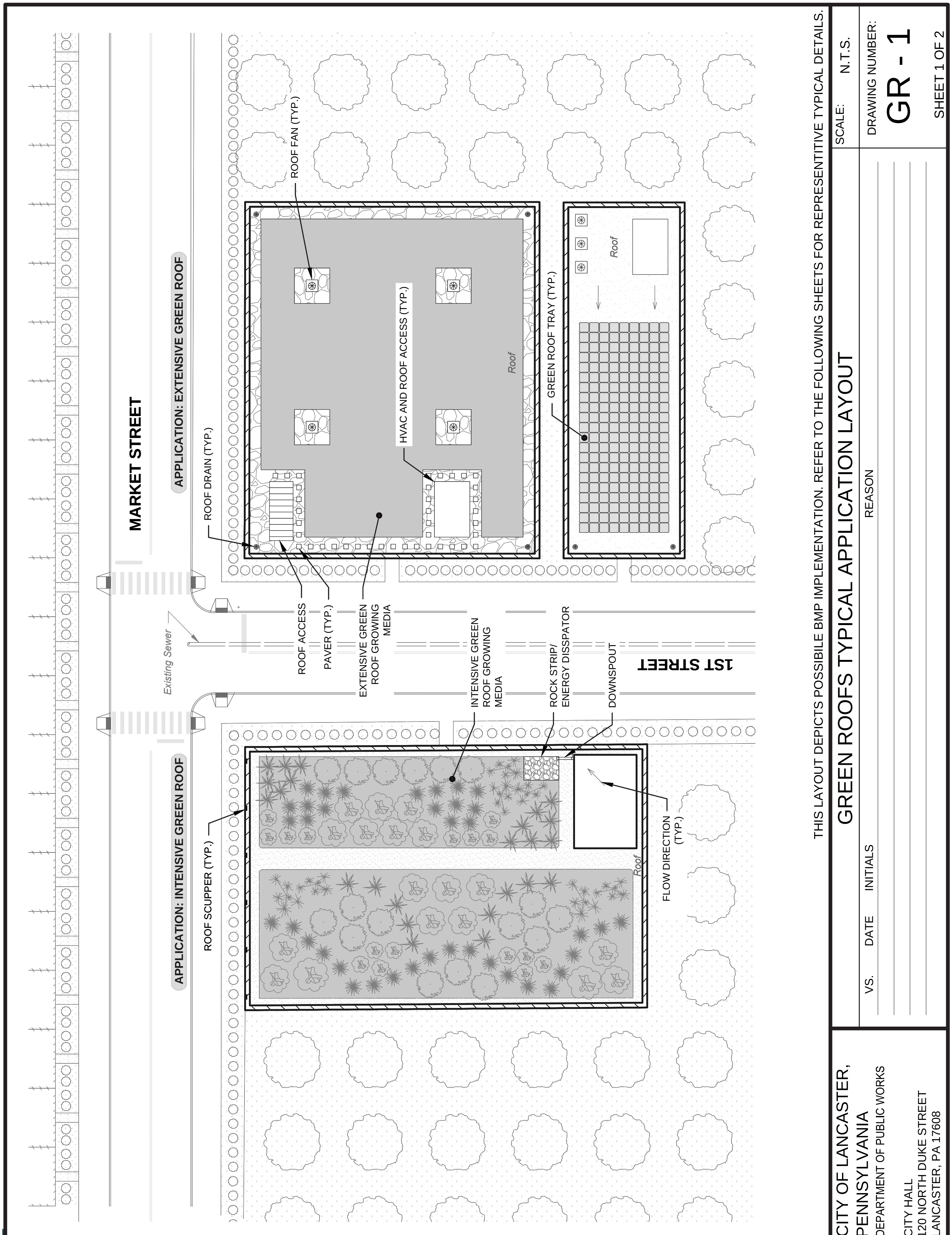
CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL POROUS ASPHALT PARKING LOT	SCALE: N.T.S. DRAWING NUMBER: PP - 4 SHEET 4 OF 5
	VS. DATE INITIALS REASON	

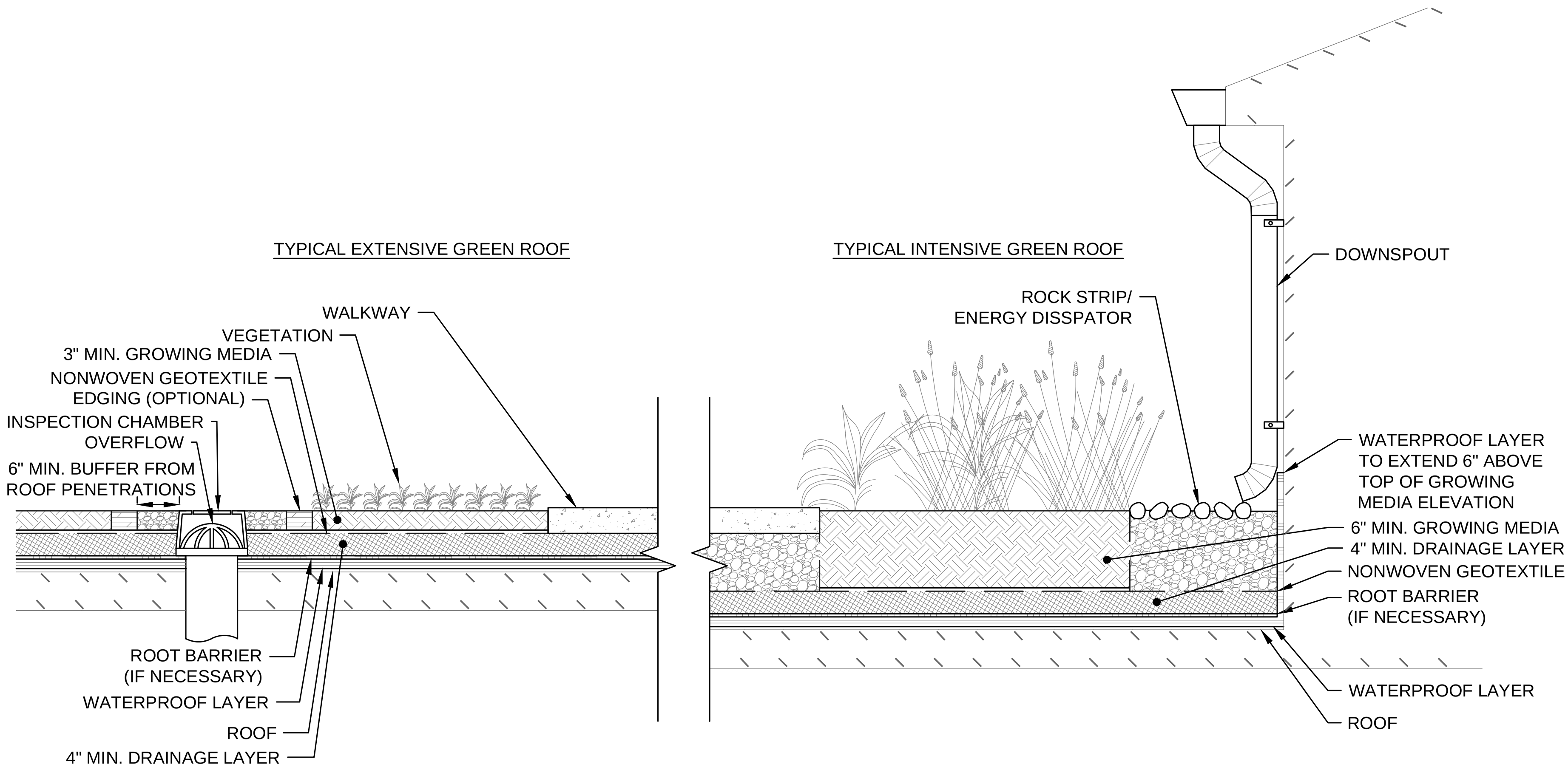


NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. PERMEABLE PAVEMENT SHALL NOT BE USED IN AREAS WHERE LONGITUDINAL SLOPE IS GREATER THAN 5%. SLOPES GREATER THAN 5% WILL BE CONSIDERED WITH APPROVAL FROM CITY ENGINEER.
4. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
5. CATCH BASIN TO INCLUDE A CONCRETE COLLAR IN VEHICULAR APPLICATIONS.
6. CATCH BASIN TO BE ADA COMPLIANT WITH A LOCKABLE OR VANDAL PROOF LID IN PEDESTRIAN APPLICATIONS.
7. ORIFICE SIZE ON CAP TO BE DETERMINED PER DESIGN CALCULATIONS. SOLID CAP MAY BE USED IN INFILTRATION SYSTEMS PER DESIGN CALCULATIONS.
8. ALL SYSTEMS WITH STREET CROSSING MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
9. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL TERRACED POROUS PAVEMENT VS. DATE INITIALS REASON	SCALE: N.T.S. DRAWING NUMBER: PP - 5 SHEET 5 OF 5

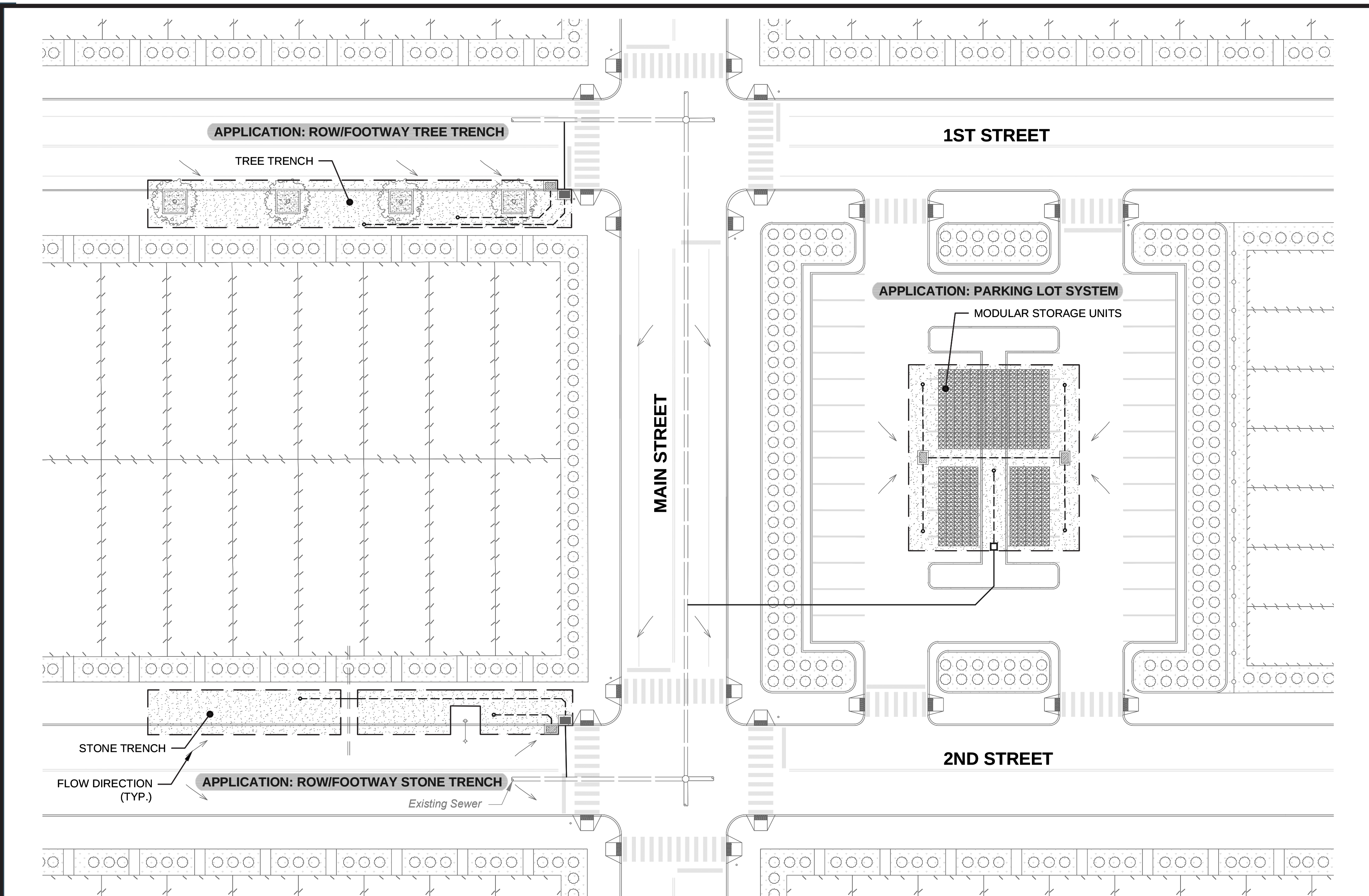

MARKET STREET
1ST STREET
APPLICATION: EXTENSIVE GREEN ROOF
APPLICATION: INTENSIVE GREEN ROOF
ROOF FAN (TYP.)
ROOF DRAIN (TYP.)
HVAC AND ROOF ACCESS (TYP.)
GREEN ROOF TRAY (TYP.)
Roof
ROOF ACCESS
PAVER (TYP.)
EXTENSIVE GREEN ROOF GROWING MEDIA
INTENSIVE GREEN ROOF GROWING MEDIA
ROCK STRIP/ ENERGY DISSPATOR
DOWNSPOUT
Existing Sewer
ROOF SCUPPER (TYP.)
FLOW DIRECTION (TYP.)
THIS LAYOUT DEPICTS POSSIBLE BMP IMPLEMENTATION. REFER TO THE FOLLOWING SHEETS FOR REPRESENTITIVE TYPICAL DETAILS.
GREEN ROOFS TYPICAL APPLICATION LAYOUT
CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS
CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608
VS.
DATE
INITIALS
REASON
SCALE:
N.T.S.
DRAWING NUMBER:
GR - 1
SHEET 1 OF 2



NOTES TO DESIGNER:

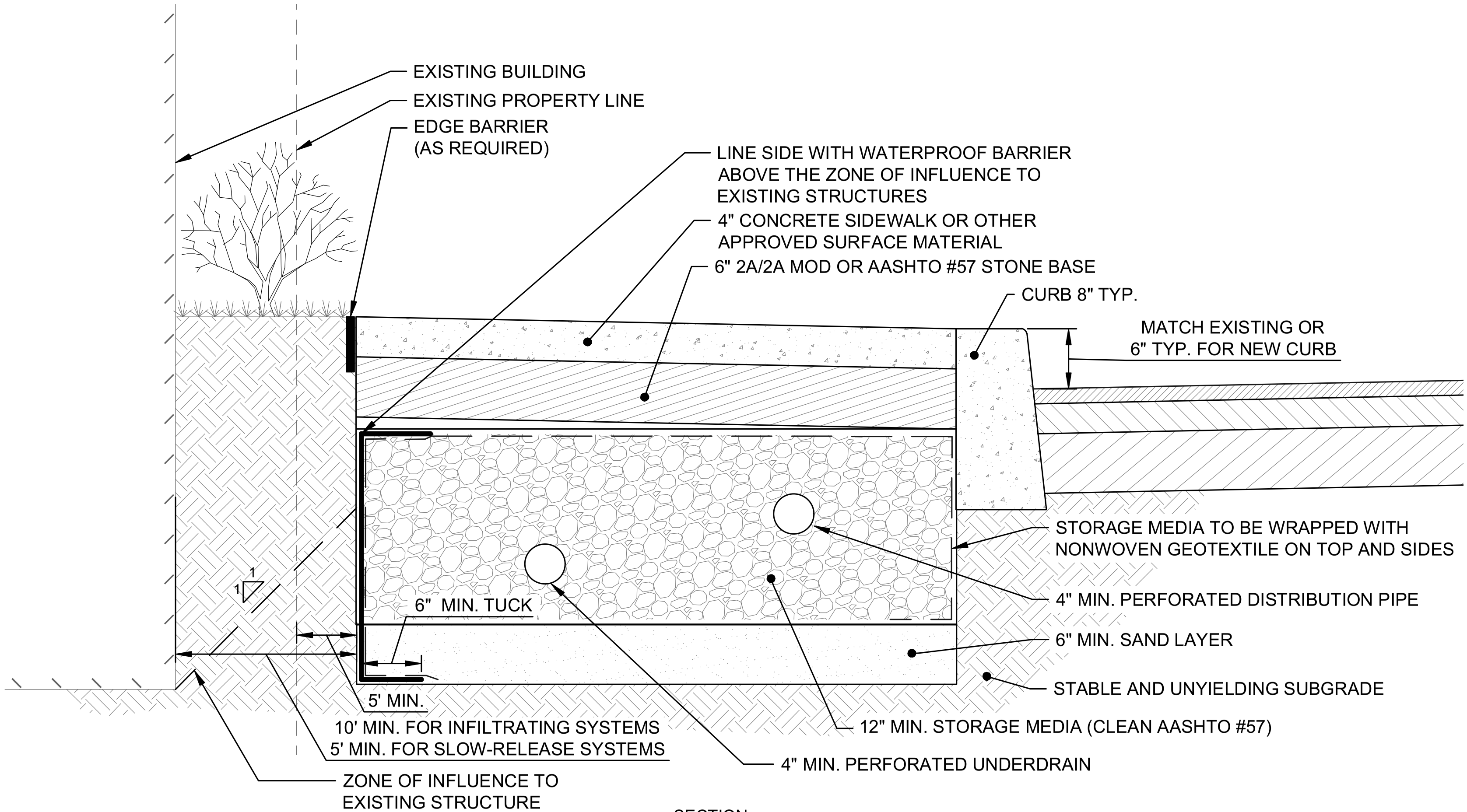
1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL EXTENSIVE AND INTENSIVE GREEN ROOFS	SCALE: N.T.S.
	VS. | DATE | INITIALS | REASON	DRAWING NUMBER: GR - 2 SHEET 2 OF 2



THIS LAYOUT DEPICTS POSSIBILE BMP IMPLEMENTATION. REFER TO THE FOLLOWING SHEETS FOR REPRESENTITIVE TYPICAL DETAILS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	SUBSURFACE INFILTRATION AND DETENTION TYPICAL APPLICATION LAYOUT	SCALE: N.T.S.
	VS. DATE INITIALS REASON	DRAWING NUMBER: SS - 1 SHEET 1 OF 4

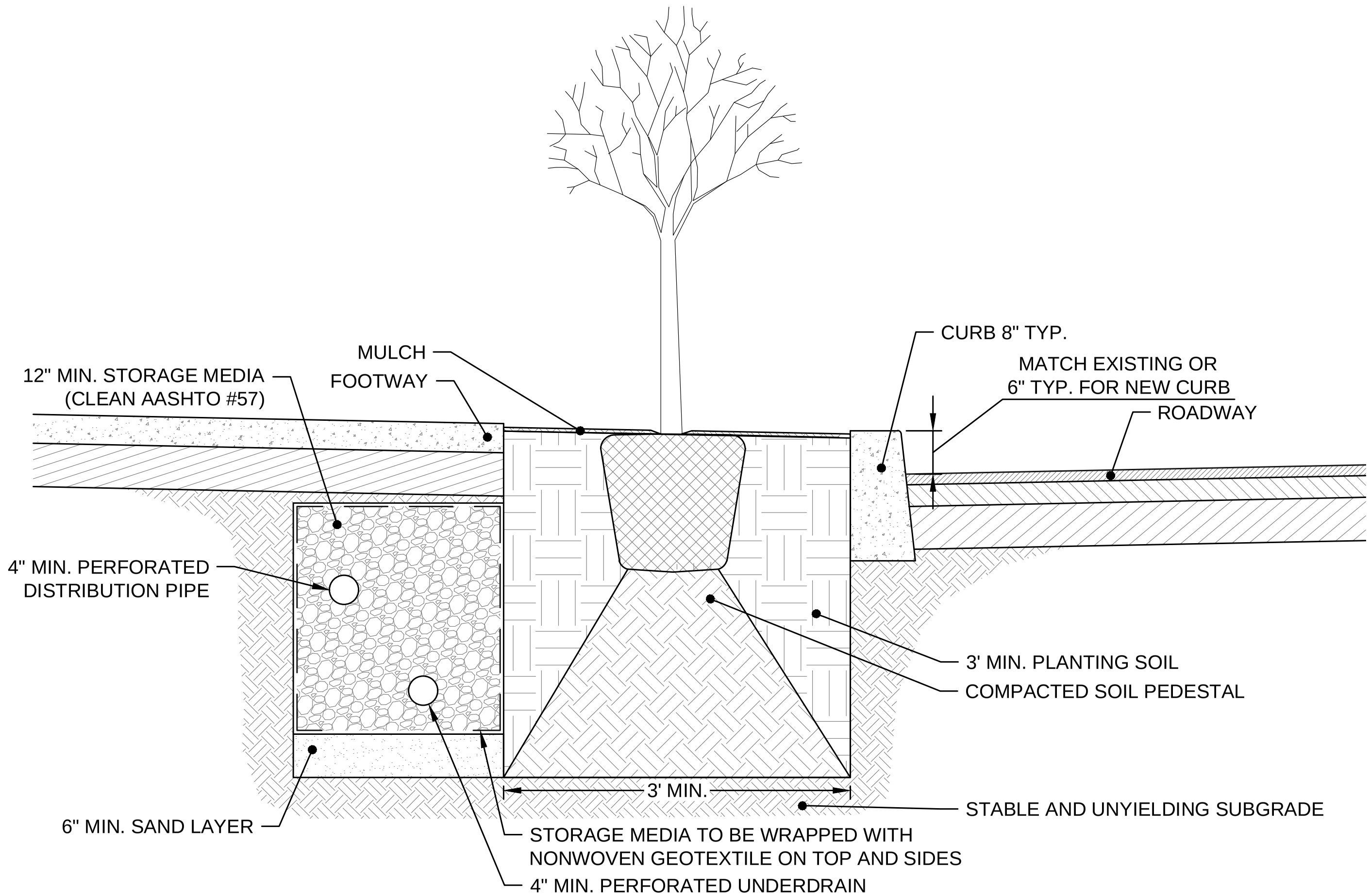


SECTION

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. ALL EDGES BETWEEN NEW AND EXISTING ASPHALT PAVEMENT SHALL BE SEALED WITH HOT ASPHALT CEMENT. ALSO, JOINTS BETWEEN UTILITY FRAMES FOR MANHOLES AND INLETS OR OTHER UTILITY OWNED STRUCTURES AND PERMEABLE ASPHALT WEARING COURSE SHALL BE SEALED WITH HOT ASPHALT CEMENT FOR A DISTANCE OF 6-INCHES FROM THE EDGE OF THE FRAME.
4. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
5. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS.
6. A 6" SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
7. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
8. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF IMPERMEABLE LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL STONE TRENCH				SCALE: N.T.S.
	VS.	DATE	INITIALS	REASON	DRAWING NUMBER: SS - 2 SHEET 2 OF 4



SECTION

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
4. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS.
5. A 6" SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
6. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
7. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF IMPERMEABLE LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS

CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608

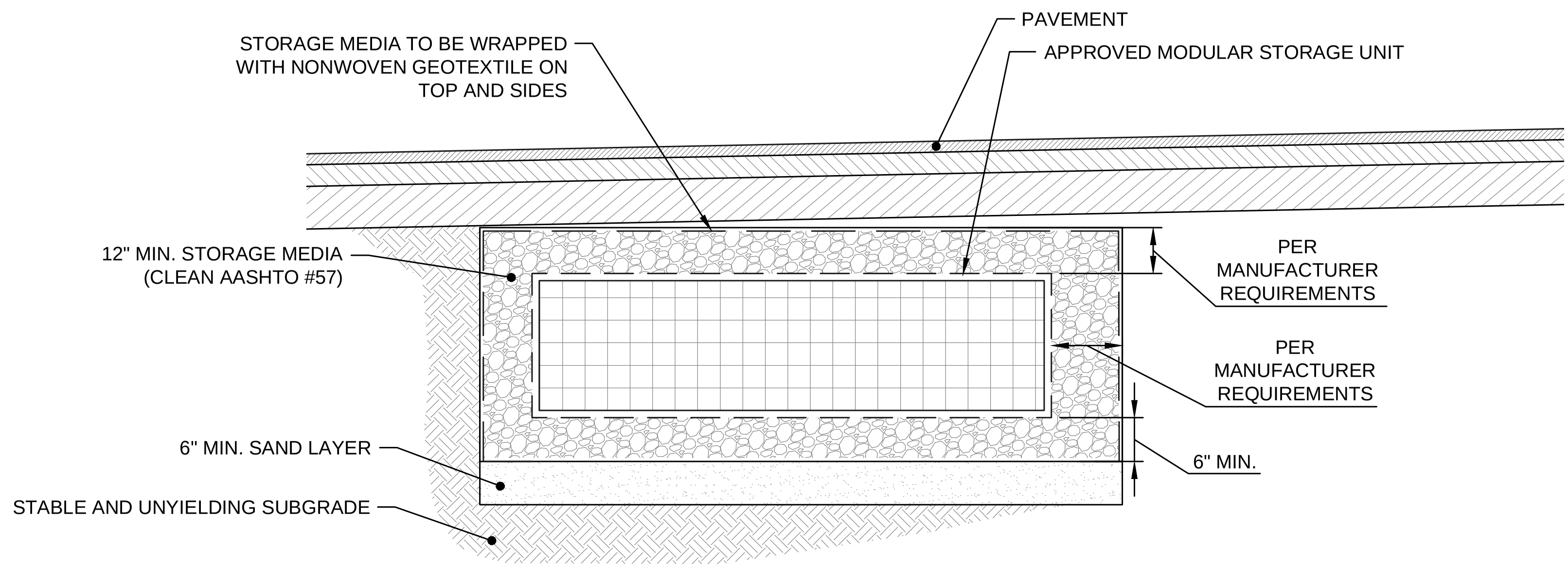
TYPICAL TREE TRENCH

VS.	DATE	INITIALS	REASON

SCALE: N.T.S.

DRAWING NUMBER: SS - 3

SHEET 3 OF 4



SECTION

NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. ALL EDGES BETWEEN NEW AND EXISTING ASPHALT PAVEMENT SHALL BE SEALED WITH HOT ASPHALT CEMENT. ALSO, JOINTS BETWEEN UTILITY FRAMES FOR MANHOLES AND INLETS OR OTHER UTILITY OWNED STRUCTURES AND PERMEABLE ASPHALT WEARING COURSE SHALL BE SEALED WITH HOT ASPHALT CEMENT FOR A DISTANCE OF 6-INCHES FROM THE EDGE OF THE FRAME.
4. TRENCH SECTIONS MUST BE LINED WITH IMPERMEABLE LINER WITHIN THE ZONE OF INFLUENCE OF EXISTING SEWER AND FOUNDATIONS.
5. ALL SYSTEMS MUST HAVE LEVEL BOTTOMS.
6. A 6" SAND LAYER MAY BE SUBSTITUTED FOR GEOTEXTILE ON BOTTOM SIDE OF SUBSURFACE STORAGE MEDIA.
7. ALL SYSTEMS WITH STREET CROSSINGS MUST BE ADA COMPLIANT AND SUBJECT TO BUREAU OF ENGINEERING APPROVAL.
8. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF IMPERMEABLE LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS

CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608

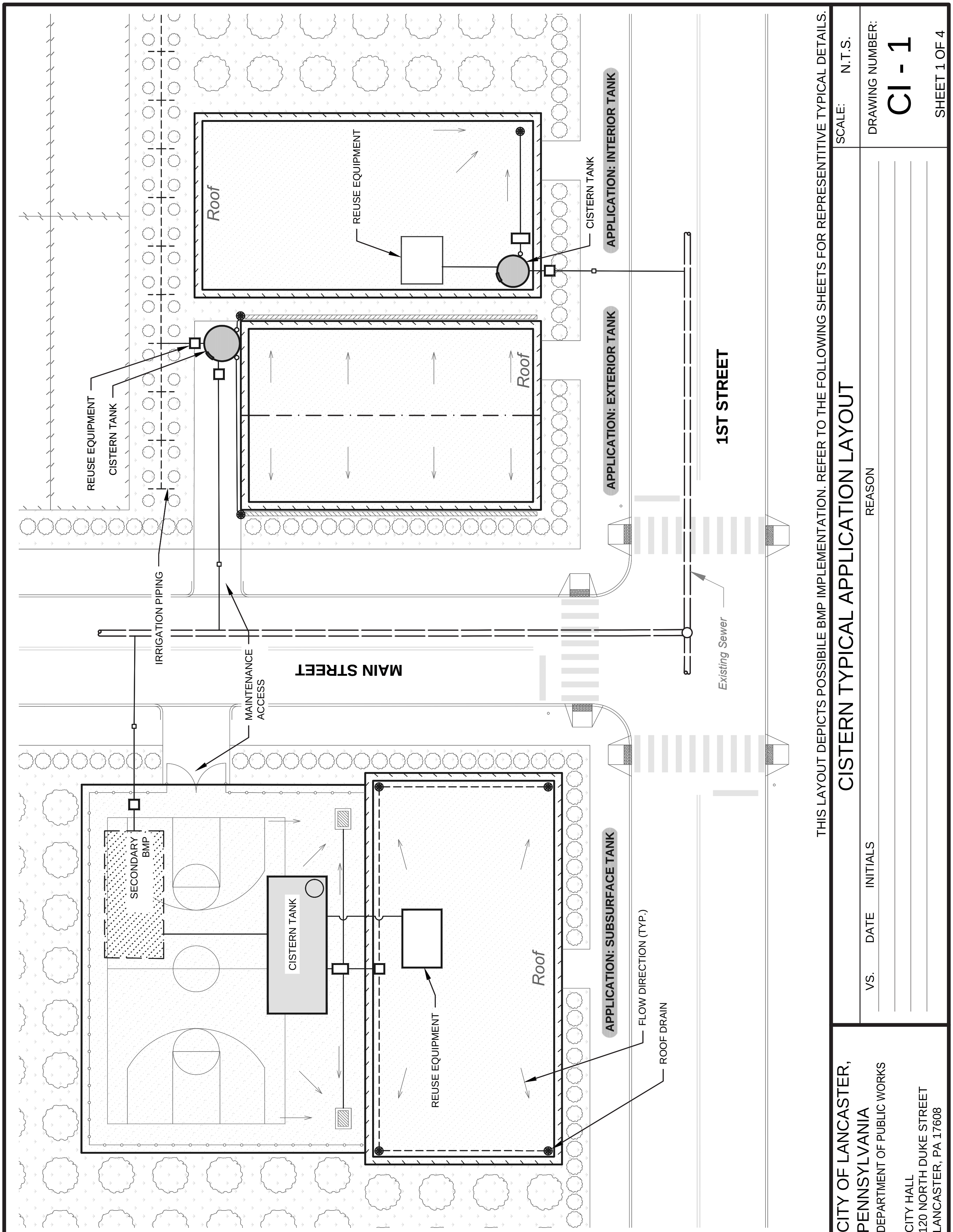
TYPICAL MODULAR STORAGE

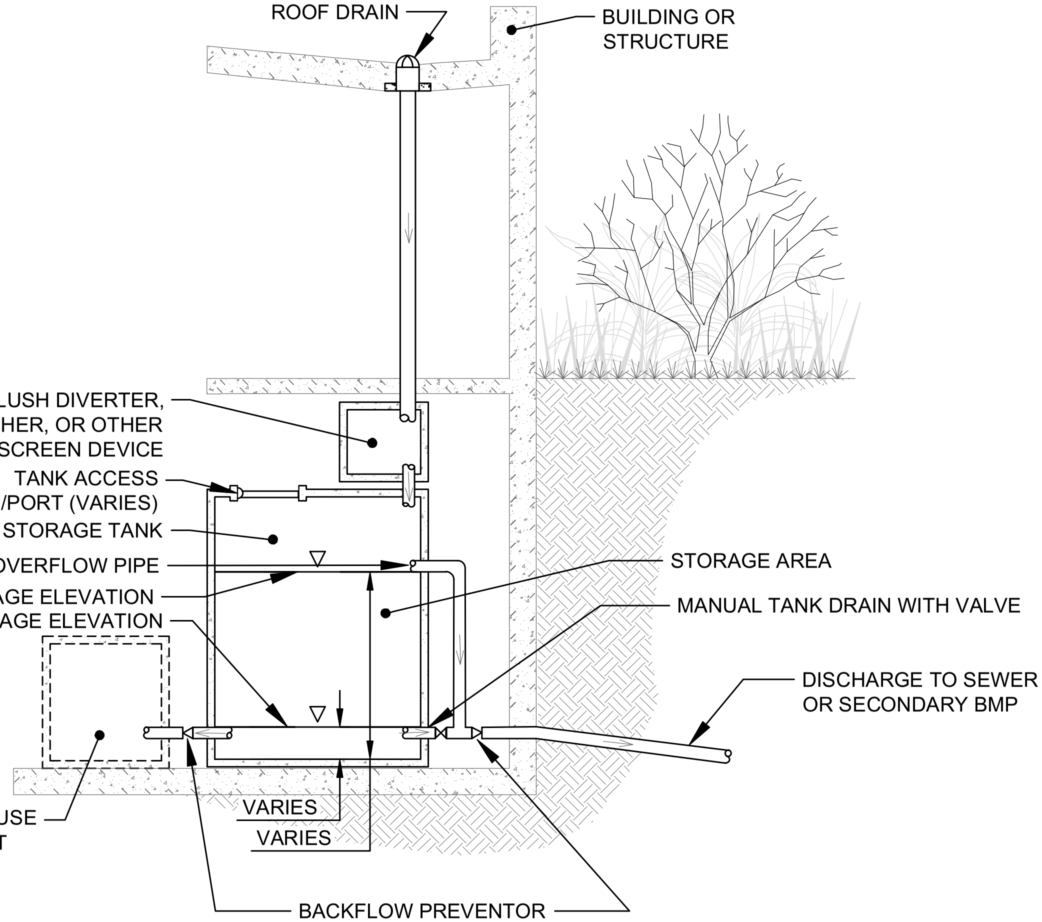
VS.	DATE	INITIALS	REASON

SCALE: N.T.S.

DRAWING NUMBER: SS - 4

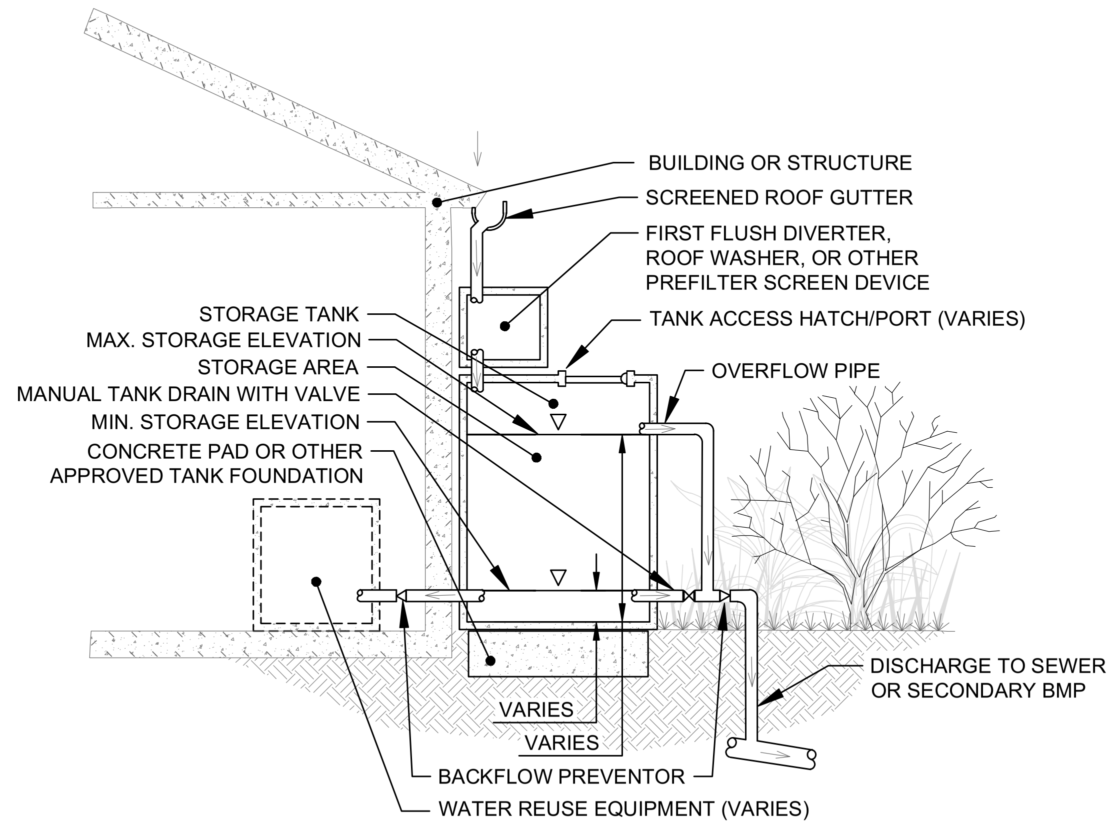
SHEET 4 OF 4


REUSE EQUIPMENT
CISTERN TANK
Roof
REUSE EQUIPMENT
CISTERN TANK
Roof
APPLICATION: INTERIOR TANK
APPLICATION: EXTERIOR TANK
IRRIGATION PIPING
MAINTENANCE ACCESS
MAIN STREET
1ST STREET
Existing Sewer
SECONDARY BMP
CISTERN TANK
REUSE EQUIPMENT
Roof
APPLICATION: SUBSURFACE TANK
FLOW DIRECTION (TYP.)
ROOF DRAIN
THIS LAYOUT DEPICTS POSSIBILE BMP IMPLEMENTATION. REFER TO THE FOLLOWING SHEETS FOR REPRESENTITIVE TYPICAL DETAILS.
CISTERN TYPICAL APPLICATION LAYOUT
SCALE: N.T.S.
DRAWING NUMBER:
CI - 1
SHEET 1 OF 4
VS.
DATE
INITIALS
REASON
CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS
CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608



NOTES TO DESIGNER:
1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. TANK LOAD MUST BE INCLUDED IN STRUCTURAL LOAD CALCULATIONS OF THE SUPPORTING INFRASTRUCTURE.
4. ANY EQUIPMENT REQUIRING ELECTRICAL AND/OR PLUMBING CONNECTIONS MUST BE PERMITTED AND WILL BE SUBJECT TO CITY CODES.

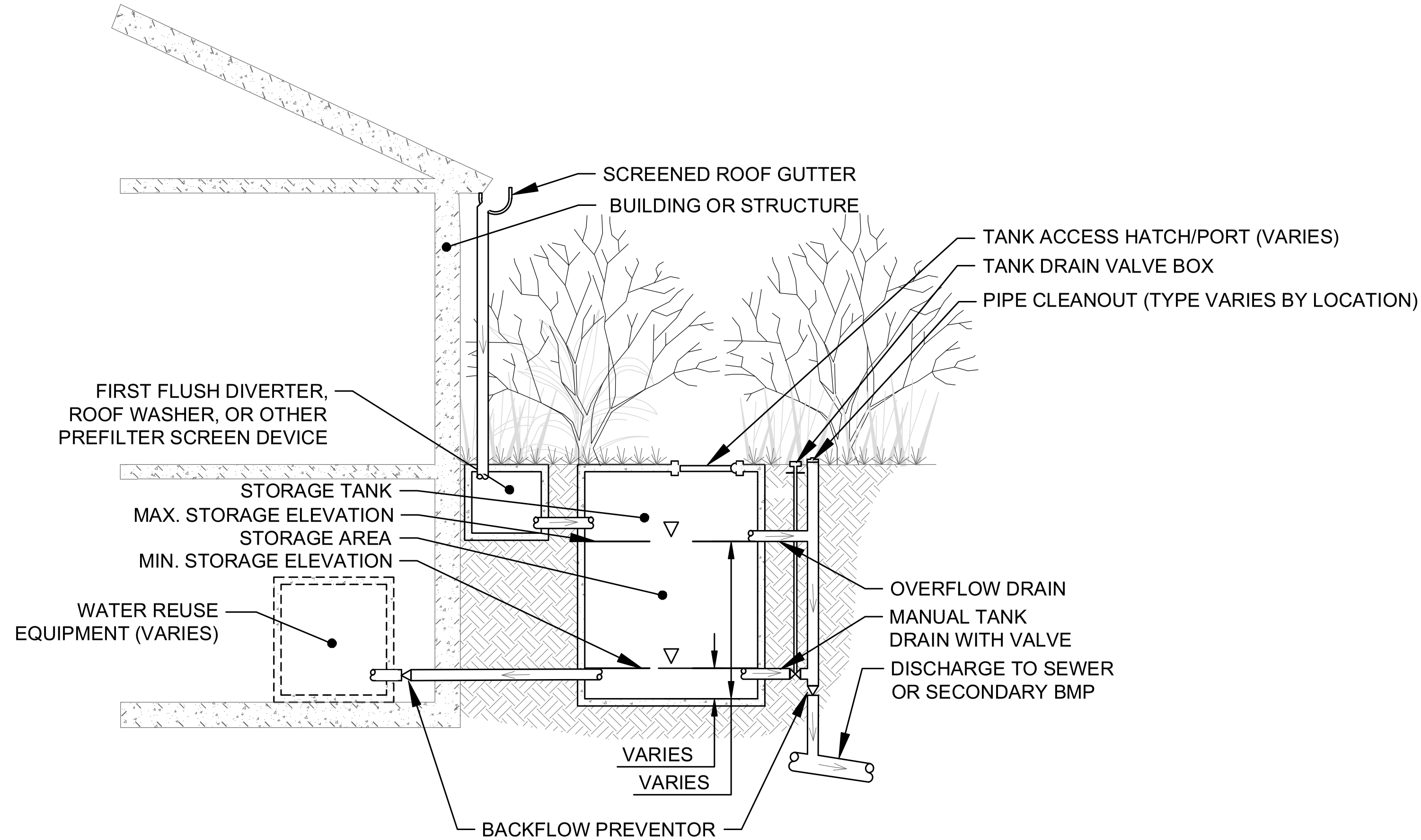
CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL INTERIOR TANK VS. DATE INITIALS REASON	SCALE: N.T.S. DRAWING NUMBER: CI - 2 SHEET 2 OF 4



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. TANK LOAD MUST BE INCLUDED IN STRUCTURAL LOAD CALCULATIONS OF THE SUPPORTING INFRASTRUCTURE.
4. ANY EQUIPMENT REQUIRING ELECTRICAL AND/OR PLUMBING CONNECTIONS MUST BE PERMITTED AND WILL BE SUBJECT TO CITY CODES.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL EXTERIOR TANK	SCALE: N.T.S.
	VS. / DATE / INITIALS / REASON	DRAWING NUMBER: CI - 3 SHEET 3 OF 4



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. TANK LOAD MUST BE INCLUDED IN STRUCTURAL LOAD CALCULATIONS OF THE SUPPORTING INFRASTRUCTURE.
4. ANY EQUIPMENT REQUIRING ELECTRICAL AND/OR PLUMBING CONNECTIONS MUST BE PERMITTED AND WILL BE SUBJECT TO CITY CODES.

CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS

CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608

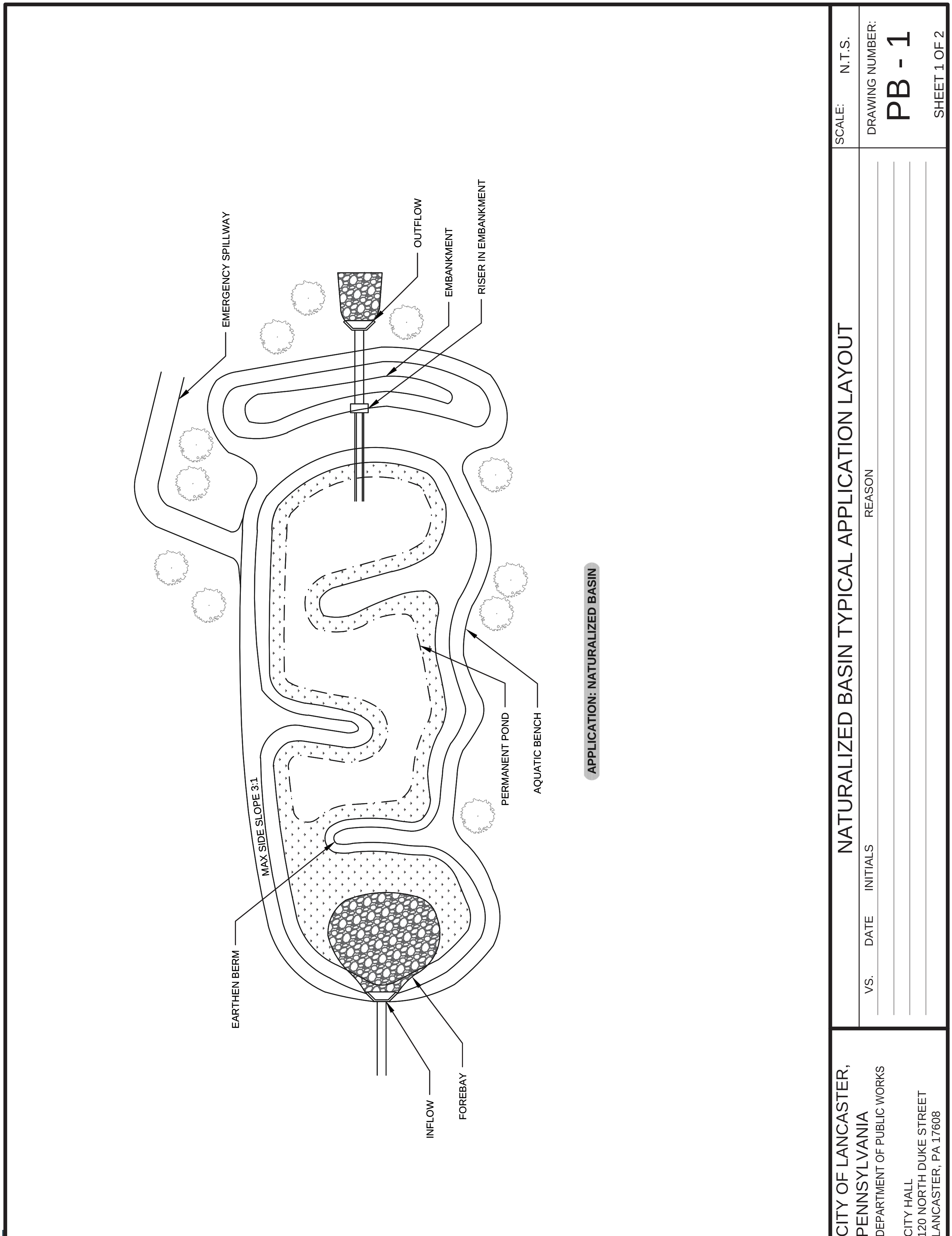
TYPICAL SUBSURFACE TANK

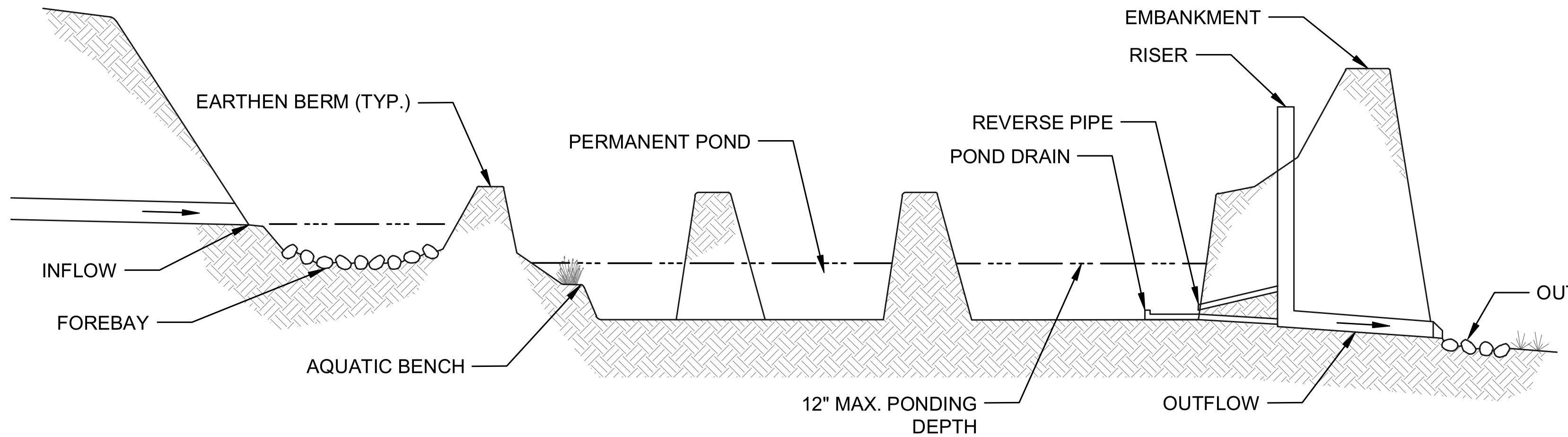
VS.	DATE	INITIALS	REASON

SCALE: N.T.S.

DRAWING NUMBER: CI - 4

SHEET 4 OF 4


EMERGENCY SPILLWAY
OUTFLOW
EMBANKMENT
RISER IN EMBANKMENT
PERMANENT POND
AQUATIC BENCH
APPLICATION: NATURALIZED BASIN
MAX SIDE SLOPE 3:1
EARTHEN BERM
INFLOW
FOREBAY
NATURALIZED BASIN TYPICAL APPLICATION LAYOUT
SCALE: N.T.S.
DRAWING NUMBER:
PB - 1
SHEET 1 OF 2
VS.
DATE
INITIALS
REASON
CITY OF LANCASTER, PENNSYLVANIA
DEPARTMENT OF PUBLIC WORKS
CITY HALL
120 NORTH DUKE STREET
LANCASTER, PA 17608



NOTES TO DESIGNER:

1. THIS DESIGN DETAIL SHOULD BE ADAPTED TO THE SPECIFIC ENGINEERED DESIGN AND ITS RESPECTIVE INSTALLATION.
2. ALL DESIGNS MUST COMPLY WITH STANDARDS OUTLINED WITHIN CHAPTER 5 OF THE CITY OF LANCASTER GREEN INFRASTRUCTURE DESIGN MANUAL AND THE CITY OF LANCASTER STORMWATER ORDINANCE (§260).
3. SEE GI DESIGN MANUAL CHAPTER 5 FOR MINIMUM OFFSETS AND PLACEMENT OF WATERPROOF LINER REQUIREMENTS.

CITY OF LANCASTER, PENNSYLVANIA DEPARTMENT OF PUBLIC WORKS CITY HALL 120 NORTH DUKE STREET LANCASTER, PA 17608	TYPICAL NATURALIZED BASIN DETAIL				SCALE: N.T.S.
	VS.	DATE	INITIALS	REASON	DRAWING NUMBER: PB - 2 SHEET 2 OF 2

APPENDIX C – DEVELOPER'S CHECKLIST

BMP PLACEMENT CONSIDERATIONS (SEE CHAPTER 3, TABLE 3.2.2-2)	
CONSIDERED	STRATEGY
☐	Assessing space constraints
☐	Choosing areas with infiltration potential
☐	Avoiding utilities
☐	Avoiding sensitive features
☐	Avoiding hotspots and contamination
☐	Avoiding unstable fill
☐	Considering appropriate conditions for vegetated BMPs

STORMWATER CONVEYANCE CONSIDERATIONS (SEE CHAPTER 3, TABLE 3.2.2-3)	
CONSIDERED	STRATEGY
☐	Prioritizing low-lying areas
☐	Providing downstream points of relief
☐	Minimizing conveyance requirements

SITE USE CONSIDERATIONS (SEE CHAPTER 3, TABLE 3.2.2-4)	
CONSIDERED	STRATEGY
☐	Creating on-site amenities
☐	Providing maintenance access
☐	Developing smart parking lot layouts
☐	Using alternative hardscapes
☐	Managing traffic
☐	Reducing landscape maintenance needs
☐	Using rainwater harvesting as an architectural feature
☐	Maintaining sight lines
☐	Ensuring safety
☐	Reducing potential bird collisions

STANDARD SITE & DESIGN REQUIREMENTS	
COMPLETE	REQUIREMENTS
☐	All building, property and utility offsets specified within the Manual have been satisfied.
☐	Testing for native soils surrounding BMPs have been performed and properly documented.
☐	All planting species meet the approved planting list included in Appendix D.
☐	Infiltration BMPs are not located within karst geology or areas of environmental contamination.
☐	Infiltration BMPs have native soil infiltration rates within the acceptable range.

Appendix C

VOLUME CONTROL CALCULATIONS	
COMPLETE	REQUIREMENTS
☐	Predevelopment and postdevelopment impervious areas have been delineated as defined in the City of Lancaster SWM Ordinance 260-301
☐	Volume control requirements have been calculated.
☐	Retention volume for all non-structural BMPs has been determined.
☐	Required retention volume for structural BMPs has been calculated.
☐	Impervious and pervious drainage areas for each structural BMP have been delineated.
☐	All loading ratios meet the requirements specified in Chapter 4.
☐	Total BMP storage capacity is greater than or equal to the required retention volume.
☐	Surface drawdown time calculations have been performed for structural BMPs with surface ponding and are less than 24 hours.
☐	Drawdown time calculations for the storage volume of structural BMPs have been performed and are not less than 24 hours and not more than 72 hours.
☐	Release rate has been calculated for all slow-release structural BMPs and does not exceed the project specific release rate provided by the City.
☐	Postdevelopment runoff does not exceed the predevelopment runoff volume.
☐	Annual stormwater volume reduction has been calculated.
☐	Annual pollutant load reduction has been calculated.
☐	Structural BMPs safely convey the 25-year, 24-hour storm for on on-site runoff.
☐	Structural BMPs safely convey the 50-year, 24-hour storm for off-site runoff.
☐	Postdevelopment peak rate is less than or equal to predevelopment peak rate.

RATE CONTROL CALCULATIONS	
COMPLETE	REQUIREMENTS
☐	A point of discharge within the watershed has been determined for comparison of predevelopment and postdevelopment conditions.
☐	A drainage area map within the limits of the project has been developed.
☐	Predevelopment and postdevelopment runoff to the point of discharge has been determined using an acceptable computation methodology from Table III-1 provided in the City of Lancaster SWM Ordinance 260-305.
☐	BMPs have been designed to meet City of Lancaster SWM ordinance rate control requirements.

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APPENDIX D – GREEN INFRASTRUCTURE PLANT LIST

INTRODUCTION

This appendix is intended to be used by BMP designers to develop planting plans for vegetated BMPs in conjunction with vegetation requirements listed in Chapter 5. Plant species used in BMPs shall be selected from the tables in this appendix unless substitutions are approved by the City of Lancaster. Note that multiple cultivars are available for a broad range of species. Cultivars may differ in characteristics and environmental tolerances.

Tree selection shall include consideration of spring dig/fall hazards in relation to project construction schedules. Trees that cannot be dug in time for scheduled construction may need to be planted in the following year or replaced with an approved substitution.

Instructions

Each table in this appendix provides a list of species that may be used based on type of plant (i.e., trees, shrubs, and herbaceous). For each species listed, the following information, where available and applicable, is provided.

Characteristics

Form – This only applies to trees and describes the overall shape of the tree canopy.

Height – Each species has a typical range that is reached at maturity if site conditions support the growth requirements of the plant.

Width – The ultimate width, or spread, of a plant at maturity determines the spacing and number of plants needed in a system.

Foliage Texture – Consider for visual interest.

Flowering Period – Consider for visual interest and wildlife value. Early blooming species can provide food for early migrants while late-blooming species can extend the seasonal availability of resources.

Flower Color – Consider for visual interest. Not relevant as an aesthetic factor for species with inconspicuous flowers.

Fall Leaf Color – Consider for visual interest. Not relevant as an aesthetic factor if fall coloration is unremarkable.

Native to US/Nativar – Native species are open-pollinated straight species with high genetic diversity; native cultivars ("nativar") are genetic variants that have been cultivated for specific traits. Cultivars have less genetic diversity and some may not provide all the wildlife benefits of straight species, although they provide other ecosystem services, such as uptake and evapotranspiration of stormwater runoff.

Wildlife Value – Plant selection for BMPs shall include consideration of habitat for wildlife to the extent feasible. Vegetated BMPs can contribute to enhanced urban ecosystems for migratory songbirds and invertebrates by providing food, nesting materials and sites, and roosting sites. Wildlife value is indicated where known. Nativars have not been thoroughly studied, but some have shown reduced value to invertebrates as a food source (e.g., red- and purple-leaved varieties have different leaf chemistry that deters some insect feeding); for that reason, preference has been given to straight species.

Environmental Tolerances

Hydrologic Zone Elevation – Plant selection for BMPs shall take into consideration species characteristics in relation to the hydrology of engineered systems, which is a function of the designed maximum ponding depth, infiltration rate, drawdown time, stormwater soil mix, and steepness of side slopes. Select plants based on location within the following four zones:

- **Inflow/Entry Zone** – High stress zone: plants must be able to tolerate salt spray, soil salt, high energy flow, sedimentation, and pollutants.
- **Lowest Zone** – Deepest zone with the greatest amount of ponding; plants must be able to tolerate inundation.
- **Middle Zone** – In systems with side slopes (i.e., rain gardens), this is the highest limit of ponding; plants must be able to tolerate fluctuating water levels and soil moisture.
- **Highest Zone** – In systems with side slopes (i.e., rain gardens); above ordinary ponding elevation, periodic/extended drought.

Light Requirements – Plants have different requirements and tolerances for sunlight and shade that must be considered when developing a planting design for BMPs.

Soil Salinity Tolerance – BMPs adjacent to pavements treated with deicing chemicals expose plants to potential salt damage. Plants with high salt tolerance shall be used in the right-of-way. Note that a plant's tolerance to soil salt may differ from its tolerance to salt spray.

pH Tolerance – Plant species have optimal pH ranges in which they thrive. For a majority of species, the optimal pH range is between 5.5 and 7; however, many plants can still grow outside of their adapted pH range. Note that pH tolerances are provided only in the Wetland Plants tables since wet ponds and constructed wetlands can receive runoff with high levels of dissolved nutrients that can directly affect the pH level in the water.

Applicable BMP Type

Corner Bumpout – Bioretention/bioinfiltration BMP that extends the existing curbline into the roadway, located at the corner of a city block.

Midblock Bumpout – Bioretention/bioinfiltration BMP that extends the existing curbline into the roadway, located along the length of a city block.

Sidewalk Planter – Bioretention/bioinfiltration BMP with curbs or fencing, located within the sidewalk.

Rain Garden – Bioretention/bioinfiltration BMP typically located off the right-of-way.

Tree Pit/Trench – Subsurface infiltration/detention BMP with a series of trees, typically located within the sidewalk.

Naturalized Basin – BMP designed to appear as a naturally occurring feature, located off the right-of-way.

Green Roof – Vegetated BMP located on rooftops.

Applicable Naturalized Basin Type

Wet Pond – Naturalized basin BMP with a permanent pool and temporary storage.

Stormwater Wetland –Naturalized basin BMP with a permanent pool and temporary storage. The configuration is more complex than a wet pond (e.g., microtopography, extent of ponding, flow path, and plant zones).

Symbology

✓ = Applicable
X = Not Applicable

List of Planting Tables

TABLE D–1. TREES - MEDIUM TO LARGE

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Acer rubrum	Red Maple	Oval / Round	35–75'	30-50'	Coarse	Mar–Apr	Red	Red, Orange, Yellow	✓	✓	Lowest–Highest	Part Shade	Low	X	✓	✓	✓	✓	✓
Acer rubrum 'Bowhall'	'Bowhall' Red Maple	Oval / Columnar	45–50'	18–25'	Coarse	Mar–Apr	Red	Red, Orange, Yellow	✓	X	Lowest–Highest	Part Shade	Low	X	✓	✓	✓	✓	X
Acer saccharum	Sugar Maple	Oval / Round	50–80'	35–50'	Coarse	April	Yellow, Green	Orange, Red	✓	X	Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	✓	✓
Acer x freemani	Freeman Maple	Oval / Columnar	40–60'	20–40'	Coarse	April	Green, Yellow, Red	Red, Orange	✓	X	Lowest–Highest	Full Sun	Low	X	✓	✓	✓	✓	X
Aesculus x carnea	Red Horse Chestnut	Oval / Round	30–40'	25–35'	Fine	May	Red	Green	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Betula nigra	River Birch	Oval / Pyramidal	40–50'	25–35'	Coarse	Apr–May	Brown	Yellow	✓	✓	Lowest–Highest	Full Sun–Part Shade		X	✓	✓	✓	✓	✓
Betula nigra 'Cully' Heritage	Heritage River Birch	Oval / Pyramidal	40–70'	25–35'	Coarse	Apr–May	Brown	Yellow	✓	X	Lowest–Highest	Full Sun–Part Shade		X	✓	✓	✓	✓	X
Betula nigra 'Dura Heat'	'Dura-Heat' River Birch	Oval / Pyramidal	30–40'	25-30'	Coarse	Apr–May	Brown, Green	Yellow	✓	X	Lowest–Highest	Full Sun–Part Shade		X	✓	✓	✓	✓	X
Carpinus betulus	European Hornbeam	Round	40–60'	30–40'	Coarse	March	Yellow (male), Green (female)	Yellow, Orange	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X

TABLE D–1. TREES - MEDIUM TO LARGE (CONT.)

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Celtis occidentalis	Common Hackberry	Oval	40–60'	40–60'	Coarse	Apr–May	Green	Yellow	✓	✓	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	✓
Celtis occidentalis 'Prairie Pride'	'Prairie Pride' Common Hackberry	Oval	40–55'	40–50'	Coarse	Apr–May	Green	Yellow	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Cercidiphyllum japonicum	Katsura Tree	Round	40–60'	25–60'	Coarse	Mar–Apr	Green	Yellow, Orange	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Chamaecyparis thyoides	Atlantic White Cedar	Columnar	30–50'	30–40'	Fine	X	Green	Green	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	✓
Cladrastis kentukea	Yellowwood	Round	30–50'	40–55'	Coarse	May	White, Pink	Yellow	✓	✓	Highest	Full Sun	High	X	X	X	✓	✓	✓
Fagus sylvatica	European Beech	Oval / Round	50–60'	35–50'	Coarse	Apr–May	Green	Orange, Gold, Bronze	X	X	Highest	Full Sun	Low	X	X	X	✓	✓	X
Ginkgo biloba (male only)	Maidenhair Tree	Columnar	40–50'	20–30'	Coarse	April	Green (male)	Yellow	X	X	Highest	Full Sun	High	X	X	X	✓	✓	X
Ginkgo biloba 'Autumn Gold' (male only)	'Autumn Gold' Maidenhair Tree	Columnar	40–50'	20–30'	Coarse	April	Green (male)	Yellow	X	X	Highest	Full Sun	High	X	X	X	✓	✓	X
Gleditsia tricanthos 'Inermis'	Thornless Honeylocust	Round / Vase	35–45'	25–35'	Fine	May–June	Green, White	Yellow	✓	X	Lowest–Highest	Full Sun	High	X	✓	✓	✓	✓	✓
Juniperus virginiana	Eastern Red Cedar	Columnar	30–50'	10–20'	Fine	X	Green	Green	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓

Appendix D

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Liquidambar styraciflua 'Rotundiloba'	'Rotundiloba' Sweet Gum	Columnar	60–70'	20–30'	Coarse	Apr–May	Green	Orange, Gold, Bronze	X	X	Lowest–Highest	Full Sum	High	X	X	✓	✓	✓	X
Liriodendron tulipifera	Tulip Tree	Oval/ Pyramidal	60–90'	20–50'	Coarse	May–June	Yellow, Orange	Yellow, Gold	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓
Magnolia virginiana	Sweetbay Magnolia	Oval / Vase	15–35'	10–20'	Coarse	May–June	White	Green	✓	✓	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	✓
Magnolia grandiflora	Southern Magnolia	Oval / Pyramidal	60–80'	30–50'	Coarse	May–June	White	Green	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓
Metasequoia glyptostroboides	Dawn Redwood	Oval / Pyramidal	70–100'	15–25'	Fine	X	X	Red, Bronze	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	✓
Nyssa sylvatica	Blackgum (Black Tupelo, Sour Gum)	Oval / Pyramidal	40–50'	30–40'	Coarse	May–June	Green, White	Orange, Yellow, Purple, Red	✓	✓	Lowest–Highest	Full Sun	Medium	X	✓	✓	✓	✓	✓
Nyssa sylvatica 'Wildfire'	Blackgum (Black Tupelo, Sour Gum)	Oval / Pyramidal	40–50'	30–40'	Coarse	May–June	Green, White	Orange, Yellow, Purple, Red	✓	X	Lowest–Highest	Full Sun	Medium	X	✓	✓	✓	✓	X
Ostrya virginiana	Eastern Hop Hornbeam	Round	25–40'	20–30'	Coarse	April	Red-brown (male), Light Green (female)	Yellow	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓

TABLE D–1. TREES - MEDIUM TO LARGE (CONT.)

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Platanus x acerifolia	London Planetree	Round	70–85'	50–70'	Coarse	April	Red	Yellow	X	X	Lowest–Highest	Full Sun	Medium	X	X	X	✓	✓	X
Prunus sargentii 'Columnaris'	'Columnaris' Sargent Cherry	Oval / Columnar	20–30'	15-20'	Coarse	April	Pink	Orange, Red	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Prunus sargentii 'Spire'	'Spire' Sargent Cherry	Oval / Columnar	10–15'	25–30'	Coarse	April	Pinky	Orange, Red	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Quercus imbricaria	Shingle Oak	Pyramidal / Round	40–60'	40–60'	Coarse	April	Yellow, Green	Red, Yellow, Brown	✓	X	Highest	Full Sun	High	X	X	X	✓	✓	✓
Quercus muehlenbergii	Chinkapin Oak (Chinquapin Oak)	Round	40–60'	50–70'	Coarse	April	Yellow, Green	Yellow, Brown	✓	X	Highest	Full Sun	Medium	X	X	X	✓	✓	✓
Quercus palustris 'Pringreen'	'Pringreen' Pin Oak	Columnar	50–60'	12–15'	Coarse	April	Green	Red, Scarlet	X	X	Lowest–Highest	Full Sun	Low	X	✓	✓	✓	✓	X
Quercus phellos	Willow Oak	Oval / Round	40–75'	25–50'	Coarse	April	Yellow, Green	Yellow, Gold, Brown	✓	✓	Lowest–Highest	Full Sun	High	X	✓	✓	✓	✓	✓
Quercus rubra	Red Oak	Round	50–75'	50–75'	Coarse	May	Yellow, Green	Brown, Red	✓	✓	Highest	Full Sun	High	X	X	X	✓	✓	✓
Quercus shumardii	Shumard Oak	Round	40–60'	30–40'	Coarse	April	Green	Brown, Red	✓	✓	Middle–Highest	Full Sun	Medium	X	X	X	✓	✓	✓
Taxodium distichum	Bald Cypress	Pyramidal	50–70'	20–45'	Fine	X	Brown	Orange, Brown	✓	✓	Lowest–Highest	Full Sun	Medium	X	✓	✓	✓	✓	✓
Tilia americana	Basswood, American Linden	Oval / Round	60–80'	40–60'	Coarse	June	Yellow	Yellow	✓	✓	Middle–Highest	Full Sun	Low	X	X	X	✓	✓	✓
Tilia americana 'Legend'	'Legend' American Linden	Oval / Pyramidal	40'	30'	Coarse	June	Yellow	Yellow	X	X	Middle–Highest	Full Sun	Low	X	X	X	✓	✓	X

TABLE D–2. TREES - SMALL

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Acer campestre	Hedge Maple	Oval	25–35'	25–35'	Coarse	Apr–May	Yellow, Green	Yellow, Gold, Orange	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X
Acer buergerianum	Trident Maple	Round	20–30'	20–30'	Fine	Apr–May	Green, Yellow	Red, Orange, Yellow	X	X	Highest	Full Sun	Medium	X	X	X	✓	✓	X
Amelanchier canadensis	Canadian Serviceberry (Shadblow Serviceberry)	Round	25–35'	15–20'	Fine	Apr–May	White	Red, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	✓	✓
Amelanchier laevis 'Majestic'	'Majestic' Allegheny Serviceberry	Oval / Round	15–25'	15–25'	Fine	April	White	Red, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Amelanchier x grandiflora	Apple Serviceberry	Oval / Vase	15–25'	15–25'	Fine	April	Pink, White	Red, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	✓	X
Amelanchier x grandiflora 'Autumn Brilliance'	'Autumn Brilliance' Apple Serviceberry	Oval	15–25'	15–25'	Fine	April	White	Red, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	✓	X
Amelanchier x grandiflora 'Princess Diana'	'Princess Diana' Apple Serviceberry	Round	15–20'	12–15'	Fine	April	White	Red, Yellow, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	✓	X
Carpinus caroliniana	American Hornbeam	Round	20–35'	20–35'	Coarse	February	White (female), Green (male)	Red, Orange, Yellow	✓	✓	Lowest–Highest	Part Shade–Full Shade	Low	X	✓	✓	✓	✓	✓
Cercis canadensis	Eastern Redbud	Round	20–30'	25–35'	Coarse	April	Pink	Red, Purple, Orange	✓	X	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	✓	✓
Chionanthus virginicus	Fringetree	Round	12–20'	12–20'	Fine	May–June	White	Yellow	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓

TABLE D–2. TREES - SMALL (CONT.)

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Cornus florida	Flowering Dogwood	Round / Vase	15–30'	15–30'	Fine	Apr–May	Red, White	Maroon	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓
Cornus kousa	Kousa Dogwood	Oval / Round	15–20'	15–20'	Coarse	Apr–May	Pink	Yellow, Red, Purple	X	✓	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Cornus mas	Cornelian cherry Dogwood	Vase	15–25'	12–20'	Coarse	March	Yellow	Red, Maroon	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X
Cornus x rutban	Aurora Dogwood	Vase / Oval	14–18'	14–18'	Coarse	Apr–May	White	Purple	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X
Cotinus obovatus	American Smoke Tree	Round	20–30'	20–30'	Coarse	May–June	Yellow, Green	Yellow, Red, Orange, Purple	✓	X	Highest	Full Sun	Low	X	X	X	✓	✓	✓
Crataegus crus-galli	Thornless Cockspur Hawthorn	Oval / Round	20-35'	25-35'	Coarse	May–June	White, Pink	Red, Orange	✓	✓	Highest	Full Sun	High	X	X	X	✓	✓	✓
Crataegus viridis 'inermis'	Thornless Green Hawthorn	Round	25–35'	25–35'	Coarse	May	White	Red, Purple	✓	✓	Highest	Full Sun	Low	X	X	X	✓	✓	X
Crataegus phaenopyrum 'Princeton Sentry'	Thornless Washington Hawthorn	Columnar	25–30'	20'	Coarse	June	White	Red, Orange, Yellow	✓	✓	Highest	Full Sun	Medium	X	X	X	✓	✓	X
Crataegus punctata 'Ohio Pioneer'	'Ohio Pioneer' Thornless Dotted Hawthorn	Round	20–30'	20–30'	Coarse	May–June	White	Red	✓	✓	Highest	Full Sun	Medium	X	X	X	✓	✓	X
Malus spp.	Flowering Crabapple	Round	15–22'	20–24'	Coarse	Apr–May	Pink, Red	Red, Orange	X	✓	Highest	Full Sun	Low	X	X	X	✓	✓	X
Prunus serrulata	Japanese Cherry (Mt. Fuji Cherry, Oriental Cherry)	Vase	10–15'	15–20'	Fine	April	White	Orange, Red	X	X	Highest	Full Sun	Medium	X	X	X	✓	✓	X

TABLE D–2. TREES - SMALL (CONT.)

Plant Name		Characteristics									Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Form	Height	Width	Foliage Texture	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Prunus subhirtilla	Higan Cherry	Vase / Round	20–30'	15–25'	Fine	April	White, Pink	Yellow	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X
Prunus virginiana	Common Chokecherry	Oval / Round	20–30'	15–20'	Coarse	Apr–May	White, Purple	Yellow, Orange	✓	✓	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	✓
Prunus x yedoensis	Yoshino Cherry	Round / Vase	35–45'	30–40'	Coarse	Mar–Apr	White, Pink	Yellow	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X
Prunus maackii	Manchurian Cherry (Amur Cherry, Amur Chokeberry)	Round	20–30'	18–25'	Fine	Apr–May	White	Yellow	X	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X
Prunus sargentii	Sargent Cherry	Round	20–30'	15–30'	Fine	Mar–Apr	Pink	Red, Purple	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Styrax japonicas	Japanese Snowbell (Snowbell)	Vase / Round	20–30'	20–30'	Coarse	May–June	White	Yellow, Red	X	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Syringa reticulata	Japanese Tree Lilac	Oval / Round	20–25'	15–20'	Coarse	May–June	White	Yellow, Gold	X	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X
Syringa reticulata 'Ivory Silk'	'Ivory Silk' Japanese Tree Lilac	Oval / Round	20–25'	15–20'	Coarse	May–June	White	Yellow, Gold	X	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X
Syringa reticulata 'Summer Snow'	'Summer Snow' Japanese Tree Lilac	Round	20–30'	20–25'	Coarse	June	White	Yellow	X	X	Highest	Full Sun	High	X	X	X	✓	✓	X
Syringa reticulata 'Regent'	'Regent' Japanese Tree Lilac	Oval	25–30'	15–25'	Coarse	June	Cream	Yellow	X	X	Highest	Full Sun	High	X	X	X	✓	✓	X

TABLE D–3. SHRUBS

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Aronia arbutifolia	Red Chokeberry (Chokeberry)	6–10'	3–5'	May	White	Red	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Aronia arbutifolia 'Brilliantissima'	Brilliantissima Red Chokeberry (Chokeberry)	6–8'	3–4'	April	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X
Aronia melanocarpa	Black Chokeberry (Chokeberry)	3–6'	3–6'	May	White	Red	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	✓
Aronia melanocarpa 'Viking'	Viking Black Chokeberry (Chokeberry)	3–6'	3–6'	May	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	X
Aronia melanocarpa 'Autumn Magic'	'Autumn Magic' Black Chokeberry (Chokeberry)	3–6'	4–7'	May	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	X
Aronia melanocarpa var. 'Elata'	'Elata' Black Chokeberry (Chokeberry)	5–8'	6–10'	May	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	✓	X
Clethra alnifolia	Summersweet	3–8'	4–6'	July–Aug	White	Red	✓	✓	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Cornus alba	Tatarian Dogwood	8–10'	8–10'	May–June	Yellow, White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Cornus alba 'Sibirica'	'Sibirica' Tatarian Dogwood	4–7'	3–5'	May–June	Yellow, White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Cornus alba 'Elegantissima'	'Elegantissima' Tatarian Dogwood (Red-barked Dogwood)	8–13'	8–13'	May–June	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Cornus sericea	Red Twig Dogwood (Red Osier Dogwood)	6–10'	6–10'	May	White	Maroon, Red	✓	✓	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓

TABLE D–3. SHRUBS (CONT.)																		
PLANT NAME		CHARACTERISTICS							ENVIRONMENTAL TOLERANCES			APPLICABLE BMP TYPE						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Cornus sericea 'Kelseyi'	'Kelseyi' Red Twig Dogwood (Red Osier Dogwood)	2–3'	2–3'	May	White	Maroon, Red	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Cornus sericea 'Flaviramea'	'Flaviramea' Yellow Twig Dogwood (Yellow Osier Dogwood)	5–6'	5–6'	May–June	White	Yellow	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Cornus sericea 'Isanti'	'Isanti' Red Twig Dogwood (Red Osier Dogwood)	4–5'	4–7'	May–June	White	Red	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Diervilla lonicera	Northern Bush Honeysuckle	1–3'	1–3'	June–Aug	Yellow, Red, Orange, Purple	Yellow, Red	✓	X	Highest	Part Shade–Shade	Medium	X	X	X	✓	✓	✓
Diervilla lonicera 'Copper'	'Copper' Dwarf Bush Honeysuckle	2–3'	2–3'	June	Yellow	Bronze, Orange, Red	✓	X	Highest	Full Sun–Part Shade	Medium	X	X	X	✓	✓	X
Fothergilla gardenii	Dwarf Fothergilla	1½ –3'	2–4'	May	White	Bronze, Orange, Red	✓	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Fothergilla gardenii 'Mount Airy'	'Mount Airy' Dwarf Fothergilla	3–5'	3–5'	Apr–May	White	Bronze, Orange, Red	✓	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Hamamelis virginiana	Witch Hazel	15–20'	15–20'	Oct–Dec	Yellow	Soft Yellow	✓	X	Lowest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Hamamelis virginiana 'Little Suzie'	'Little Suzie' Witch Hazel	4–5'	4–5'	Oct–Dec	Yellow	Soft Yellow	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X

TABLE D–3. SHRUBS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Hypericum densiflorum	St. John's Wort	2–6'	3–6'	June–Aug	Yellow	Green, Orange, Yellow	✓	X	Lowest	Full Sun	High	✓	✓	✓	✓	✓	✓
Hypericum frondosum	Golden St. John's Wort	3–4'	3–4'	June–July	Yellow	Green, Orange, Yellow	✓	X	Lowest	Full Sun	High	✓	✓	✓	✓	✓	✓
Hypericum frondosum 'Sunburst'	'Sunburst' Golden St. John's Wort	3–4'	3–4'	June–July	Yellow	Red, Brown, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	X
Hypericum kalmianum	Kalm St. John's Wort	2–3'	2–3'	July–Aug	Yellow	Red, Brown, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	✓
Hypericum prolificum	Shrubby St. John's Wort	1–5'	1–4'	June–Aug	Yellow	Gold, Yellow	✓	X	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	✓
Ilex verticillata	Winterberry (Holly)	3–12'	3–12'	June–July	Green, White	Green, Brown	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Ilex verticillata 'Winter Gold'	'Winter Gold' Winterberry (Holly)	5–8'	5–8'	May–June	Green, White	Green, Brown	✓	X	Lowest	Full Sun–Part Shade	High	X	X	✓	✓	X	X
Ilex verticillata 'Winter Red'	'Winter Red' Winterberry (Holly)	6–8'	6–8'	June–July	White	Red, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	X	X	X	✓	X	X
Ilex verticillata 'Nana' or 'Red Sprite'	'Nana' or 'Red Sprite' Winterberry (Holly)	2½–3	2½–3	June–July	White	Red, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	X
Ilex verticillata 'Maryland Beauty'	'Maryland Beauty' Winterberry (Holly)	5–7'	5–7'	May	Green, White	Red, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X

TABLE D–3. SHRUBS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Ilex verticillata 'Southern Gentleman'	'Southern Gentleman' Winterberry (Holly); male pollinator	6'	3–5'	Apr–May	White	Yellow-Green, Purple, Bronze	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Itea virginica	Virginia Sweetspire	4–5'	4–5'	May–June	White	Red, Orange, Gold	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓
Itea virginica 'Henry's Garnet'	'Henry's Garnet' Virginia Sweetspire	3–4'	3–4'	May–June	White	Red, Orange, Gold	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	✓	✓
Itea virginica 'Little Henry'	'Little Henry' Virginia Sweetspire	2–3'	2–3'	June–July	White	Red, Orange, Gold	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	✓	✓
Juniperus horizontalis	Creeping Juniper	6–12"	5–8'	X	X	Blue, Green (Needled Evergreen)	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X
Juniperus horizontalis 'Blue Chip'	'Blue Chip' Creeping Juniper	6–9"	8'–10'	X	X	Blue, Green (Needled Evergreen)	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X
Juniperus horizontalis 'Bar Harbor'	'Bar Harbor' Creeping Juniper	9–12"	5–6'	X	X	Silver-Blue, Purple, Green (Needled Evergreen)	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X

TABLE D–3. SHRUBS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Juniperus horizontalis 'Blue Rug'	'Blue Rug' Creeping Juniper	4–6"	6–8'	X	X	Silver-Blue, Purple, Green (Needled Evergreen)	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X
Juniperus virginiana 'Grey Owl'	Grey Owl Red Cedar	2–3'	4–6'	X	X	Silver-Gray, Green (Needled Evergreen)	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X
Myrica pensylvanica	Bayberry (Northern Bayberry)	5–10'	5–10'	May	Green, Yellow	Brown	✓	✓	Lowest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Physocarpus opulifolius	Ninebark	5–8'	4–6'	May–June	White, Pink	Purple	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Physocarpus opulifolius 'Summer Wine'	'Summer Wine' Ninebark	4–6'	4–6'	May–June	White, Pink	Red, Maroon	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Physocarpus opulifolius 'Amber Jubilee'	'Amber Jubilee' Ninebark (Eastern Ninebark)	6'	4'	May–June	Yellow, Orange, Red	Yellow, Green, Purple	✓	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Physocarpus opulifolius 'Little Devil'	'Little Devil' Ninebark	3–4'	3–4'	May–June	White, Pink	Red, Maroon	✓	X	Lowest–Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Rhus aromatica	Fragrant Sumac	2–6'	6–10'	April	Yellow	Red, Orange	✓	X	Highest	Full Sun	High	✓	✓	✓	✓	✓	✓
Rhus aromatica 'Gro-Low'	'Gro-Low' Fragrant Sumac	1½–2'	6–8'	Apr–May	Yellow	Red, Orange	✓	X	Highest	Full Sun	High	✓	✓	✓	✓	✓	X

TABLE D–3. SHRUBS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Rosa carolina	Carolina Rose (Pasture Rose)	3–6'	5–10'	May	Pink	Red	✓	✓	Lowest–Highest	Full Sun	High	X	X	X	✓	X	✓
Spiraea betulifolia 'Tor'	'Tor' Spirea (Birchleaf Spirea, White Spiraea)	2–3'	2–3'	May–June	White	Orange, Red, Purple	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Spiraea japonica	Japanese Spiraea	4–6'	5–7'	June–July	Pink	Yellow, Brown	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Spiraea japonica 'Little Princess'	'Little Princess' Japanese Spiraea	1½–2'	2–3'	May–July	Pink	Red	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Spiraea japonica 'Neon Flash'	'Neon Flash' Japanese Spiraea	3'	3'	May–Sep	Red	Copper, Maroon	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Viburnum dentatum	Arrowwood Viburnum	6–10'	6–10'	May–June	White	Orange, Maroon, Purple	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Viburnum dentatum 'Chistom' or 'Blue Muffin'	'Chistom' or 'Blue Muffin' Arrowwood Viburnum	3–5'	3–5'	May–June	White, Blue	Orange, Maroon, Purple	✓	X	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X
Viburnum dentatum 'KLMseventeen' or 'Little Joe'	'KLMseventeen' or 'Little Joe' Arrowwood Viburnum	4–5'	4–5'	May–June	White, Blue	Orange, Maroon, Purple	✓	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X
Viburnum dentatum 'Blue Blaze'	'Blue Blaze' Arrowwood Viburnum	5–6'	5–6'	April	White	Red	✓	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X
Viburnum lentago	Nannyberry Viburnum	14–16'	6–12'	May	White	Green-yellow, Red-purple	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓

TABLE D–3. SHRUBS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Viburnum nudum	Possumhaw Viburnum (Smooth Witherod)	12–20'	12–20'	June–July	White	Red, Maroon	✓	✓	Lowest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Viburnum nudum 'Bulk' or 'Brandywine'	Possumhaw Viburnum (Smooth Witherod)	5–12'	5–12'	Apr–May	White	Red, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X
Viburnum nudum 'Winterthur'	Possumhaw Viburnum (Smooth Witherod)	5–12'	5–12'	Apr–May	White	Red-Purple, Maroon	✓	X	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X
Viburnum prunifolium	Blackhaw Viburnum	12–15'	6–12'	May–June	White	Red, Purple	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Viburnum seiboldii 'Wavecrest'	'Wavecreast' Wayfaringtree Viburnum (Variegated Wayfaringtree Viburnum)	15–18'	15–18'	May	White	Dark Red	✓	X	Lowest–Middle	Full Sun–Part Shade	High	X	X	X	✓	X	X
Viburnum trilobum	Cranberry Bush	8–12'	8–12'	Apr–May	White	Maroon, Red	✓	✓	Lowest–Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	✓
Viburnum trilobum 'Alfredo'	'Alfedo' American Cranberry Bush	6–12'	6–12'	Apr–June	White	Maroon, Red	✓	X	Lowest–Highest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Viburnum trilobum 'Bailey Compact'	'Bailey Compact' American Cranberry Bush	6'	6'	May	White	Red	✓	X	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	X	X
Viburnum trilobum 'Compactum'	Dwarf American Cranberry Bush	6'	6'	Apr–June	White	Red	✓	X	Lowest–Highest	Full Sun–Part Shade	Medium	X	✓	✓	✓	X	X

TABLE D–4. HERBACEOUS – GRASSES & FERNS

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Acorus gramineus	Japanese Sweet Flag	6–12"	6–12"	June–July	Green, Yellow	Green, Yellow	X	X	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X
Bouteloua gracilis	Blue Grama Grass	9–24"	18–24"	July–Oct	Yellow	Orange, Red	✓	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Calamagrostis acutiflora 'Avalanche'	'Avalanche' Feather Reed Grass	36"–60"	12"–24"	June–Oct	Purple, Green	Purple	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Calamagrostis acutiflora 'Karl Foerster'	'Karl Foerster' Feather Reed Grass	36"–60"	18–24"	May–Oct	Pink, Purple	Gold, Purple, Pink	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Calamagrostis acutiflora 'Overdam'	'Overdam' Feather Reed Grass	30–36"	18–24"	July–Oct	Green, Pink	Green, Tan	X	X	Lowest–Highest	Full Sun	Low	X	X	X	✓	X	X
Carex amphibola	Creek Sedge (Eastern Narrowleaf Sedge)	8–12"	8–12"	Mar–June	Green	Gold, Tan	✓	X	Lowest	Part Shade–Full Shade	Low	X	X	X	✓	X	✓
Carex cherokeensis	Cherokee Sedge	6–12"	6–12"	Apr–June	Green, White	Gold, Tan	✓	X	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Carex emoryi	Riverbank Sedge	18-24"	12-24"	July–Aug	Green	Gold, Tan	✓	X	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Carex flacca (glauca)	Blue (Glaucous) Sedge	6–12"	12–18"	June–July	Green, White	Green, Tan	X	X	Lowest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Carex flacca (glauca) 'Blue Zinger'	'Blue Zinger' (Glaucous) Sedge	8–16"	12–24"	July–Aug	Blue, Green	Blue, Gray	X	X	Lowest	Part Shade–Full Shade	Low	X	X	X	✓	X	X
Carex flaccosperma	Blue Wood Sedge	6–10"	6–12"	May–June	Green, White	Green	✓	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	X	X
Carex laxiculmis	Bunny Blue Sedge	8–12"	8–12"	May–June	Blue, Green	Green	✓	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	X	X

TABLE D–4. HERBACEOUS – GRASSES & FERNS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Carex laxiculmis 'Hobb'	'Hobb' Bunny Blue® Sedge (Spreading Sedge)	8–12"	12–16"	May–June	Silver, Blue	Green	✓	✓	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	✓	X
Carex morrowii	Japanese Sedge	12–36"	24"	Apr–July	Green, Yellow	Gold, Tan	X	X	Lowest	Part Sun–Full Shade	High	✓	✓	✓	✓	✓	X
Carex morrowii 'Variegata'	Varigated Japanese Sedge	12–18"	18–24"	Apr–July	Brown	Green, White	X	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	✓	X
Carex morrowii 'Ice Dance'	'Ice Dance' Japanese Sedge	12–15"	12–18"	Apr–July	Brown	Green	X	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	✓	X
Carex morrowii 'Ice Ballet'	Japanese Sedge	9–12"	12–24"	Apr–July	Brown	Green	X	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	✓	X
Carex morrowii 'Silver Sceptre'	Silver Sceptre Japanese Sedge	9–12"	12–18"	Apr–July	Brown	Green, White	X	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	✓	X
Carex oshimensis	Japanese Sedge	10–20"	10–20"	May	Brown	Green, White	X	X	Lowest	Full Sun–Part Shade	Medium	X	X	X	✓	X	X
Carex oshimensis 'Evergold'	Evergold Japanese Sedge	9–12"	12–18"	May	Brown	Green, White	X	X	Lowest	Part Shade	Medium	X	X	X	✓	X	X
Carex oshimensis 'Everoro'	'Everoro' Japanese Sedge	12"–18"	12"–18"	May	Brown	Green, White	X	X	Lowest	Part Shade	Medium	X	X	X	✓	X	X
Carex oshimensis 'Everillo'	'Everillo' Japanese Sedge	12–18"	12–18"	May	Brown	Green, White	X	X	Lowest	Full Sun–Full Shade	Medium	X	X	X	✓	X	X
Carex oshimensis 'Everest'	'Everest' Japanese Sedge	12–24"	12–24"	May	Brown	Green, White	X	X	Lowest	Part Shade	Medium	X	X	X	✓	X	X
Carex pensylvanica	Pennsylvania Sedge (Oak Sedge)	6–12"	6–12"	May	Green, Brown	Gold, Tan	✓	X	Highest	Part Shade–Full Shade	High	X	X	X	✓	✓	✓

TABLE D–4. HERBACEOUS – GRASSES & FERNS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Carex stricta	Tussock Sedge	12–36"	12–24"	May–June	Red, Brown	Green	✓	X	Inflow, Lowest	Full Sun–Part Shade	Medium	X	✓	✓	✓	X	✓
Carex vulpinoidea	Fox Sedge	12–36"	12–24"	May–July	Green	Gold, Tan	✓	X	Inflow, Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Chasmanthium latifolium	Northern Sea Oats (Inland Sea Oats, River Oats)	24–60"	12–30"	Aug–Sept	Green	Gold, Tan	✓	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Chasmanthium latifolium 'River Mist'	'River Mist' Northern Sea Oats	24–36"	24–36"	Aug–Sept	Silver, White	Gold, Tan	✓	X	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓
Dennstaedtia punctilobula	Hay-scented Fern	18–24"	24–36"	X	X	Yellow	✓	X	Lowest–Highest	Part Shade–Full Shade	High	X	X	X	✓	X	✓
Deschampsia cespitosa	Tufted Hair Grass	24–36"	12–24"	July–Sept	Green, Pur[le, White	Green, Yellow	✓	X	Lowest	Part Shade	Medium	X	X	X	✓	X	✓
Deschampsia cespitosa 'Goldtau'	'Goldtau' Tufted Hair Grass	12–24"	24–30"	July–Sept	Dark Green, Gold, Yellow	Gold, Yellow	✓	X	Lowest	Part Shade–Full Shade	High	✓	✓	✓	✓	X	✓
Deschampsia cespitosa 'Schottland'	Scottish Tufted Hair Grass	34-48"	34-48"	May–June	Green, Tan	Tan	X	X	Lowest	Full Sun–Part Shade	Medium	✓	✓	✓	✓	X	X
Deschampsia cespitosa 'Pixie Fountain'	'Pixie Fountain' Tufted Hair Grass	18–24"	12–18"	July–Sept	Silver, White, Brown	Brown	X	X	Lowest	Part Shade	High	✓	✓	✓	✓	X	X
Deschampsia cespitosa 'Tardiflora'	'Tardiflora' Tufted Hair Grass	24–36"	24–36"	July–Sept	Green, Gold, Purple, Silver	Tan	X	X	Lowest	Part Shade	High	✓	✓	✓	✓	X	X
Dryopteris marginalis	Eastern Woodfern	18–24"	18–24"	X	X	Yellow	✓	X	Lowest	Part Shade	Medium	X	X	X	✓	X	✓

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Eragrostis spectabilis	Purple Love Grass	12–24"	12–24"	July–Aug	Red, Purple	Red, Orange	✓	X	Highest	Full Sun	High	X	X	X	✓	X	✓
Festuca glauca	Blue Fescue	9–12"	12–18"	June–July	Green, Purple	Green, Yellow	X	X	Highest	Full Sun	High	X	X	X	✓	X	X
Festuca glauca 'Elijah Blue'	'Elijah Blue' Blue Fescue	10–14"	6–9"	June–July	Green, Purple	Blue	X	X	Highest	Full Sun	High	✓	✓	✓	✓	X	X
Festuca glauca 'Beyond Blue'	'Beyond Blue' Fescue	10–12"	15–18"	June–July	Tan	Blue	X	X	Highest	Full Sun	High	✓	✓	✓	✓	✓	X
Festuca longifolia	Hard Fescue	<12"	<12"	Mar–June	Green	Green, Gray	X	X	Lowest–Highest	Part Shade–Full Shade	Low	X	X	X	✓	X	X
Festuca rubra	Red Fescue	12–36"	12–36"	April–Sept	Yellow	Green, Gray	✓	X	Highest	Full Sun	Low	X	X	X	✓	X	✓
Helictotrichon sempervirens	Blue Oat Grass	24–36"	24–36"	June	Blue, Brown	Gold, Tan	X	X	Highest	Full Sun	Medium	X	✓	✓	✓	X	X
Helictotrichon sempervirens 'Saphiresprudel'	Saphiresprudel Blue Oat Grass	24–36"	18–24"	May–June	Blue, Green	Blue, Brown, Tan	X	X	Highest	Full Sun	Medium	X	✓	✓	✓	X	X
Juncus effusus	Common Rush	24–36"	24–36"	June–Aug	Green, Yellow	Yellow, Brown	✓	X	Inflow, Lowest	Full Sun	Low	✓	✓	✓	✓	X	✓
Juncus effusus 'Quartz Creek'	'Quartz Creek' Corkscrew Rush	18–36"	18–36"	June–Aug	Green, Yellow, Tan	Yellow	✓	X	Inflow, Lowest	Full Sun	Low	✓	✓	✓	✓	X	X
Leymus arenarius	Blue Dune Grass	18–36"	18–36"	July–Sept	Yellow, White	Blue Green	✓	X	Lowest–Highest	Full Sun–Part Shade	High	X	X	✓	✓	X	X
Leymus arenarius 'Blue Dune'	'Blue Dune' Lyme Grass (Sand ryegrass)	24–36"	24–36"	May–Aug	Green, Blue	Blue, Gray, Tan	X	X	Lowest–Highest	Full Sun	High	X	✓	✓	✓	X	X

TABLE D–4. HERBACEOUS – GRASSES & FERNS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Liriope muscari	Lily Turf	12"–18"	9–12"	Aug–Sept	Lavender	Green	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Liriope muscari 'Big Blue'	'Big Blue' Lily Turf	12–24"	12–24"	Aug–Sept	Lavender	Green	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	✓	✓	X	X
Liriope muscari 'Royal Purple'	'Royal Purple' Lily Turf	10–15"	9–18"	Aug–Sept	Purple	Green	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	✓	✓	X	X
Liriope muscari 'Variegata'	Varigated Lily Turf	12–20"	12–24"	August	Purple	Green	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	✓	✓	X	X
Muhlenbergia capillaris	Pink Muhly Grass	24–36"	24–36"	Sept–Nov	Pink, Red	Pink, Red	✓	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Muhlenbergia capillaris 'White Cloud'	'White Cloud' Pink Muhly Grass	36–48"	24–36"	Sept–Nov	White	Pink, Red	X	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	X
Muhlenbergia reveronchii	Ruby Muhly Grass	24–36"	18–24"	Aug–Nov	White, Pink, Brown	Pink, Red	✓	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓
Panicum virgatum	Switch Grass	36–72"	24–36"	July–Feb	Pink	Yellow, Orange	✓	X	Inflow, Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓
Panicum virgatum 'Heavy Metal'	'Heavy Metal' Switch Grass	48–60"	12–24"	July–Feb	Pink	Yellow, Orange	X	X	Inflow, Lowest	Full Sun–Part Shade	Medium	X	✓	✓	✓	X	X
Panicum virgatum 'Cape Breeze'	'Cape Breeze' Switch Grass	24–30"	18–24"	July–Feb	Blue, Green, Yellow	Burgundy, Red	X	X	Inflow, Lowest	Full Sun–Part Shade	Medium	✓	✓	✓	✓	X	X
Panicum virgatum 'Rotstrahlbusch'	'Rotstrahlbusch' Red Switch Grass	48–60"	24–36"	July–Feb	Pink	Burgundy, Red	X	X	Inflow, Lowest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X

TABLE D–4. HERBACEOUS – GRASSES & FERNS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Panicum virgatum 'Ruby Ribbon'	'Ruby Ribbon' Switch Grass	36–48"	24–30"	July–Feb	Purple	Blue, Green, Red, Purple	X	X	Inflow, Lowest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Panicum virgatum 'Shenandoah'	'Shenandoah' Switch Grass	36–48"	36–48"	July–Feb	Red, Pink	Beige	X	X	Inflow, Lowest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Pennisetum alopecuroides	Fountain Grass	30–60"	30–60"	July–Feb	Silver, Pink, White	Gold, Yellow	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Pennisetum alopecuroides 'Hameln'	'Hameln' Fountain Grass	18–30"	18–30"	Aug–Oct	Pink, White	Orange, Bronze, Beige	X	X	Lowest–Highest	Full Sun–Part Shade	Low	✓	✓	✓	✓	X	X
Pennisetum alopecuroides 'Little Bunny'	'Little Bunny' Fountain Grass	12–18"	18–24"	Aug–Oct	Green, White	Gold, Beige	X	X	Lowest–Highest	Full Sun–Part Shade	Low	✓	✓	✓	✓	X	X
Pennisetum alopecuroides 'Piglet'	'Piglet' Fountain Grass	9–12"	12–24"	Aug–Oct	Pink, White	Purple, Pink, White	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Pennisetum alopecuroides 'Burgundy Bunny'	'Burgundy Bunny' Dwarf Fountain Grass	12–18"	12–18"	Aug–Oct	White	Burgundy, Beige	X	X	Lowest–Highest	Full Sun	Medium	✓	✓	✓	✓	X	X
Pennisetum orientale	Oriental Fountain Grass	24–36"	24–36"	June–Aug	Pink, White	Yellow, Tan	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Pennisetum orientale 'Karly Rose'	'Karly Rose' Oriental Fountain Grass	24–36"	24–36"	June–Aug	Rose-Purple	Yellow, Tan	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Pennisetum orientale 'Tall Tails'	'Tall Tails' Oriental Fountain Grass	48–60"	24–36"	Jun–Sep	Pink, White	Yellow, Tan	X	X	Lowest–Highest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	X
Schizachyrium scoparium	Little Bluestem	24–48"	18–24"	Aug–Feb	Purple, Bronze	Bronze, Orange	✓	X	Highest	Full Sun	Low	X	X	X	✓	X	✓

TABLE D–4. HERBACEOUS – GRASSES & FERNS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type					
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin
Schizachyrium scoparium 'Standing Ovation'	'Standing Ovation' Little Bluestem	36–48"	12–18"	Aug–Oct	Silver	Orange, Red, Yellow, Purple, Brown	X	X	Highest	Full Sun	Low	X	X	X	✓	X	X
Schizachyrium scoparium 'The Blues'	'The Blues' Little Bluestem	24–48"	18–24"	Aug–Oct	Purple, Bronze	Burgundy, Red	X	X	Highest	Full Sun	Low	X	X	X	✓	X	X
Schizachyrium scoparium 'Blaze'	'Blaze' Little Bluestem	24–36"	18–24"	Aug–Feb	Red, Brown	Red, Pink, Orange, Purple	X	X	Highest	Full Sun	Low	X	X	X	✓	X	X
Schizachyrium scoparium 'Prairie Munchkin'	'Prairie Munchkin' Little Bluestem	24–48"	24–36"	Aug–Feb	Green, Tan	Red, Pink, Orange, Purple	X	X	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X
Schizachyrium scoparium 'Twilight Zone'	'Twilight Zone' Little Bluestem	48–56"	24–36"	Aug–Feb	Green, Tan	Red, Pink, Orange, Purple	X	X	Highest	Full Sun	Medium	X	X	X	✓	X	X

TABLE D–5. HERBACEOUS – FLOWERS

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Agastache rupestris 'Apache Sunset'	'Apache Sunset' Threadleaf Giant Hyssop	18–24"	12–18"	July–Sept	Pink, Orange	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Amsonia hubrichtii	Blue Star	24–36"	24–36"	Apr–May	White, Blue	Gold	✓	✓	Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X
Aquilegia canadensis	Columbine	24–36"	12-18"	Apr–May	Pink, Yellow, Red	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	✓
Asclepias incarnata	Swamp Milkweed (Pink Milkweed)	24–60"	24–60"	June–Oct	Pink, Purple	X	✓	✓	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓	X
Asclepias incarnata 'Cinderella'	'Cinderella' Swamp Milkweed (Butterfly Weed)	36–48"	18–36"	July–Aug	Pink	X	X	✓	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Asclepias incarnata 'Ice Ballet'	'Ice Ballet' Swamp Milkweed	36–42"	18–24"	July–Aug	White	X	X	✓	Lowest	Full Sun	Low	X	X	X	✓	X	X	X
Asclepias incarnata 'Soulmate'	'Soulmate' Swamp Milkweed	36–42"	18–24"	July–Aug	Rose pink	X	X	✓	Lowest	Full Sun	Low	X	X	X	✓	X	X	X
Asclepias tuberosa	Butterfly Weed	12–30"	18–36"	June–Aug	Yellow, Orange	X	✓	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	✓	X
Astilbe sp.	Astilbe	12–36"	18–36"	May–July	Red, Pink, White, Purple	X	✓	✓	Lowest	Part Shade–Full Shade	High	X	✓	✓	✓	✓	✓	X
Allium sp.	Flowering Onion	6–36"	6–12"	May–June	Blue, Pink, Purple, Red, White, Yellow	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	✓
Allium sp. 'Summer Beauty'	'Summer Beauty' Summer Beauty Onion	12–18"	18–24"	July–Aug	Purple	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	✓

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)																			
Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type							
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Allium sp. 'Millenium'	'Millenium' Ornamental Onion	12–18"	12–18"	July–Aug	Pink, Purple	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Baptisia australis	Blue False Indigo	36–48"	36–48"	May–June	Indigo Blue	X	✓	✓	Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓	X
Baptisia australis var. Minor	Minor Dwarf Blue False Indigo	18–24"	12–24"	May–June	Purple, Blue	X	X	✓	Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X	X
Calamintha nepeta	Calamint	12–24"	12–24"	June–Oct	White	X	X	✓	Highest	Full Sun	High	✓	✓	✓	✓	X	X	X
Calamintha nepeta ssp. glandulosa 'White Cloud'	'White Cloud' Lesser Calamint	12–24"	12–24"	June–Oct	White	X	X	✓	Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X	X
Calamintha nepeta 'Montrose White'	'Montrose White' Calamint	12–18"	12–18"	June–Oct	White	X	X	✓	Highest	Full Sun	High	✓	✓	✓	✓	X	X	X
Chelone lyonii	Turtlehead (Pink Turtlehead, Lyon's Turtlehead, Shellflower)	24–48"	18–30"	July–Sept	Pink	X	✓	✓	Lowest	Full Sun–Part Shade	Low	X	X	X	✓	X	✓	X
Coreopsis grandiflora	Large-flowered Tickseed	12–36"	12–36"	June–Sept	Yellow	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓	X
Coreopsis grandiflora 'Baby Sun'	'Baby Sun' Large-flowered Tickseed	20"	20"	June–Sept	Yellow, Gold, Burgundy	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis grandiflora 'Early Sunrise'	'Early Sunrise' Large-flowered Tickseed	18–24"	18–24"	May–Aug	Yellow	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis grandiflora 'Sunfire'	'Sunfire' Large-flowered Tickseed (Butter Daisy)	18"	18–20"	May–Aug	Yellow, Gold, Burgundy	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Coreopsis grandiflora 'Sunray'	'Sunray' Large-flowered Tickseed (Threadleaf Coreopsis)	18–24"	18–24"	June–Sept	Yellow	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis lanceolata 'Sterntaler'	'Sterntaler' Lance-leaf Tickseed	16–18"	12–16"	June–Sept	Yellow, Red	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis verticillata	Whorled Tickseed (Threadleaf Coreopsis)	30–36"	18–24"	June–Sept	Yellow	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓	X
Coreopsis verticillata 'Moonbeam'	'Moonbeam' Whorled Tickseed (Threadleaf Coreopsis)	18–24"	18–24"	June–Aug	Yellow	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis verticillata 'Zagreb'	'Zagrab' Whorled Tickseed (Threadleaf Coreopsis)	12–18"	12–18"	May–June	Yellow	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis verticillata 'Route 66'	'Route 66' Whorled Tickseed (Threadleaf Coreopsis)	24–28"	24–28"	June–Sept	Yellow, Red	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Coreopsis pubescens	Star Tickseed	9–12"	6–8"	June–Sept	Yellow, Orange	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓	X
Coreopsis pubescens 'Sunshine Superman'	Sunshine Superman Star Tickseed	9–12"	6–8"	June–Sept	Yellow, Orange	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Crocus vernus	Spring Crocus	3–6"	3–6"	April	Purple, White	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Crocus vernus 'Pickwick'	'Pickwick' Spring Crocus	3–6"	3–6"	April	Silver, Lilac	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Echinacea purpurea	Purple Coneflower (Eastern Purple Coneflower)	24–60"	18–24"	June–Aug	Purple, Pink	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	✓	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Echinacea purpurea 'Evening Glow'	'Evening Glow' Purple Coneflower (Eastern Purple Coneflower)	24–36"	12–24"	July–Aug	Purple, Red, White, Yellow	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Echinacea purpurea 'Magnus'	'Magnus' Purple Coneflower (Eastern Purple Coneflower)	30–36"	12–18"	June–Aug	Rose purple	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Echinacea purpurea 'White Swan'	'White Swan' Purple Coneflower (Eastern Purple Coneflower)	24–36"	12–24"	June–Aug	White, Copper, Orrange	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Echinacea purpurea 'Ruby Star'	'Ruby Star' Purple Coneflower (Eastern Purple Coneflower)	24–36"	18–24"	July–Aug	Purple	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Echinacea purpurea 'Green Envy'	'Green Envy' Purple Coneflower (Eastern Purple Coneflower)	24–36"	18–24"	July–Aug	Green, Purple	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	X	X	X
Eupatorium coelestinum	Mistflower	18–36"	18–36"	July–Oct	Blue	X	✓	✓	Lowest–Highest	Full Sun–Part Shade	Low	✓	✓	✓	✓	X	✓	X
Eupatorium (Eutrochium) dubium	Joe Pye Weed	36–48"	12–36"	July–Sept	Pink, White	Red, Gold, Orange	✓	✓	Lowest	Full Sun–Part Shade	Low	X	✓	✓	✓	X	✓	X
Eutrochium dubium 'Little Joe'	'Litte Joe' Pye Weed	36–48"	12–36"	July–Sept	Purple, Pink	Purple, Pink	✓	✓	Lowest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓	X
Eutrochium purpureum	Sweet Joe Pye Weed	60–84"	24–48"	July–Sept	Pink, White	Red, Gold, Orange	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	✓	X
Eutrochium purpureum ssp. Maculatum 'Gateway'	'Gateway' Spotted Joe Pye Weed	48–60"	36–60"	July–Sept	Pink	Pink	X	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X	X
Eutrochium purpureum 'Phantom'	'Phantom' Spotted Joe Pye Weed	24–48"	12–24"	July–Sept	Pink, Red	Pink, Red	X	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)																			
PLANT NAME		CHARACTERISTICS							ENVIRONMENTAL TOLERANCES			APPLICABLE BMP TYPE							
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Eutrochium purpureum 'Purple Bush'	'Purple Bush' Spotted Joe Pye Weed (Sweet Joe Pye Weed)	60–84"	24–48"	July–Sept	Purple, Pink	Purple, Pink	X	✓	Lowest–Highest	Full Sun–Part Shade	High	X	✓	✓	✓	X	X	X
Eurybia (Aster divaricatus) divaricata	White Wood Aster	12–30"	12–30"	Aug–Sept	White, Yellow, Red	Green	✓	✓	Highest	Part Shade–Full Shade	Medium	X	X	X	✓	✓	✓	X
Eurybia divaricata 'Eastern Star'	'Eastern Star' White Wood Aster	12–18"	12–18"	Aug–Sept	White	White	X	✓	Highest	Part Shade–Full Shade	Low	X	X	X	✓	✓	X	X
Galanthus nivalis	Snowdrop	6–9"	3–6"	February	White	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X	X
Geranium macrorrhizum	Bigroot Geranium	12–18"	12–24"	May–June	Violet, White, Pink	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X	X
Geranium macrorrhizum 'Bevan's Variety'	'Bevan's Variety' Bigroot Geranium	9–12"	18–24"	Apr–July	Magenta, Red	Red, Bronze	X	✓	Highest	Full Sun–Full Shade	Low	X	X	X	✓	✓	X	X
Geranium macrorrhizum 'Ingwersen's Variety'	'Ingwersen's Variety' Bigroot Geranium	12–18"	15"	Apr–July	Pink	Red, Purple	X	✓	Highest	Full Sun–Full Shade	Low	X	X	X	✓	✓	X	X
Geranium maculatum 'Album'	'Album' Wild Geranium (Spotted Geranium, Cranesbill)	12–24"	12–24"	Mar–July	White, Purple, Pink	X	X	✓	Highest	Part Shade–Full Shade	High	X	X	X	✓	✓	X	X
Helleborus niger	Hellebore (Christmas Rose)	9–12"	12–18"	Feb–Mar	White, Pink	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Hemercallis (Lilium) spp.	Daylily	12–36"	12–24"	May–Sept	Yellow, Orange, Red	X	X	✓	Highest	Part Shade	Low	X	X	X	✓	✓	X	X
Heuchera americana	Coral Bells (American alumroot)	18"	18"	June–Sept	White	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)																				
Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type								
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Heuchera americana 'Dale's Strain'	'Dale's Strain' Coral Bells	18"	18"	June–Sept	White	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Heuchera americana 'Green Spice'	'Green Spice' Coral Bells	18"	18"	June–Sept	White	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Heuchera americana 'Marvelous Marble'	'Marvelous Marble' Coral Bells	8–12"	12"	May–Aug	Green, Purple	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	X
Hibiscus coccineus	Scarlet Rose Hibiscus / Mallow	36–72"	24–36"	June–Sept	Red	X	✓	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X
Hibiscus moscheutos	Hardy Hibiscus (Swamp Rose Mallow)	24–36"	12–24"	July–Sept	Red, Pink, White	X	✓	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X
Hibiscus moscheutos 'Cranberry Crush'	'Cranberry Crush' Hardy Hibiscus (Swamp Rose Mallow)	36–48"	36–48"	July–Sept	Red	X	X	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X	X
Hibiscus moscheutos 'Luna Red'	'Luna Red' Hardy Hibiscus (Swamp Rose Mallow)	24–36"	18–24"	July–Sept	Burgundy Red	X	X	✓	Lowest	Full Sun	High	✓	✓	✓	✓	X	X	X
Iris versicolor	Blue Flag (Northern Blue Flag) Iris	24–30"	24–30"	May–July	Purple, Blue	X	✓	✓	Inflow, Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X
Leucanthemum sp.	Shasta Daisy	36–48"	24–36"	July–Sept	White	X	X	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	X	X
Liatris spicata	Blazing Star	24–48"	9–18"	July–Sept	Red, Purple	X	✓	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	✓	X
Liatris spicata 'Kobold'	'Kobold' Blazing Star	24–30"	6–12"	July–Aug	Purple	X	X	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Liatris spicata 'Gayfeather'	'Gayfeather' Blazing Star	36–60"	24"	July–Aug	Purple, Pink	X	X	✓	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X	X
Monarda bradburiana	Eastern Bee Balm	12–24"	12–24"	May	Purple, Pink, White	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	X
Monarda didyma	Bee Balm (Bergamot, Oswego Tea)	24–48"	24–36"	July–Aug	Red	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	X
Monarda didyma 'Coral Reef'	'Coral Reef' Bee Balm	24–30"	36"	July–Aug	Coral-Pink	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Monarda didyma 'Jacob Cline'	'Jacob Cline' Bee Balm	36–60"	24"	July–Aug	Red	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Monarda didyma 'Marshall's Delight'	'Marshall's Delight' Bee Balm	24–48"	24"	July–Aug	Rose-Pink	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	✓	✓	X
Monarda fistulosa	Wild Bergamot	24–48"	24–36"	July–Sept	Pink, Lavender	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓		✓	X
Narcissus minor	Trumpet Daffodil	4–5"	3–6"	Mar–Apr	Yellow	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X	X
Packera aurea	Golden Ragwort (Golden Groundsel, Squaw Weed)	6–30"	6–18"	April	Yellow	X	✓	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	✓	X
Packera obovata	Groundleaf Groundsel	12–18"	6–12"	Apr–June	Yellow	X	✓	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	✓	✓	X
Penstemon digitalis	Beardtongue (Foxglove)	36–60"	18–24"	Apr–June	White	Red, Gold, Orange	✓	✓	Highest	Full Sun	Low	X	X	X	✓	✓	✓	X
Penstemon digitalis 'Husker Red'	'Husker Red' Beardtongue (Foxglove)	24–36"	12–24"	Apr–June	White, Pink	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	✓	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)																			
Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type							
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Penstemon digitalis 'Pocahontas'	'Pocahontas' Beardtongue (Foxglove)	36–48"	24–36"	Apr–June	Lavender Pink, Burgundy	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	✓	X	X
Penstemon digitalis 'Dark Towers'	'Dark Towers' Beardtongue (Foxglove)	18–36"	12–24"	May–June	Pink, Red	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	✓	✓	X
Perovskia atriplicifolia	Russian Sage	36–60"	24–48"	July–Oct	Lavender, Blue	Silver, Blue	X	✓	Highest	Full Sun	Low	X	X	X	✓	✓	X	X
Phlox paniculata	Garden Phlox	24–48"	24–36"	July–Sept	Pink, Purple, White	X	✓	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	✓	X
Phlox paniculata 'David'	'David' Garden Phlox	36–48"	24–36"	July–Sept	White	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Phlox paniculata 'David's Lavendar'	'David's Lavendar' Garden Phlox	36–48"	24–36"	July–Sept	Lavender	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Phlox paniculata 'Jeana'	'Jeana' Garden Phlox	48–60"	24–36"	Aug–Oct	Pink	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Phlox paniculata 'Blue Paradise'	'Blue Paradise' Garden Phlox	24-36"	24"	July–Aug	Violet-Blue	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Phlox paniculata 'Zenith'	'Zenith' Garden Phlox	24-36"	24"	July–Aug	Pink, White	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Phlox paniculata 'Wanda'	'Wanda' Garden Phlox	24-36"	24"	July–Aug	Pink	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Physostegia virginiana	Obedient Plant	36–48"	24–36"	June–Sept	Pink, White	X	✓	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Physostegia virginiana 'Pink Manners'	'Pink Mannars' Obedient Plant	24–36"	18–24"	June–Sept	Pink	X	X	✓	Lowest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	X	X
Physostegia virginiana 'Vivid'	'Vivid' Obedient Plant	12–24"	12–18"	June–Sept	Pink	X	X	✓	Lowest	Full Sun	High	✓	✓	✓	✓	X	X	X
Physostegia virginiana 'Miss Manners'	'Miss Manners' Obedient Plant	24–30"	24–30"	June–Sept	White	X		✓	Lowest	Full Sun	High	✓	✓	✓	✓	X	X	X
Pycnanthemum muticum	Mountain Mint (Short-toothed Mountain Mint, Clustered Mountain Mint)	12–36"	12–36"	July–Sept	Pink	X	✓	✓	Lowest–Highest	Full Sun–Part Shade	High	✓	✓	✓	✓	X	✓	X
Rudbeckia fulgida	Black-eyed Susan (Orange Coneflower)	24–36"	24–30"	June–Oct	Yellow, Orange	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Rudbeckia hirta	Black-eyed Susan (Gloriosa Daisy)	24–36"	12–24"	June–Sept	Yellow, Orange	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Rudbeckia subtomentosa	Sweet Coneflower	36–60"	12–24"	July–Oct	Yellow, Orange	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Rudbeckia triloba	Brown-eyed Susan	24–36"	12–18"	July–Oct	Yellow	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Salvia nemorosa	Sage	12–36"	12–36"	June–Sept	Violet-Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Salvia nemorosa 'Caradonna'	'Caradonna' Sage (May Night Sage)	12–24"	12–24"	June–Sept	Violet-Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Salvia nemorosa 'Blue Hill'	'Blue Hill' Garden Sage (Blauhügel)	18–30"	12–15"	June–Aug	Violet-Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)																			
Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type							
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Salvia nemorosa 'May Night'	May Night Garden Sage (Mainacht)	18–24"	12"	July–Sept	Violet-Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Salvia nemorosa 'April Night'	'April Night' Garden Sage	12–14"	18–20"	June–Sept	Purple, Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Sedum rupestre	Stonecrop (Sedum)	6–10"	8–12"	May–Oct	Chartreuse, Gold, Yellow	Orange, Red	✓	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Sedum rupestre 'Angelina'	'Angelina' Stonecrop (Sedum)	6–10"	8–12"	May–Oct	Chartreuse, Gold, Yellow	Orange, Red	X	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Sedum ternatum	Three-leaved Stonecrop (Sedum)	3–6"	6–9"	May–June	White	Copper, Green	✓	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	X	✓
Sedum ternatum 'Larinem Park'	Three-leaved Stonecrop (Shale Barrens, Whorled Sedum)	2–6"	12–18"	Apr–May	White	Copper, Green	X	X	Highest	Full Sun–Part Shade	High	X	X	X	✓	X	X	✓
Sedum x 'Autumn Joy'	'Autumn Joy' Stonecrop (Sedum)	12–18"	24–36"	Apr–June	Pink	Copper, Red	X	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Sedum x 'Autumn Fire'	'Autumn Fire' Stonecrop (Sedum)	24–36"	24"	August	Rose-Pink	Bronze, Red	X	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Sedum x 'Dynamite'	'Dynamite' Stonecrop (Sedum)	24–36"	24"	August	Rose-Pink	Bronze, Red	X	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Sedum x 'Cherry Chocolate'	'Cherry Chocolate' Stonecrop (Sedum)	24–36"	24"	August	Rose-Pink	Bronze, Red	X	X	Highest	Full Sun	High	X	X	X	✓	X	X	✓
Solidago rugosa	Roughleaf Goldenrod (Wrinkleleaf goldenrod, Roughstem goldenrod)	36–72'	36–72'	September	Yellow	X	✓	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	✓	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Solidago rugosa 'Fireworks'	'Fireworks' Rough Goldenrod	30–36"	30-36"	Sept–Oct	Yellow	X	X	✓	Lowest–Highest	Full Sun	High	✓	✓	✓	✓	X	X	X
Solidago sphacelata	Goldenrod (Autumn Goldenrod)	12–18"	12–18"	Aug–Sept	Yellow	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓	X
Solidago sphacelata 'Golden Fleece'	'Golden Fleece' Goldenrod (Autumn Goldenrod)	18-24"	24–36"	Aug–Sept	Gold, Yellow	X	X	✓	Highest	Full Sun–Part Shade	High	X	X	X	✓	✓	X	X
Solidago sphacelata 'Little Lemon'	'Little Lemon' Goldenrod (Autumn Goldenrod)	12–18"	18–24"	Aug–Sept	Yellow	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Symphyotrichum cordifolium (cordifolius)	Blue Wood Aster (Heart-leaved Aster)	24–60"	18–24"	Aug–Sept	Blue, Yellow	X	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓	X
Symphyotrichum cordifolium (cordifolius) 'Avondale'	'Avondale' Blue Wood Aster	24–36"	18–24"	Aug–Oct	Light Blue	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X	X
Symphyotrichum laeve (laevis)	Smooth Aster	24–48"	12–24"	Sept–Oct	Violet, White, Yellow	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Symphyotrichum laeve (laevis) 'Bluebird'	'Bluebird' Smooth Aster	18–36"	24–30"	Sept–Oct	Violet, Yellow	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Symphyotrichum novae-angliae	New England Aster	36–72"	24–36"	Aug–Sept	Purple	X	✓	✓	Highest	Full Sun	Low	X	X	X	✓	X	✓	X
Symphyotrichum novae-angliae 'Purple Dome'	'Purple Dome' New England Aster	18–24"	24–36"	Aug–Sept	Dark Purple	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Symphyotrichum novi-angilae 'Woods Purple'	'Wood Purple' New York Aster (Michaelmas Daisy)	36–60"	36"	Aug–Oct	Light Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X

TABLE D–5. HERBACEOUS – FLOWERS (CONT.)

Plant Name		Characteristics							Environmental Tolerances			Applicable BMP Type						
Botanical Name	Common Name	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Zone Elevation	Light Requirements	Soil Salinity Tolerance	Corner Bumpout	Midblock Bumpout	Sidewalk Planter	Rain Garden	Tree Pit/Trench	Naturalized Basin	Green Roof
Symphyotrichum novi-belgii	New York Aster	36–48"	36–48"	Aug–Oct	Lavender	X	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓	X
Symphyotrichum oblongifolium	Aromatic Aster	12–36"	12–36"	Aug–Sept	Purple, Blue	X	✓	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	✓	X
Symphyotrichum oblongifolium 'Raydon's Favorite'	'Raydon's Favorite' Aromatic Aster	24–36"	12"	Sept–Nov	Lavender	X	X	✓	Highest	Full Sun–Part Shade	Low	X	X	X	✓	✓	X	X
Symphyotrichum oblongifolium 'October Skies'	'October Skies' Aromatic Aster	18–24"	18–24"	Aug–Oct	Blue, Violet-Blue	X	X	✓	Highest	Full Sun	Low	X	X	X	✓	X	X	X
Thermopsis villosa (caroliniana)	Carolina Lupine (Aaron's rod)	36–60"	24–36"	July	Yellow	X	✓	✓	Highest	Full Sun	High	X	X	X	✓	X	✓	X
Vernonia fasciculata	Prairie Ironweed (Smooth Ironweed)	24–48"	18–36"	July–Sept	Purple	X	✓	✓	Lowest	Full Sun	High	X	X	X	✓	X	✓	X
Vernonia lettermanii 'Iron Butterfly'	'Iron Butterfly' Ironweed	30–36"	30–36"	Aug–Oct	Purple	X	X	✓	Highest	Full Sun	High	X	X	X	✓	X	X	X
Vernonia noveboracensis	New York Ironweed	48–72"	36–48"	Aug–Sept	Purple	X	✓	✓	Lowest	Full Sun	High	X	✓	✓	✓	X	✓	X
Veronica spicata	Spiked Speedwell	24–36"	24–30"	June–Aug	Blue	X	X	✓	Highest	Full Sun	Medium	X	X	X	✓	X	X	X
Veronica spicata 'Glory'	'Glory' Spiked Speedwell	9–12"	6–9"	June–Aug	Dark Violet-Blue	X	X	✓	Highest	Full Sun	Medium	X	X	X	✓	X	X	X
Veronica spicata 'Rotfuchs'	'Rotfuchs' Spiked Speedwell	12–18"	12–18"	June–Aug	Pink, Red	X	X	✓	Highest	Full Sun	Medium	X	X	X	✓	X	X	X
Veronica spicata 'Noah Williams'	'Noah Williams' Speedwell	18–24"	18–24"	June–Aug	White	X	X	✓	Highest	Full Sun	Medium	X	X	X	✓	X	X	X

TABLE D–6. WETLAND PLANTS

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Acorus americanus	Sweetflag	Herbaceous–Broadleaf	24–48"	12"	Apr–June	Green-Yellow	X	✓	✓	Permanently Saturated	FACU	Full Sun–Part Shade	Low	5.6–7.2	✓	✓
Alisma subcordata	Water Plantain	Herbaceous–Broadleaf	36"	24"	June–Oct	White	X	✓	✓	0–6" of Inundation	OBL	Full Sun	Low	5.0–7.0	✓	✓
Caltha palustris	Marsh Marigold	Herbaceous–Broadleaf	12"	12"	May	Yellow	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Shade–Part Shade	Low	4.9–6.8	✓	✓
Carex comosa	Bristly Sedge	Herbaceous–Grass	24–48"	18–36"	May–July	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	Low	4.6–7.5	✓	✓
Carex crinita	Fringed Sedge	Herbaceous–Grass	36–48"	12–24"	May–June	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	Low	4.0–7.6	✓	✓
Carex hystericina	Porcupine Sedge	Herbaceous–Grass	24–36"	24–36"	June–Aug	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	Moderate	--	✓	✓
Carex intumescens	Bladdar Sedge	Herbaceous–Grass	12–24"	12–18"	June–Aug	White	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	FACW	Part Shade–Full Shade	Low	4.8–6.9	✓	✓

Appendix D

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Carex lacustris	Lake Bank Sedge	Herbaceous–Grass	12–24"	12–18"	May	Brown	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Full Shade	Low	5.6–6.8	✓	✓
Carex lupulina	Hop Sedge	Herbaceous–Grass	36–48"	12–24"	June–Aug	Green	X	✓	✓	0–6" of Inundation, Permanently Saturated	FACW+	Full Sun–Full Shade	Low	6.2–7.0	✓	✓
Carex lurida	Lurid Sedge	Herbaceous–Grass	24–36"	24–36"	Mar–May	White	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Part Shade–Full Sun	Low	4.9–6.8	✓	✓
Carex scoparia	Pointed Broom Sedge	Herbaceous–Grass	12–30"	12–24"	June–Aug	Yellow	X	✓	✓	0–6" of Inundation, Permanently Saturated	FACW	Full Sun–Part Shade	Low	4.6–6.9	✓	✓
Carex stricta	Tussock Sedge	Herbaceous–Grass	12-24"	12-24"	May	Silver	Light brown	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	Low	3.0–7.0	✓	✓
Carex vulpinodes	Fox Sedge	Herbaceous–Grass	12–24"	12–24"	July–Aug	White	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Part Sun	Moderate	6.8–8.9	✓	✓
Glyceria striata	Fowl Managrass	Herbaceous–Grass	24-42"	24-36"	June–July	Green	Light brown	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Full Shade	Low	4.0–8.0	✓	✓

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Hisbiscus mosheutos	Swamp Rose-mallow	Herbaceous–Broadleaf	48–72"	48–72"	July–Aug	Pink, White	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun	Low	4.0–7.0	✓	✓
Iris prismatica	Blue Iris	Herbaceous–Broadleaf	12–36"	12–24"	May–July	Blue-Purple	X	✓	✓	Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	Moderate	<6.8	✓	✓
Iris versicolor	Blue Flag Iris	Herbaceous–Broadleaf	24–30"	24–30"	May–June	Blue-Purple	X	✓	✓	Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	High	<6.8	✓	✓
Juncus effusus	Soft Rush	Herbaceous–Grass	24-48"	24-48"	June–Aug	Brown	Yellow, Brown	✓	✓	0–6" of Inundation, Permanently Saturated	FACW+, OBL	Full Sun–Part Shade	High	5.5–8.0	✓	✓
Justica americana	Water Willow	Herbaceous–Broadleaf	12-24"	12-24"	June–Sept	Pink, White	Yellow	✓	✓	6–12" of Inundation, 0–6" of Inundation, Permanently Saturated	OBL	Full Sun	Low	5.4–7.6	✓	✓
Leersia oryzoides	Rice Cut Grass	Herbaceous–Grass	36–72"	36–48"	June–Oct	Green	X	✓	✓	6–12" of Inundation, 0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	Low	5.1–8.8	✓	✓
Lobelia cardinalis	Cardinal Flower	Herbaceous–Broadleaf	24-48"	12-24"	May–Oct	Red	Burgundy	✓	✓	Permanently Saturated, Seasonally Saturated	FACW+	Full Sun–Part Shade	Moderate	5.8–7.8	✓	✓

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Lobelia syphilitica	Great Blue Lobelia	Herbaceous–Broadleaf	24–48"	12–24"	July–Oct	Blue	X	✓	✓	Permanently Saturated, Seasonally Saturated	FACW+	Full Sun–Part Shade	Moderate	6.0–8.0	✓	✓
Ludwigia palustris	Marsh Purslane	Herbaceous–Broadleaf	6"	12"	July–Sept	Green	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun	Low	5.0–8.5	✓	✓
Mimulus ringens	Monkey Flower	Herbaceous–Broadleaf	24–48"	6–12"	July–Sept	Blue	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	Moderate	6.5–7.5	✓	✓
Nelumbo lutea	Native Yellow Waterlily	Herbaceous–Broadleaf	36–72"	36–48"	June–July	Yellow	X	✓	✓	1–6' of Inundation	OBL	Full Sun	Low	5.5–8.2	✓	✓
Nuphar lutea	Spatterdock	Herbaceous–Broadleaf	18"	18"	May–Oct	Yellow	X	✓	✓	1–6' of Inundation	OBL	Full Sun–Part Shade	Low	--	✓	✓
Nymphaea odorata	Native White Waterlily	Herbaceous–Broadleaf		60–84"	Mar–Oct	White	X	✓	✓	1–6' of Inundation	OBL	Full Sun	Low	--	✓	✓
Orontium aquaticum	Golden Club	Herbaceous–Broadleaf	12–24"	18–24"	Apr–June	White	X	✓	✓	1–6' of Inundation, 6–12" of Inundation	OBL	Full Sun–Part Shade	Low	6.0–6.8	✓	✓
Osmunda regalis	Royal Fern	Herbaceous–Broadleaf	24–36"	24–36"	N/A	N/A	X	✓	✓	Permanently Saturated	OBL	Full Shade–Part Shade	None	4.0–6.0	✓	✓

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Peltandra virginica	Arrow Arum	Herbaceous–Broadleaf	18–24"	18–24"	Apr–June	Green-White	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	None	5.0–8.8	✓	✓
Pontederia cordata	Pickerelweed	Herbaceous–Broadleaf	24–48"	18–24"	June–Oct	Purple	X	✓	✓	Permanently Saturated, Seasonally Saturated	OBL	Full Sun	Low	4.9–8.7	✓	✓
Rosa palustris	Swamp Rose	Deciduous shrub	3-6'	3-6'	June–July	Pink	Red, Orange	✓	✓	Permanently Saturated	OBL	Full Sun	None	4.0–7.0	✓	✓
Sagittaria latifolia	Duck Potato	Herbaceous–Broadleaf	12–48"	12–36"	July–Sept	White	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	None	4.7–8.9	✓	✓
Saururus cernuus	Lizard's Tail	Herbaceous–Broadleaf	12"–24"	12"–24"	June–Sept	White	X	✓	✓	6–12" of Inundation, 0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	None	6.0–6.8	✓	✓
Scirpus cyperinus	Woolgrass	Herbaceous–Grass	36–60"	24–48"	June–July	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	None	4.8–7.2	✓	✓
Scirpus atrovirens	Green Bulrush	Herbaceous–Grass	48–60"	36–48"	June–July	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun	None	4.0–8.0	✓	✓

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Bolboschoenus fluviatilis	River Bulrush	Herbaceous–Grass	36–72"	24–48"	June–July	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	None	--	✓	✓
Schoenoplectus acutus	Hardstem Bulush	Herbaceous–Grass	72"	24–36"	Apr–May	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun	Low	5.2–8.5	✓	✓
Schoenoplectus tabernaemontani	Softstem Bulrush	Herbaceous–Grass	48–96"	36–48"	May–Sept	N/A	X	✓	✓	0–6" of Inundation, Permanently Saturated	OBL	Full Sun	Low	5.4–7.5	✓	✓
Sparganium eurycarpum	Greater Bur-reed	Herbaceous–Broadleaf	24–84"	24–36"	June–July	Green	X	✓	✓	1–6' of Inundation, 0–6" of Inundation, Permanently Saturated	OBL	Full Sun–Part Shade	None	5.0–8.5	✓	✓
Symphyotrichum puniceum	Purple-stemmed Aster	Herbaceous–Broadleaf	72–96"	24–36"	Aug–Sept	Purple	X	✓	✓	Permanently Saturated, Seasonally Saturated	OBL	Full Sun	None	4.5–7.5	✓	✓
Typha latifolia	Broadleaf Cattail	Herbaceous–Broadleaf	48–72"	48–72"	June–July	Green-Yellow	X	✓	✓	1–6' of Inundation, 6–12" of Inundation, 0-6" of Inundation, Permanently Saturated, Seasonally Saturated	OBL	Full Sun–Part Shade	Low	5.5–8.7	✓	✓

TABLE D–6. WETLAND PLANTS (CONT.)

Plant Name		Characteristics								Environmental Tolerances					Applicable Naturalized Basin Type	
Botanical Name	Common Name	Plant Type	Height	Width	Bloom Time	Bloom Color	Fall Leaf Color	Native to US/Nativar	Wildlife Value	Hydrologic Condition	Wetland Indicator Status	Light Requirements	Water/Soil Salinity Tolerance	pH Tolerance	Wet Pond	Stormwater Wetland
Verbena hastata	Blue Vervain	Herbaceous–Broadleaf	24–72"	12–30"	June–Sept	Purple	X	✓	✓	Seasonally Saturated	FACW	Full Sun	None	6.5–7.0	✓	✓
Zizania aquatica	Wild Rice	Herbaceous–Grass	36–120"	36–48"	June–Aug	Green	X	✓	✓	1–6' of Inundation, 0–6" of Inundation, Permanently Saturated	OBL	Full Sun	Low	6.4–7.4	✓	✓
Zizia aurea	Golden Alexander	Herbaceous–Broadleaf	18–36"	18–24"	May–June	Yellow	X	✓	✓	Seasonally Saturated	FAC	Full Sun–Part Shade	Moderate	7.0–8.5	✓	✓

APPENDIX E – STORMWATER MANAGEMENT ORDINANCE

Chapter 260

STORMWATER MANAGEMENT

GENERAL REFERENCES

Planning Commission — See Ch. 22. Art. VI.

Building construction and floodplain management — See Ch. 109.

Construction codes — See Ch. 116.

Sewers — See Ch. 249.

Stormwater management fee — See Ch. 261.

Subdivision and land development — See Ch. 265.

Water — See Ch. 295.

Zoning — See Ch. 300.

ARTICLE I
General Provisions

§ 260-101. Short title.

This chapter shall be known and may be cited as the "The City of Lancaster Stormwater Management (SWM) Ordinance."

§ 260-102. Statement of findings.

The Lancaster City Council finds that:

A. Inadequate management of accelerated stormwater runoff resulting from development throughout a watershed increases flood flows and velocities, contributes to erosion and sedimentation, overtaxes the carrying capacity of existing streams and storm sewers, greatly increases the cost of public facilities to convey and manage stormwater, undermines floodplain management and flood reduction efforts in upstream and downstream communities, reduces groundwater recharge, and threatens public health and safety.

B. A comprehensive program of stormwater management, including reasonable regulation of development and activities causing accelerated erosion, is fundamental to the public health, safety, welfare, and the protection of the people of the City of Lancaster and all the people of the commonwealth, their resources, and the environment.

C. Stormwater is an important water resource, which provides groundwater recharge for water supplies and base flow of streams, which also protects and maintains surface water quality.

D. Federal and state regulations require certain cities to implement a program of stormwater controls. These cities are required to obtain a permit for stormwater discharges from their municipal separate storm sewer systems (MS4) under the National Pollutant Discharge Elimination System (NPDES).

E. Riparian forest buffers enhance water quality by filtering pollutants in runoff, providing light control and temperature moderation, processing pollutants, increasing infiltration and providing channel and shoreline stability thus decreasing erosion (DEP Riparian Forest Buffer Guidance, November 27, 2010).

F. Much of the City is served by a combined sewer system that collects and transports both domestic sewage and rainwater that flows from impervious surfaces such as roofs, streets, and parking lots. The City's Advanced Wastewater Treatment Facility is normally able to manage and clean the volume of wastewater flowing through the combined sewer system; however, during intense rainstorms and other wet weather events, the system becomes overwhelmed, causing untreated wastewater to overflow into the Conestoga River. These events are referred to as "combined sewer overflows."

§ 260-103. Purpose.

The purpose of this chapter is to promote health, safety, and welfare within the City of Lancaster by minimizing the damages described in § 260-102 of this chapter through provisions designed to:

A. Manage accelerated runoff and erosion and sedimentation problems at their source by regulating activities that cause these problems.

B. Utilize and preserve the existing natural drainage systems.

C. Encourage recharge of groundwater where appropriate and prevent degradation of groundwater quality.

D. Maintain existing flows and quality of streams, watercourses and water conveyance facilities in the City of Lancaster and the commonwealth.

E. Preserve and restore the flood-carrying capacity of streams.

F. Provide proper operation and maintenance of all stormwater management best management practices (SWM BMPs) that are Implemented within the City.

G. Provide performance standards and design criteria for watershed-wide stormwater management and planning.

H. Meet legal water quality requirements under state law, including regulations at 25 Pa. Code Chapter 93 to protect, maintain, reclaim, and restore the existing and designated uses of the waters of the commonwealth.

I. Prevent scour and erosion of stream banks and streambeds.

J. Provide standards to meet NPDES permit requirements.

K. Help preserve and protect exceptional natural resources, and conserve and restore natural resource systems.

L. Promote stormwater management practices that emphasize infiltration, evaporation, and transpiration.

M. Reduce combined sewer overflows.

§ 260-104. Statutory authority.

A. Primary authority. The City of Lancaster is empowered to regulate land use activities that affect runoff by the authority of the Act of October 4, 1978, P.L. 864 (Act 167), 32 P.S. § 680.1 et seq., as amended, the Storm Water Management Act; the Pennsylvania Flood Plain Management Act;[1] and the Federal Clean Water Act (33 U.S.C. § 1342, 40 CFR 122.26 through 123.35).

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1. Editor's Note: See 32 P.S. § 679.101 et seq.

B. Secondary authority. The City also is empowered to regulate land use activities that affect runoff by the authority of the Act of July 31, 1968, P.L. 805, No. 247, the Pennsylvania Municipalities Planning Code (MPC),[2] as amended.

§ 260-105. Applicability.

A. This chapter shall apply to all development and land disturbance within all watershed areas of the City of Lancaster, as delineated on the City of Lancaster Watersheds Map, Appendix A.[3] [Note: The City of Lancaster is located within the following watersheds: Little Conestoga; Conestoga; Mill Creek.]

B. This chapter shall apply to permanent stormwater management facilities constructed as part of any of the regulated activities listed in this section and to stormwater management and erosion and sediment control during construction activities.

C. Refer to current E&S and NPDES requirements in Appendix E.[4]

D. The following activities are identified as "regulated activities" and shall be regulated by this chapter unless shown as exempt under § 260-502:

(1) Land disturbance.

(2) Land development.

(3) Subdivision.

(4) Construction of new or additional impervious or semipervious surfaces (driveways, parking lots, etc.).

(5) Construction of new buildings or additions to existing buildings.

(6) Diversion or piping of any natural or man-made stream channel.

(7) Installation of stormwater management facilities or appurtenances thereto.

§ 260-106. Repealer; continuation of prior regulations.

A. Except as otherwise required by law, this chapter is intended as a continuation of, and not a repeal of, existing regulations governing the subject matter. To the extent that this chapter restates regulations contained in ordinances previously enacted by the City of Lancaster, this chapter shall be considered a restatement and not a repeal of such regulations. It is the specific intent of the City of Lancaster that all provisions of this chapter shall be considered in full force and effect as of the date such regulations were initially enacted. All ordinances

2. Editor's Note: See 53 P.S. § 10101 et seq.

3. Editor's Note: Appendix A is included as an attachment to this chapter.

4. Editor's Note: Appendix E is included as an attachment to this chapter.

or parts of ordinances inconsistent with the provisions of this chapter are hereby repealed. It is expressly provided that the provisions of this chapter shall not affect any act done, contract executed or liability incurred prior to its effective date, or affect any suit or prosecution pending or to be instituted to enforce any rights, rule, regulation or ordinance, or part thereof, or to punish any violation which occurred under any prior stormwater regulation or ordinance. In the event any violation has occurred under any prior stormwater regulation or ordinance of the City of Lancaster, prosecution may be initiated against the alleged offender pursuant to the provisions of said prior stormwater regulation or ordinance, and the provisions and penalties provided in said prior stormwater regulation or ordinance shall remain effective as to said violation.

B. Any plan (hereinafter defined) pending at the time of the effective date of this chapter shall be allowed to proceed with revisions, finalization and implementation in accordance with any ordinance in effect prior hereto. Any subdivision and land development plan filed pursuant to the provisions of the Pennsylvania Municipalities Planning Code where there is not a prior stormwater management ordinance in effect may proceed with development in accordance with the filing at the time of the effective date of this chapter.

§ 260-107. Severability.

Should any section, provision or part thereof of this chapter be declared invalid by a court of competent jurisdiction, such decision shall not affect the validity of any of the remaining provisions of this chapter.

§ 260-108. Compatibility with other ordinance requirements.

A. Approvals issued pursuant to this chapter do not relieve the applicant of the responsibility to secure required permits or approvals for activities regulated by any other applicable law, regulation, code, rule, act, or ordinance.

B. All improvements required by this chapter shall be designed and constructed in conformance with this chapter and the ordinances for the City of Lancaster and the technical standards set forth in the "Construction Specifications and Guidelines Manual of the City of Lancaster," which standards and guidelines are incorporated herein by reference as if fully set forth, unless the appropriate City official with authority to review the proposed construction designates an alternative method or standard. Except as specifically provided for in this chapter, nothing contained in this chapter shall be construed to affect the other ordinances of the City of Lancaster. The "Construction Specifications and Guidelines Manual of the City of Lancaster" is on file in the office of the City Clerk and the City Department of Economic and Community Development, Bureau of Planning, where copies are available for public examination.

C. In their interpretation and application, the provisions of this chapter shall be held to be minimum requirements, adopted for the promotion of the public health, safety and general welfare. Whenever the requirements of this chapter are at variance with the requirements of any other lawfully adopted laws, acts, rules, regulations, ordinances, deed restrictions or covenants, the most restrictive or that imposing the highest standards shall govern.

§ 260-109. Erroneous permit.

Any permit or authorization issued or approved based on false, misleading or erroneous information provided by an applicant is void without the necessity of any proceedings for revocation. Any work undertaken or use established pursuant to such permit or other authorization is unlawful and shall be enforced in accordance with Article IX, Enforcement and Penalties. No action may be taken by a board, agency or employee of the City purporting to validate such a violation.

§ 260-110. City liability.

Except as specifically provided by the Pennsylvania Storm Water Management Act, Act of October 4, 1978, P.L. 864, No. 167, as amended, 32 P.S. § 680.1 et seq., the making of any administrative decision by the City of Lancaster or any of its officials or employees shall not constitute a representation, guarantee or warranty of any kind by the City of Lancaster of the practicability or safety of any proposed structure or use with respect to damage from erosion, sedimentation, stormwater runoff, flood, or any other matter and shall create no liability upon or give rise to any cause of action against the City of Lancaster and its officials and employees. The City of Lancaster, by enacting and amending this chapter, does not waive or limit any immunity granted to the City of Lancaster and its officials and employees by the Governmental Immunity Act, 42 Pa.C.S.A. § 8541 et seq., and does not assume any liabilities or obligations.

§ 260-111. Duty of persons engaged in the development of land.

Notwithstanding any provision(s) of this chapter, including exemptions, any landowner or any person engaged in the alteration or development of land which may affect stormwater runoff characteristics shall implement such measures as are reasonably necessary to prevent injury to health, safety, or other property. Such measures also shall include actions as are required to manage the rate, volume, direction, and quality of resulting stormwater runoff in a manner which otherwise adequately protects health, safety and welfare.

§ 260-112. Financial security.

A. A financial security (bond, restricted escrow or letter of credit) for stormwater-related improvements shall be supplied by the applicant in conjunction with any subdivision/land development approval, or in conjunction with the SWM site plan approval if no subdivision/land development plan is required, except very small projects, as defined in this chapter, shall be exempt from this requirement.

B. The applicant shall provide a financial security to the City of Lancaster for the timely installation and proper construction of all SWM facilities except for very small projects, as defined herein, including E&S BMPs, as required by the approved SWM site plan and this chapter and, as applicable, in accordance with the provisions of Sections 509, 510, and 511 of the MPC.[5]

C. As the work of installing the required SWM facilities proceeds, the party posting the financial security may request the City of Lancaster to release or authorize the release, from time to time, of such portions of the financial security necessary for payment to the contractor or contractors performing the work. Any such requests shall be in writing addressed to the City of Lancaster, and the City of Lancaster shall have 45 days from receipt of such request within which to allow the City Engineer to certify, in writing, to the City of Lancaster that such portion of the work upon the SWM facilities has been completed in accordance with the approved SWM site plan. Upon such certification the City of Lancaster shall authorize release by the bonding company or lending institution of an amount as estimated by the City Engineer fairly representing the value of the SWM facilities completed. The City of Lancaster may, prior to final release at the time of completion and certification by its engineer, require retention of not more than 15% of the estimated cost of the aforesaid SWM facilities for 18 months.

D. In the event that any SWM facilities which may be required have not been installed as provided in the approved SWM site plan, the Planning Commission of the City of Lancaster is hereby granted the power to enforce any corporate bond or other security by appropriate legal and equitable remedies. If proceeds of such bond or other security are insufficient to pay the cost of installing or making repairs or corrections to all the SWM facilities covered by said security, the Planning Commission of the City of Lancaster may, at its option, install part of such SWM facilities and may institute appropriate legal or equitable action to recover the monies necessary to complete the remainder of the SWM facilities. All of the proceeds, whether resulting from the security or from any legal or equitable action brought against the applicant, or both, shall be used solely for the installation of the SWM facilities covered by such security, and not for any other City purpose.

5. Editor's Note: See 53 P.S. §§ 10509, 10510, and 10511.

ARTICLE II
Definitions of Terms

§ 260-201. Interpretation and word usage.

The language set forth in the text of this chapter shall be interpreted in accordance with the following rules of construction:

A. Words used or defined in one tense or form shall include other tenses or derivative forms.

B. Words in the singular number shall include the plural number, and words in the plural number shall include the singular number.

C. The masculine gender shall include the feminine and neuter. The feminine gender shall include the masculine and neuter. The neuter gender shall include the masculine and feminine.

D. The word "person" includes individuals, firms, partnerships, joint ventures, trusts, trustees, estates, corporations, associations and any other similar entities.

E. The word "lot" includes the words "plot," "tract," and "parcel."

F. The words "shall," "must," and "will" are mandatory in nature and establish an obligation or duty to comply with the particular provision. The words "may" and "should" are permissive.

G. The time within which any act required by this chapter is to be performed shall be computed by excluding the first day and including the last day. However, if the last day is a Saturday or Sunday or a holiday declared by the United States Congress or the Pennsylvania General Assembly, it shall also be excluded. The word "day" shall mean a calendar day, unless otherwise indicated.

H. Any words not defined in this chapter or in Section 107 of the MPC[6] shall be construed as defined in standard dictionary usage.

I. References to officially adopted regulations, standards, or publications of DEP or other governmental agencies shall include the regulation, publication, or standard in effect on the date when a SWM site plan is first filed. It is the intent of the City of Lancaster in enacting this section to incorporate such changes to statutes, regulations, and publications to the extent authorized by 1 Pa.C.S.A. § 1937.

§ 260-202. Definitions of terms.

As used in this chapter, the following terms shall have the meanings indicated:

6. Editor's Note: See 53 P.S. § 10107.

ACCELERATED EROSION — The removal of the surface of the land through the combined action of man's activity and the natural processes at a rate greater than would occur because of the natural process alone.

ACCESS EASEMENT — A right granted by a landowner to a grantee, allowing entry for the purpose of inspecting, maintaining and repairing SWM facilities.

ACT 167 PLAN — A plan prepared under the authority of Pennsylvania's Storm Water Management Act of October 4, 1978.

AGRICULTURAL ACTIVITY — Activities associated with agriculture such as agricultural cultivation, agricultural operation, and animal heavy use areas. This includes the work of producing crops and raising livestock, including tillage, land clearing, plowing, disking, harrowing, planting, harvesting crops, or the pasturing and raising of livestock and installation of conservation practices. Construction of new buildings or impervious areas is not considered an agricultural activity.

ALTERATION — As applied to land, a change in topography as a result of the moving of soil and rock from one location or position to another; also the changing of surface conditions by causing the surface to be more or less impervious; earth disturbance activity.

APPLICANT — A landowner and/or developer, as hereinafter defined, including his heirs, successors and assigns, who has filed an application to the City of Lancaster for approval to engage in any regulated activity at a development site located within the City of Lancaster.

BMP (BEST MANAGEMENT PRACTICE) — Activities, facilities, control measures, planning or procedures used to minimize accelerated erosion and sedimentation and manage stormwater to protect, maintain, reclaim, and restore the quality of waters and the existing and designated uses of waters within this commonwealth before, during and after earth disturbance activities[1].[7] See also "nonstructural BMP" and "structural BMP."

BMP MANUAL — The Pennsylvania Stormwater Best Management Practices Manual of December 2006, or most recent version thereof.

BUILDING — Any structure which is enclosed and isolated by exterior walls and roof, built or used for residential, commercial, industrial or other public or private purposes, including accessory structures. Where the context requires, the word "building" shall be construed as if followed by the words "or part or parts thereof." For the purposes of this chapter, each portion of a structure separated from other portions by a fire wall shall be considered as a separate building. (Per Lancaster City SALDO.)[8]

CARBONATE GEOLOGY — Limestone or dolomite bedrock. Carbonate geology is often associated with karst topography.

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7. Editor's Note: See Art. X, References.

8. Editor's Note: See Ch. 265, Subdivision and Land Development.

CERTIFICATE OF COMPLETION — Documentation verifying that all permanent SWM facilities have been constructed according to the plans and specifications and approved revisions thereto.

CISTERN — A reservoir or tank for storing rainwater.

CITY — The City of Lancaster, Pennsylvania, or its designee.

CITY ENGINEER — A professional engineer registered by the Commonwealth of Pennsylvania and employed or retained by the City and designated as the City Engineer.

CLEAN WATER ACT — Amendments to the Federal Water Pollution Control Act, P.L. 92-500 of 1972, 33 U.S.C. § 1251 et seq.

COMBINED SEWER OVERFLOW — Intermittent overflow or other untreated discharge from a combined sewer system during periods of heavy rainfall.

COMBINED SEWER SYSTEM — A type of sewer system that collects sanitary sewage and stormwater runoff in a single pipe system.

CONSERVATION PLAN — A plan written by an NRCS certified planner that identifies conservation practices and includes site-specific BMPs for agricultural plowing or tilling activities and animal heavy-use areas.

CONSERVATION PRACTICES — Practices installed on agricultural lands to improve farmland, soil and/or water quality which have been identified in a current conservation plan.

CONTRIBUTORY DRAINAGE AREA — The total area that contributes runoff to a given point of discharge.

CONVEYANCE — (n) Any structure that carries a flow. (v) The ability of a pipe, culvert, swale or similar facility to carry the peak flow from the design storm.

CULVERT — A structure with appurtenant works which can convey a stream under or through an embankment or fill.

DEP (also PA DEP or PADEP) — The Pennsylvania Department of Environmental Protection or any agency successor to the Pennsylvania Department of Environmental Protection.

DESIGN STORM — The magnitude and temporal distribution of precipitation from a storm event measured in probability of occurrence (e.g., a five-year storm) and duration (e.g., 24 hours), used in the design and evaluation of SWM systems.

DESIGN STORM DEPTH — The amount of rainfall, based on the Design Storm Method described in § 260-303A, that can be captured and infiltrated in a particular BMP.

DETENTION BASIN — An impoundment structure designed to manage stormwater runoff by temporarily storing the runoff and releasing it at a controlled rate.

DEVELOPER — A person, partnership, association, corporation, or other entity, including governmental or municipal agency or authority, that undertakes any regulated activity of this chapter.

DEVELOPMENT SITE (SITE) — The specific area of land where regulated activities in the City of Lancaster are planned, conducted or maintained.

DIRECTOR — The Director of the Department of Public Works or her or his designee.

DISAPPEARING STREAM — A stream in an area underlain by limestone or dolomite that flows underground for a portion of its length.

DISTURBED AREA — A land area where an earth disturbance activity is occurring or has occurred.

DRAINAGE AREA — See "contributory drainage area."

DRAINAGE EASEMENT — Rights to occupy and use another person's real property for the installation and operation of stormwater management facilities or for the maintenance of natural drainageways to preserve and maintain a channel for the flow of stormwater therein or to safeguard health, safety, property, and facilities.

E&S — Erosion and sediment.

E&S PLAN (also EROSION AND SEDIMENT CONTROL PLAN) — A site-specific plan consisting of both drawings and a narrative that identifies BMPs to minimize accelerated erosion and sedimentation before, during and after earth disturbance activities.

EARTH DISTURBANCE ACTIVITY — A construction or other human activity which disturbs the surface of the land, including, but not limited to, clearing and grubbing; grading; excavations; embankments; land development; agricultural plowing or tilling; operation of animal heavy-use areas; timber-harvesting activities; road maintenance activities; oil and gas activities; well drilling; mineral extraction; building construction; and the moving, depositing, stockpiling, or storing of soil, rock, or earth materials[1].[9]

ENVIRONMENTALLY SENSITIVE AREA — Slopes greater than 15%, shallow bedrock (located within six feet of ground surface[2]),[10] wetlands, natural heritage areas and other areas designated as conservation or preservation in Greenscapes, the green infrastructure element of the County Comprehensive Plan, where encroachment by land development or land disturbance results in degradation of the natural resource.

EROSION — The natural process by which the surface of the land is worn away by water, wind, or chemical action. See also "accelerated erosion," as defined above.

EXISTING CONDITIONS — The dominant land cover during the five-year period immediately preceding a proposed regulated activity.

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9. Editor's Note: See Art. X, References.

10. Editor's Note: See Art. X, References.

Appendix E

FEMA — The Federal Emergency Management Agency.

FLOOD — A general but temporary condition of partial or complete inundation of normally dry land areas from the overflow of streams, rivers, and other waters of the commonwealth.

FLOOD-FRINGE — That portion of the floodplain outside of the floodway[3].[11]

FLOODPLAIN — Any land area susceptible to inundation by water from any natural source or delineated by applicable Department of Homeland Security, Federal Insurance Administration Flood Hazard Boundary - Mapped, as being a special flood hazard area. Also, the area of inundation that functions as a storage or holding area for floodwater to a width required to contain a base flood of which there is a one-percent chance of occurrence in any given year. The floodplain contains both the floodway and the flood-fringe.

FLOOD PLAIN MANAGEMENT ACT — Act of October 4, 1978, P.L. 851, No. 166, as amended 32 P.S. § 679.101 et seq.

FLOODWAY — That portion of the floodplain which is effective in carrying flow, within which this carrying capacity must be preserved and where the flood hazard is generally highest, that is, where water depths and velocities are the greatest. It is that area which provides for the discharge of the base flood so the cumulative increase in water surface elevation is no more than one foot[3]. [12]

FOREST MANAGEMENT/TIMBER OPERATIONS — Planning and activities necessary for the management of forestland. These include conducting a timber inventory and preparation of forest management plans, silvicultural treatment, cutting budgets, logging road design and construction, timber harvesting, site preparation and reforestation.

FREQUENCY — The probability or chance that a given storm event/flood will be equaled or exceeded in a given year.

GARDEN — A plot of ground where herbs, fruits, flowers, or vegetables are cultivated for personal use.

GRADE — A slope, usually of a road, channel or natural ground, specified in percent and shown on plans as specified herein. To grade is to finish the surface of a roadbed, top of embankment or bottom of excavation.

GREEN INFRASTRUCTURE — Small-scale stormwater management practices, nonstructural techniques, and better site planning to mimic natural hydrologic runoff characteristics and minimize the impact of development on water resources.

GROUNDWATER RECHARGE — The process by which water from above the ground surface is added to the saturated zone of an aquifer, either directly or indirectly.

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11. Editor's Note: See Art. X, References.

12. Editor's Note: See Art. X, References.

HYDROLOGIC SOIL GROUP (HSG) — Refers to soils grouped according to their runoff-producing characteristics by NRCS. There are four runoff potential groups ranging from A to D.

A. (Low runoff potential) Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well- to excessively drained sands or gravels. These soils have a high rate of water transmission (greater than 0.30 inch/hour).

B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately well- to well-drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (from 0.15 to 0.30 inch/hour).

C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission (from 0.05 to 0.15 inch/hour).

D. (High runoff potential) Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission (from zero to 0.05 inch/hour).

IMPERVIOUS SURFACE (IMPERVIOUS AREA) — Surface which prevents or limits the infiltration of water into the ground. Any structure, building, parking area, driveway, road, street, sidewalk, patio, deck, and any area of concrete, asphalt, pavement, compacted gravel, packed stone, stone, brick, tile, swimming pool, or artificial turf, and highly compacted soil shall be considered "impervious surface" if they prevent or limit infiltration. Impervious surface also includes any area used by or for motor vehicles or heavy commercial equipment, regardless of surface type or material, including any road, road shoulder, driveway, or parking area.

IMPOUNDMENT — A retention or detention facility designed to retain stormwater runoff and infiltrate it into the ground (in the case of a retention basin) or release it at a controlled rate (in the case of a detention basin).

INFILTRATION STRUCTURES — A structure designed to direct runoff into the ground (e.g., french drains, seepage pits, seepage trench, rain gardens, vegetated swales, pervious paving, infiltration basins, etc.).

INLET — A surface connection to a closed drain. The upstream end of any structure through which water may flow.

INTERMITTENT — A natural, transient body or conveyance of water that exists for a relatively long time but for weeks or months of the year is below the local water table and obtains its flow from both surface runoff and groundwater discharges.

INVASIVE VEGETATION (INVASIVES) — Plants which grow quickly and aggressively, spreading, and displacing other plants. Invasives typically are introduced into a region far from their native habitat. See Invasive Plants in Pennsylvania by the Department of Conservation and Natural Resources.

KARST — A type of topography or landscape characterized by features including but not limited to surface depressions, sinkholes, rock pinnacles/ uneven bedrock surface, underground drainage, and caves. Karst is formed on carbonate rocks, such as limestone or dolomite.

LAND DEVELOPMENT — Any of the following activities:

A. The improvement of one lot or two or more contiguous lots, tracts or parcels of land for any purpose involving:

   (1) A group of two or more residential or nonresidential buildings, whether proposed initially or cumulatively, or a single nonresidential building on a lot or lots regardless of the number of occupants or tenure; or

   (2) The division or allocation of land or space, whether initially or cumulatively, between or among two or more existing or prospective occupants by means of or for the purpose of streets, common areas, leaseholds, condominiums, building groups, or other features.

B. Any subdivision of land.

C. Development in accordance with Section 503(1.1) of the Pennsylvania Municipalities Planning Code.[13]

LAND DISTURBANCE — See "earth disturbance activity."

LANDOWNER — The legal or beneficial owner or owners of land, including the holder of an option or contract to purchase (whether or not such option or contract is subject to any condition), a lessee if he is authorized under the lease to exercise the rights of the landowner, or other person having a proprietary interest in land.

LANDSCAPING — The planting, configuration and maintenance of any combination of trees, ground cover, shrubbery, and other vegetative plant material.

LIMITING ZONE — A rock formation, other stratum, or soil condition which is so slowly permeable that it effectively limits downward passage of effluent[12].[14] Seasonal high water tables, whether perched or regional, also constitute a limiting zone.

LINEAMENT — A linear feature in a landscape which is an expression of an underlying geological structure such as a fault.

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13. Editor's Note: See 53 P.S. § 10503(1.1).

14. Editor's Note: See Art. X, References.

MANNING'S EQUATION — An equation for calculation of velocity of flow (e.g., feet per second) and flow rate (e.g., cubic feet per second) in open channels based upon channel shape, roughness, depth of flow and slope. Manning's Equation assumes steady, gradually varied flow.

MAXIMUM EXTENT PRACTICABLE (MEP) — Applies when the applicant demonstrates to the City of Lancaster's satisfaction that the performance standard is not achievable. The applicant shall take into account the best available technology, cost effectiveness, geographic features, and other competing interests, such as protection of human safety and welfare, protection of endangered and threatened resources, and preservation of historic properties, in making the assertion that the performance standard cannot be met and that a different means of control is appropriate.[5]

MPC — The Pennsylvania Municipalities Planning Code, Act of 1968, P.L. 805, No. 247, as reenacted and amended, 53 P.S. § 10101 et seq.

MUNICIPAL SEPARATE STORM SEWER — A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains), which is all of the following:

A. Owned or operated by a state, city, town, borough, township, county, district, association, or other public body (created under state law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes;

B. Designed or used for collecting or conveying stormwater;

C. Not a combined sewer; and

D. Not part of a publicly owned treatment works as defined at 40 CFR 122.2.

MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4) — All separate storm sewers that are defined as "large" or "medium" or "small" municipal separate storm sewer systems pursuant to 40 CFR 122.26(b)(18), or designated as regulated under 40 CFR 122.26(a)(1)(v).

NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) — The national system for the issuance of permits under Section 402 of the Federal Clean Water Act (33 U.S.C. § 1342), including a state or interstate program which has been approved in whole or in part by the EPA, including the regulations codified in Pa. Code Chapter 92 (relating to National Pollutant Discharge Elimination System permitting, monitoring and compliance)[15] and as specified in Pa. Code Chapter 102.

NATIVE VEGETATION — Plant species that have evolved or are indigenous to a specific geographical area. These plants are adapted to local soil and weather conditions as well as pests and diseases.

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15. Editor’s Note: Former 25 Pa. Code Ch. 92 was repealed effective 10-9-2010. See now 25 Pa. Code Ch. 92a.

NATURAL DRAINAGEWAY — An existing channel for water runoff that was formed by natural processes.

NATURAL GROUND COVER — Ground cover which mimics the infiltration characteristics of predominant hydrologic soil group found at the site.

NONPOINT SOURCE POLLUTION — Any source of water pollution that does not meet the legal definition of "point source" in Section 502(14) of the Clean Water Act.[16]

NONSTRUCTURAL BMPs — Planning and design approaches, operational and/or behavior-related practices which minimize stormwater runoff generation resulting from an alteration of the land surface or limit contact of pollutants with stormwater runoff.

NRCS — Natural Resources Conservation Service (previously Soil Conservation Service or SCS).

OPEN CHANNEL — A drainage element in which stormwater flows with an open surface. Open channels include, but shall not be limited to, natural and man-made drainageways, swales, streams, ditches, canals, and pipes flowing partly full. Open channels may include closed conduits so long as the flow is not under pressure.

OUTFALL — Point where water flows from a conduit, stream, pipe, or drain.

OVERFLOW EVENT — See "combined sewer overflow."

PA. CODE CHAPTER 102 — 25 Pa. Code Chapter 102, Erosion and Sediment Control.

PA. CODE CHAPTER 105 — 25 Pa. Code, Chapter 105, Dam Safety and Waterway Management.

PA. CODE CHAPTER 106 — 25 Pa. Code, Chapter 106, Floodplain Management.

PEAK DISCHARGE — The maximum rate of stormwater runoff from a specific storm event.

PennDOT — The Pennsylvania Department of Transportation or any agency successor thereto.

PERVIOUS AREA (PERMEABLE OR POROUS SURFACE) — Any material/surface that allows water to pass through at a rate equal to or greater than natural ground cover.

PIPE — A culvert, closed conduit, or similar structure (including appurtenances) that conveys stormwater.

PLANNING COMMISSION — The Planning Commission of the City of Lancaster, Lancaster County, Pennsylvania.

PLANS — The SWM and erosion and sediment control plans and narratives.

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16. Editor's Note: See 33 U.S.C. § 1362(4).

PROCESS WASTEWATER — Water that comes in contact with any raw material, product, by-product, or waste during any production or industrial process.

QUALIFIED PERSON — Any person licensed by the Pennsylvania Department of State or otherwise qualified by law to perform the work required by this chapter.

RATE CONTROL — SWM controls used to manage the peak flows for the purposes of channel protection and flood mitigation.

RATIONAL METHOD (RATIONAL FORMULA) — A rainfall-runoff relation used to estimate peak flow.

REDEVELOPMENT — Any physical improvement to a previously developed lot that involves earthmoving, removal, or addition of impervious surfaces.

REGIONAL STORMWATER MANAGEMENT PLAN — A plan to manage stormwater runoff from an area larger than a single development site. A regional stormwater management plan could include two adjacent parcels, an entire watershed, or some defined area in between. Regional stormwater management plans can be prepared for new development or as a retrofit to manage runoff from already developed areas.

REGULATED ACTIVITIES — Activities, including earth disturbance activities, that involve the alteration or development of land in a manner that may affect stormwater runoff. Regulated activities shall include, but not be limited to:

A. Land development subject to the requirements of the City of Lancaster Subdivision and Land Development Ordinance;

B. Removal of ground cover, grading, filling or excavation; replacing existing impervious surface with new (reconstructed) impervious surface, such as repairs to parking lots that require disturbing the stone base of the parking lot;

C. Construction of new or additional impervious or semi-impervious surfaces (driveways, parking lots, etc.), and associated improvements;

D. Construction of new buildings or additions to existing buildings;

E. Installation or alteration of stormwater management facilities and appurtenances thereto;

F. Diversion or piping of any watercourse;

G. Demolition or razing of all or a portion of an existing structure; and

H. Any other regulated activities where the City of Lancaster determines that said activities may affect any existing watercourse's stormwater management facilities or stormwater drainage patterns.

RELEASE RATE — For a specific design storm or list of design storms, the percentage of peak flow rate for existing conditions which may not be exceeded for the proposed conditions.

RELEASE RATE MAP — A graphical representation of the release rates for a specific area.

RETENTION BASIN — A stormwater management facility that includes a permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff storage.

RIPARIAN — Pertaining to a stream, river or other watercourse. Also, plant communities occurring in association with any spring, lake, river, stream, or creek through which waters flow at least periodically[6].[17]

RIPARIAN BUFFER — A BMP that is an area of permanent vegetation along a watercourse.

RIPARIAN CORRIDOR — A narrow strip of land, centered on a stream or river, that includes the floodplain as well as related riparian habitats adjacent to the floodplain[6].

RIPARIAN CORRIDOR EASEMENT — An easement created for the purpose of protecting and preserving a riparian corridor.

RIPARIAN FOREST BUFFER — A type of riparian buffer that consists of permanent vegetation that is predominantly native trees, shrubs, and forbs along a watercourse that is maintained in a natural state or sustainably managed to protect and enhance water quality, stabilize stream channels and banks, and separate land use activities from surface waters.

ROOFTOP DETENTION — Temporary ponding and gradual release of stormwater falling directly onto roof surfaces by incorporating controlled-flow roof drains into building designs.

RUNOFF — Any part of precipitation that flows over the land surface.

SCS — United States Department of Agriculture, Soil Conservation Service (now known as NRCS).

SEDIMENT — Soils or other materials transported by stormwater as a product of erosion[1].[18]

SEDIMENTATION — The action or process of forming or depositing sediment in waters of the commonwealth[1].

SEDIMENT BASIN — A barrier, dam, retention or detention basin located and designed to retain rock, sand, gravel, silt, or other material transported by water.

SEDIMENT POLLUTION — The placement, discharge or any other introduction of sediment into the waters of the commonwealth occurring from the failure to design, construct, implement, or maintain control measures and control facilities in accordance with the requirements of this chapter.

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17. Editor's Note: See Art. X, References.

18. Editor's Note: See Art. X, References.

SEEPAGE PIT/SEEPAGE TRENCH — An area of excavated earth filled with loose stone or similar coarse material, into which surface water is directed for infiltration into the ground.

SEMI-IMPERVIOUS/SEMIPERVIOUS SURFACE — A surface which prevents some infiltration of water into the ground.

SHEET FLOW — Runoff which flows over the ground surface as a thin, even layer, not concentrated in a channel.

SMALL PROJECT — Regulated activities that, measured on a cumulative basis, create additional impervious areas of 1,000 square feet or less or involve removal of ground cover, grading, filling, or excavation of an area less than 5,000 square feet and do not involve the alteration of stormwater facilities or watercourses.

SMALL STORM EVENT — A storm having a frequency of recurrence of once every two years or smaller.

SOIL COVER COMPLEX METHOD — A method of runoff computation developed by the SCS (now NRCS) that is based on relating soil type and land use/cover to a runoff parameter called "curve number" (CN). For more information, see "Urban Hydrology for Small Watersheds," Second Edition, Technical Release No. 55, SCS, June 1986 (or most current edition).

SOIL GROUP, HYDROLOGIC — See "hydrologic soil group."

SPEC MANUAL — The Lancaster City Specifications and Guidelines Manual.

STATE WATER QUALITY REQUIREMENTS — The regulatory requirements to protect, maintain, reclaim, and restore water quality under Title 25 of the Pennsylvania Code, the Clean Streams Law, and the Clean Water Act.

STORAGE — A volume above or below ground that is available to hold stormwater.

STORM EVENT — A storm of a specific duration, intensity, and frequency.[19]

STORM SEWER — A system of pipes and/or open channels designed to convey stormwater.

STORMWATER — Drainage runoff from the surface of the land resulting from precipitation or snow or ice melt.

STORMWATER CREDIT — A reduction in the cost to construct the required stormwater management facility.

STORM WATER MANAGEMENT ACT (ACT 167) — Act of October 4, 1978, P.L. 864, No. 167, as amended, 32 P.S. § 680.1 et seq. This stormwater act shall also be referred to herein as Act 167.

STORMWATER MANAGEMENT BEST MANAGEMENT PRACTICE (SWM BMP) — See "BMP."

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19. Editor's Note: See Art. X, References.

STORMWATER MANAGEMENT FACILITY (SWM FACILITY) — Any structure, natural or man-made, that, due to its condition, design, or construction, conveys, stores, infiltrates/evaporates/transpires, cleans, or otherwise affects stormwater runoff. Typical SWM facilities include, but are not limited to, detention and retention basins, open channels, watercourses, road gutters, swales, storm sewers, pipes, BMPs, and infiltration structures.

STORMWATER MANAGEMENT OPERATION AND MAINTENANCE PLAN (O&M PLAN) — A plan, including a narrative, to ensure proper functioning of the SWM facilities in accordance with Article VI of this chapter.

STORMWATER MANAGEMENT SITE PLAN (SWM SITE PLAN) — The plan prepared by the applicant or his representative indicating how stormwater runoff will be managed at a particular development site according to this chapter.

STREAM — A watercourse.

STRUCTURAL BMPs — Physical devices and practices that capture and treat stormwater runoff. Structural stormwater BMPs are permanent appurtenances to the development site.

STRUCTURE — Any man-made object having an ascertainable stationary location on or in land or water, whether or not affixed to the land.[8][20]

SUBDIVISION — The division or redivision of a single lot, tract or parcel of land by any means into two or more lots, tracts, parcels, or other divisions of land, including changes in existing lot lines, for the purpose, whether immediate or future, of lease, partition by the court for distribution to heirs or devises, transfer of ownership, or building, or land development, or as defined in the MPC.

SWALE — A low-lying stretch of land which gathers or carries surface water runoff.

SWM — Stormwater management.

SWM SITE PLAN — A stormwater management site plan.

TIMBER OPERATIONS — See "forest management."

TIME OF CONCENTRATION (Tc) — The time for surface runoff to travel from the hydraulically most distant point of the watershed to a point of interest within the watershed. This time is the combined total of overland flow time and flow time in pipes or channels, if any. Or the time needed for water to flow from the most remote point in a watershed to the watershed outlet.

TOP OF STREAM BANK — First substantial break in slope between the edge of the bed of the stream and the surrounding terrain. The top of streambank can either be a natural or constructed (that is, road or railroad grade) feature, lying generally parallel to the watercourse.

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20. Editor's Note: See Art. X, References.

TREATMENT TRAIN — The sequencing of structural best management practices to achieve optimal flow management and pollutant removal from urban stormwater.

USDA — United States Department of Agriculture.

VERY SMALL PROJECT — Regulated activities that have negligible impervious coverage of less than or equal to 100 square feet measured in aggregate. Very small projects shall include fence posts; mailbox posts, tombstones; doghouses; pads for trash receptacles, and outdoor grills; lawn ornaments and other nonvegetative landscape elements.

VOLUME CONTROL — SWM controls, or BMPs, used to remove a predetermined amount of runoff or the increase in volume between the pre- and postdevelopment design storm.

WATERCOURSE — A channel or conveyance of surface water having defined bed and banks, whether natural or artificial, with perennial or intermittent flow.

WATERSHED — The entire region or area drained by a watercourse.

WATERS OF THE COMMONWEALTH — Any and all rivers, streams, creeks, rivulets, impoundments, ditches, watercourses, storm sewers, lakes, dammed water, wetlands, ponds, springs, and all other bodies or channels of conveyance of surface and underground water, or parts thereof, whether natural or artificial, within or on the boundaries of Pennsylvania.

WETLAND — Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs, fens, and similar areas.

WOODLAND — Land predominantly covered with trees and shrubs. Without limiting the foregoing, woodlands include all land areas of 10,000 square feet or greater, supporting at least 100 trees per acre, so that either:

A. At least 50 trees are two inches or greater in diameter at breast height (DBH); or

B. Fifty trees are at least 12 feet in height.

ARTICLE III
Stormwater Management Standards

§ 260-301. General requirements.

A. Preparation of a SWM site plan is required for all regulated activities, unless preparation and submission of the SWM site plan is specifically exempted according to § 260-502.

B. No regulated activities shall commence until the City of Lancaster issues unconditional written approval of a SWM site plan or stormwater permit.

C. SWM site plans approved by the City of Lancaster, in accordance with § 260-505, shall be on site throughout the duration of the regulated activity.

D. The City of Lancaster may, after consultation with DEP, approve measures for meeting the state water quality requirements other than those in this chapter, provided that they meet the minimum requirements of, and do not conflict with, state law, including, but not limited to, the Clean Streams Law. The City of Lancaster shall maintain a record of consultations with DEP pursuant to this subsection. Where an NPDES permit for stormwater discharges associated with construction activities is required, issuance of an NPDES permit shall constitute satisfaction of consultation with DEP.

E. For all regulated activities, erosion and sediment control BMPs shall be designed, implemented, operated, and maintained to meet the purposes and requirements of this chapter and to meet all requirements under Title 25 of the Pennsylvania Code and the Clean Streams Law. Various BMPs and their design standards are listed in the Erosion and Sediment Pollution Control Program Manual (E&S Manual), No. 363-2134-008 (March 2012), as amended and updated.

F. Applicants have the option to propose a regional stormwater management plan or participate in a regional stormwater management plan developed by others. A regional stormwater management plan may include off-site volume and rate control, as appropriate and supported by a detailed design approved by the City of Lancaster in accordance with § 260-301D. A regional stormwater management plan must meet all of the volume and rate control standards required by this chapter for the area defined by the regional stormwater management plan, but not necessarily for each individual development site. Appropriate easement and O&M agreements must be established to ensure the requirements of this chapter and the requirements of the regional stormwater management plan are met.

G. Unless prohibited by the City of Lancaster Building Construction and Floodplain Ordinance,[21] Zoning Ordinance,[22] or any ordinance which regulates construction and development within the areas of the City of

Lancaster subject to flooding, and any other applicable requirements of the Flood Plain Management Act, stormwater management facilities located in the floodplain are permitted when designed and constructed in accordance with the provisions of the BMP Manual, the City Specifications and Guidelines Manual, the Stormwater Management Fee Policy and Procedures Manual, other regulatory requirements, and the requirements of this chapter.

H. Impervious areas.

(1) The measurement of impervious area shall include all of the impervious areas in the total proposed development even if development is to take place in stages or phases.

(2) For development taking place in stages or phases, the entire development plan must be used in determining conformance with this chapter.

(3) Any areas designed to initially be gravel or crushed stone shall be assumed to be impervious.

I. All regulated activities shall include such measures as necessary to:

(1) Protect health, safety, and welfare of people and property;

(2) Meet the water quality goals of this chapter by implementing measures to:

(a) Protect and/or improve the function of floodplains, wetlands, and wooded areas.

(b) Protect and/or improve native plant communities, including those within the riparian corridor.

(c) Protect and/or improve natural drainageways from erosion.

(d) Minimize thermal impacts to waters of the commonwealth.

(e) Disconnect impervious surfaces by directing runoff to pervious areas, wherever possible.

(3) Incorporate the techniques for low-impact development practices described in the Pennsylvania Stormwater BMP Manual (BMP Manual).

(4) Incorporate green infrastructure stormwater management facilities in accordance with applicable City codes and specifications.

J. A planting plan is required for all vegetated stormwater BMPs.

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21. Editor's Note: See Ch. 109, Building Construction and Floodplain Management.

22. Editor's Note: See Ch. 300, Zoning.

(1) All trees and other vegetation shall be planted in accordance with the standards and regulations set forth in applicable City codes and ordinances, including but not limited to Chapter 265, the Subdivision and Land Development Ordinance; Chapter 273, the Trees Ordinance; and Chapter 300, the Zoning Ordinance.

(2) Native or naturalized/noninvasive vegetation suitable to the soil and hydrologic conditions of the development site shall be used unless otherwise specified in applicable state and local codes and regulations, including but not limited to the City Spec Manual and the BMP Manual.

(3) Invasive Vegetation may not be included in any planting schedule. (See Invasive Plants in Pennsylvania by the Department of Conservation and Natural Resources [DCNR].)

(4) The limit of existing native vegetation to remain shall be delineated on the plan, along with proposed construction protection measures.

(5) Prior to construction, a tree protection zone shall be delineated in accordance with the City Tree Ordinance or no less than at the dripline of the tree canopy. All trees scheduled to remain during construction shall be marked; however, where groups of trees exist, only the trees on the outside edge need to be marked. A barrier, such as a forty-eight-inch-high snow fence or forty-eight-inch-high construction fence mounted on steel posts located eight feet on center, shall be placed along the tree protection boundary. No construction, storage of material, temporary parking, pollution of soil, or regrading shall occur within the tree protection zone.

(6) All planting shall be performed in conformance with good nursery and landscape practice. Plant materials shall conform to the standards recommended by the American Association of Nurseryman, Inc., in the American Standard of Nursery Stock.

(a) Planting designs are encouraged to share planting space for optimal root growth whenever possible.

(b) No staking or wiring of trees shall be allowed without a maintenance note for the stake and/or wire removal within one year of planting.

K. Areas proposed for infiltration BMPs shall be protected from sedimentation and compaction during the construction phase to maintain maximum infiltration capacity. Staging of earthmoving activities and selection of construction equipment should consider this protection.

L. Infiltration BMPs shall not be constructed nor receive runoff from disturbed areas until the entire contributory drainage area to the infiltration BMP has achieved final stabilization, unless otherwise authorized by the City.

M. Where required by the City Engineer or Director, a minimum ten-foot-wide access easement for inspection and maintenance shall be provided for all stormwater facilities with tributary areas equal or greater than 1,000 square feet and not located within a public right-of-way. Easements shall provide for ingress and egress to a public right-of-way.

N. Drainage easements shall be provided where the conveyance, treatment, or storage of stormwater, either existing or proposed, is identified on the SWM site plan. Drainage easements shall be provided to contain and convey the one-hundred-year frequency flood.

O. The City of Lancaster may require additional stormwater control measures for stormwater discharges to special management areas, including but not limited to:

(1) Water bodies listed as "impaired" on Pennsylvania's Clean Water Act 303(d)/305(b) Integrated List.

(2) Any water body or watershed with an approved total maximum daily load (TMDL).

(3) Critical areas with sensitive resources (e.g., state-designated special protection waters, cold-water fisheries, carbonate or other groundwater recharge areas highly vulnerable to contamination, drainage areas to water supply reservoirs, source water protection zones, etc.)

P. Roof drains and sump pumps shall be tributary to infiltration or vegetative BMPs. Use of catchment facilities for the purpose of reuse is also permitted.

Q. Nonstructural BMPs shall be utilized for all regulated activities unless proven to be impractical by the Director.

R. All GI and BMPs shall be implemented on the development site, or on an abutting site with properly executed easements, as may be required by this chapter. However, if the installation of GI and BMPs is proven to be impractical due to existing site constraints, BMPs may be installed off site, within the same drainage basin as the development site, upon the approval by the Director.

§ 260-302. Performance standards.

A. All regulated activities, except those exempted in § 260-502, and very small projects as defined in § 260-202 shall not increase the postdevelopment total runoff volume or shall permanently remove the first one inch of runoff through infiltration, for all storms equal to or less than the two-year, twenty-four-hour storm event, whichever is greater.

B. The design of all stormwater management facilities over karst shall include an evaluation of measures to minimize adverse effects, where such evaluation shall be carried out in accordance with § 260-405A of this chapter.

C. Infiltration BMPs shall be designed to the maximum extent practicable to fit the site constraints and limitation and located to maximize use of natural on-site infiltration features while still meeting the other requirements of this chapter. Infiltration BMPs shall include pretreatment BMPs unless shown to be unnecessary.

D. Infiltration BMPs intended to receive runoff from developed areas shall be selected based on suitability of soils and development site conditions and shall be constructed on soils that have the following characteristics:

(1) A minimum depth of 24 inches between the bottom of the facility and the limiting zone, unless it is demonstrated to the satisfaction of the City of Lancaster that the selected BMP has design criteria which allow for a smaller separation.

(2) A stabilized infiltration rate sufficient to accept the additional stormwater load and drain completely as determined by field tests conducted by the applicant's professional designer.

(a) The stabilized infiltration rate is to be determined in the same location and within the same soil horizon as the bottom of the infiltration facility.

(b) The stabilized infiltration rate is to be determined as specified in the BMP Manual.

E. The design storm volumes and precipitation intensities to be used in the analysis of peak rates of discharge shall be as required in § 260-305.

F. Runoff from impervious areas shall be drained to pervious areas within the development site, unless the site has 85% or more impervious cover and is a redevelopment[10],[23] in which case alternative methods of SW management shall be incorporated, including but not limited to GI and on-site detention.

G. Stormwater runoff from a development site to an adjacent property shall flow directly into a natural drainageway, a watercourse, or an existing storm sewer system, or onto adjacent properties in a manner similar to the runoff characteristics of the predevelopment flow, unless such predevelopment characteristics were inadequate to control adverse impacts such as erosion, flooding, ponding, etc.

H. Stormwater flows onto adjacent property shall not be created, increased, decreased, relocated, or otherwise altered without written

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23. Editor's Note: See Art. X, References.

notification of the adjacent property owner(s) by the applicant. Such stormwater flows shall be subject to the requirements of this chapter, including the establishment of a drainage easement. Copies of all such notifications shall be included in SWM site plan submissions.

I. Existing on-site natural SWM facilities shall be used to the maximum extent practicable.

J. Stormwater runoff shall not be transferred from one subwatershed to another unless they are subwatersheds of a common watershed that join together within the perimeter of the development site, the effect of the transfer does not alter the peak discharge onto adjacent lands, and drainage easements from the affected landowners are provided.

K. Minimum floor elevations for all structures that would be affected by a basin, other temporary impoundments, or open conveyance systems where ponding may occur shall be two feet above the one-hundred-year water surface elevation. If basement or underground facilities are proposed, detailed calculations addressing the effects of stormwater ponding on the structure and waterproofing and/or floodproofing design information shall be submitted for approval.

L. All stormwater conveyance facilities (excluding detention, retention, and wetland basin outfall structures) shall be designed to convey a twenty-five-year storm event.* All stormwater conveyance facilities (excluding detention, retention, and wetland basin outfall structures) conveying water originating from off site shall be designed to convey a fifty-year storm event.* Safe conveyance of the one-hundred-year runoff event* to appropriate peak rate control BMPs must be demonstrated in the design.

*A twenty-four-hour SCS type II storm or an IDF Curve Rational Method storm.

M. Erosion protection shall be provided along all open channels and at all points of discharge. Flow velocities from any storm sewer may not result in erosion of the receiving channel.

§ 260-303. Volume controls.

Volume control BMPs are intended to maintain existing hydrologic conditions for small storm events by promoting groundwater recharge and/or evapotranspiration as described in this section. Runoff volume controls shall be implemented using the Design Storm Method described in Subsection A below, or through continuous modeling approaches or other means as described in the BMP Manual, or from other applicable sources acceptable to the City. Small projects may use the method described in Subsection B to design volume control BMPs.

A. The Design Storm Method is applicable to any size of regulated activity that does not meet the definition of "small project" or "very small project."

(1) The Design Storm Method requires detailed modeling based on site conditions that do not increase the postdevelopment total runoff volume and, at a minimum, permanently removes the first one inch of runoff, for all storms equal to or less than the two-year, twenty-four-hour storm event.

(2) For modeling purposes:

(a) Existing (predevelopment) nonforested pervious areas must be considered meadow in good condition in the hydrologic soils group B soils.

(b) When the existing project site contains impervious area, 20% of existing impervious area to be disturbed shall be considered meadow in good condition in the model for existing conditions, except for repair, reconstruction, or restoration of public roadways, or repair, reconstruction, or restoration of rail lines, or construction, repair, reconstruction, or restoration of utility infrastructure when the site will be returned to existing condition. At least the first one inch of runoff from new impervious surfaces shall be permanently removed from the runoff flow, that is, it shall not be released into the surface waters of the commonwealth or combined sewer system. Removal options include reuse, evaporation, transpiration, and infiltration.

(c) The maximum loading ratio for volume control facilities in Karst areas shall be 3:1 impervious drainage area to infiltration area and 5:1 total drainage area to infiltration area. The maximum loading ratio for volume control facilities in non-Karst areas shall be 5:1 impervious drainage area to infiltration area and 8:1 total drainage area to infiltration area. A higher ratio may be approved by the City of Lancaster if justification is provided. Hydraulic depth may be used as an alternative to an area-based loading ratio if the design hydraulic depth is shown to be less than the depth that could result from the maximum area loading ratio.

(d) Irrespective of Subsection A(2)(c) above, when existing karst conditions, as determined by the City Engineer, do not allow for the installation of infiltration BMPs, the design volume of stormwater runoff shall be kept out of the combined sewer system and detained on site until the overflow event subsides.

B. Volume control for small projects.

(1) At least the first one inch of runoff from new impervious surfaces or an equivalent volume shall be permanently removed from the runoff flow, that is, it shall not be released into the surface waters of the commonwealth or combined sewer system. Removal options include reuse, evaporation, transpiration, and infiltration.

C. If required by the Director, a detailed geologic evaluation of the development site shall be performed in areas of carbonate geology to determine the design parameters of recharge facilities. A report shall be prepared in accordance with § 260-405A of this chapter.

D. Storage facilities, including normally dry, open-top facilities, shall completely drain the volume control storage over a period of time not less than 24 hours and not more than 72 hours from the end of the design storm. Any designed infiltration at such facilities is exempt from the minimum twenty-four-hour standard, that is, may infiltrate in a shorter period of time, provided that none of this water will be discharged into waters of the commonwealth or combined sewer system.

E. Any portion of the volume control storage that meets the following criteria may also be used as rate control storage:

(1) Volume control storage that depends on infiltration is designed according to the infiltration standards in § 260-301.

(2) The volume control storage which will be used for rate control is that storage which is available within 24 hours from the end of the design storm based on the stabilized infiltration rate and/or the evapotranspiration rate.

F. Volume control storage facilities designed to infiltrate shall avoid the least permeable hydrologic soil group(s) at the development site.

§ 260-304. Rate controls.

Rate control for large storms, up to the one-hundred-year event, is essential to protect against immediate downstream erosion and flooding. (See Appendix D for the Release Rate Map.)[24]

A. Match predevelopment hydrograph. Applicants shall provide infiltration facilities or utilize other techniques which will allow the postdevelopment one-hundred-year hydrograph to match the predevelopment one-hundred-year hydrograph, along all parts of the hydrograph, for the development site. To match the predevelopment hydrograph, the postdevelopment peak rate must be less than or equal to the predevelopment peak rate, and the postdevelopment runoff volume must be less than or equal to the predevelopment volume for the same storm event. A shift in hydrograph peak time of up to five minutes and a rate variation of up to 5% at a given time may be allowable to account for the timing effect of BMPs used to manage the peak rate and runoff volume. "Volume control" volumes as given in § 260-303 above may be used as part of this option.

B. Where the predevelopment hydrograph cannot be matched, one of the following shall apply:

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24. Editor's Note: Appendix D is included as an attachment to this chapter.

(1) For areas not covered by a release rate map from an approved Act 167 plan: Postdevelopment discharge rates shall not exceed the predevelopment discharge rates for the two-, ten-, twenty-five-, fifty-, and one-hundred-year, twenty-four-hour storm events.* If it is shown that the peak rates of discharge indicated by the postdevelopment analysis are less than or equal to the peak rates of discharge indicated by the predevelopment analysis for two-, ten-, twenty-five-, fifty-, and one-hundred-year, twenty-four-hour storms,* then the requirements of this section have been met. Otherwise, the applicant shall provide additional controls as necessary to satisfy the peak rate of discharge requirement.

*A twenty-four-hour SCS type II storm or an IDF Curve Rational Method storm. See Table III-1.[25]

(2) Postdevelopment rate of runoff from any regulated activity within the Little Conestoga Creek Watershed or Mill Creek Watershed shall not exceed 50% of the peak rates of runoff prior to development for all design storms unless the preexisting hydrograph is not exceeded at all points in time.

(3) For areas covered by a release rate map from an approved Act 167 plan: For the two-, ten-, twenty-five-, fifty-, and one-hundred-year, storm events,* the postdevelopment peak discharge rates will follow the applicable approved release rate maps.

*A twenty-four-hour SCS type II storm or an IDF Curve Rational Method storm. See Table III-1.

C. Normally dry, open-top storage facilities shall completely drain the rate control storage over a period of time less than or equal to 24 hours from the peak one-hundred-year water surface design elevation.

D. A variety of BMPs should be employed and tailored to suit the development site. Nonstructural BMPs and green infrastructure are preferred. The following is a partial listing of BMPs which can be utilized in SWM systems for rate control where appropriate:

(1) Decreased impervious surface coverage.

(2) Routed flow over grass.

(3) Grassed channels and vegetated strips.

(4) Bioretention areas (rain gardens).

(5) Concrete lattice block or permeable surfaces.

(6) Seepage pits, seepage trenches, or other infiltration structures.

(7) Rooftop detention.

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25. Editor's Note: See § 260-305B.

(8) Parking lot detention.

(9) Cisterns and underground reservoirs.

(10) Amended soils.

(11) Retention basins.

(12) Infiltration basins.

(13) Green (vegetated) roofs.

(14) Other methods as may be found in the BMP Manual.

E. Small projects are not required to provide for rate control.

§ 260-305. Calculation methodology.

A. Any stormwater runoff calculations involving drainage areas greater than 200 acres and time of concentration (Tc) greater than 60 minutes, including on- and off-site areas, shall use generally accepted calculation techniques based on the NRCS Soil Cover Complex Method.

B. Stormwater runoff from all development sites shall be calculated using either the Modified Rational Method, a soil cover complex methodology, or other method acceptable to the City of Lancaster. Table III-1 summarizes acceptable computation methods. It is assumed that all methods will be selected by the design professional based on the individual limitations and suitability of each method for a particular development site.

Table III-1

Acceptable Computation Methodologies for Stormwater Management Plans

Method	Method Developed By	Applicability
TR-20 (or commercial computer package based on TR-20)	USDA NRCS	Applicable where use of full hydrology computer model is desirable or necessary
Win TR-55 (or commercial computer package based on TR-55)	USDA NRCS	Applicable for land development plans within limitations described in TR-55
HEC-1/HEC-HMS	U.S. Army Corps of Engineers	Applicable where use of full hydrologic computer model is desirable or necessary

Table III-1

Acceptable Computation Methodologies for Stormwater Management Plans

Method	Method Developed By	Applicability
Rational Method (or commercial computer package based on Rational Method)	Emil Kuichling (1889)	For development sites less than 200 acres, Tc < 60 minutes or as approved by the City of Lancaster
EFH2	USDA NRCS	Applicable in rural and undeveloped areas subject to the program limits
Other methods	Varies	Other methodologies approved by the City of Lancaster

C. If the SCS method is used, Antecedent Moisture Condition 1 is to be used in areas of carbonate geology, and Antecedent Moisture Condition 2 is to be used in all other areas. A type II distribution shall be used in all areas.

D. If the Rational Method is used, the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 data (see Subsection B above) or PennDOT Publication 584, "PennDOT Drainage Manual," 2008 Edition, or latest, shall be used to determine the rainfall intensity in inches per hour based on the information for the five- through sixty-minute-duration storm events.

E. Hydrographs may be obtained from NRCS methods such as TR-55, TR20, or from use of the "modified" or "unit hydrograph" rational methods. If "modified" or "unit hydrograph" rational methods are used, the ascending leg of the hydrograph shall have a length equal to three times the time of concentration (3 x Tc) and the descending leg shall have a length equal to seven times the time of concentration (7 x Tc) to approximate an SCS type II hydrograph[11].[26]

F. Runoff calculations shall include a hydrologic and hydraulic analysis indicating volume and velocities of flow and the grades, sizes, and capacities of water-carrying structures, sediment basins, retention and detention structures and sufficient design information to construct such facilities. Runoff calculations shall also indicate both predevelopment and postdevelopment rates for peak discharge of stormwater runoff from all discharge points.

26.Editor's Note: See Art. X, References.

G. For the purpose of calculating predevelopment peak discharges, all runoff coefficients, both on site and off site, shall be based on actual land use assuming summer or good land conditions. Postdevelopment runoff coefficients for off-site discharges used to design conveyance facilities shall be based on actual land use assuming winter or poor land conditions.

H. Criteria and assumptions to be used in the determination of stormwater runoff and design of management facilities are as follows:

(1) Runoff coefficients shall be based on the information contained in Appendixes B-1 and B-2 if the actual land use is listed in those appendixes. If the actual land use is not listed in these appendixes, runoff coefficients shall be chosen from other published documentation, and a copy of said documentation shall be submitted with the SWM site plan.[27]

(2) A sample worksheet for calculating Tc is provided in Appendix B-4. Times of concentration (Tc) shall be based on the following design parameters:

(a) Sheet flow. The maximum length for each reach of sheet or overland flow before shallow concentrated or open channel flow develops is 150 feet. Flow lengths greater than 100 feet shall be justified based on the actual conditions at each development site. Sheet flow may be determined using the nomograph in Appendix B-3 or the Manning's kinematic solution shown in the sheet flow section of Worksheet No. 1 in Appendix B-4.

(b) Shallow concentrated flow. Travel time for shallow concentrated flow shall be determined using Figure 3-1 from TR-55, Urban Hydrology for Small Watersheds, as shown in Appendix B-5.

(c) Open channel flows. At points where sheet and shallow concentrated flows concentrate in field depressions, swales, gutters, curbs, or pipe collection systems, the travel times to downstream end of the development site between these design points shall be based upon Manning's Equation and/or acceptable engineering design standards as determined by the Municipal Engineer.

(3) The applicant may use stormwater credits for nonstructural BMPs in accordance with the BMP Manual. The allowable reduction will be determined by the City of Lancaster.

(4) Peak rate control is not required for off-site runoff. Off-site runoff may be bypassed around the site provided all other discharge requirements are met. If off-site runoff is routed through rate

27. **Editor's Note: Appendix B is included as an attachment to this chapter.**

control facilities, runoff coefficients for off-site discharges used to design those rate control facilities shall be based on actual land use assuming winter or poor land conditions.

I. Times of concentration (Tc) shall be calculated based on the methodology recommended in the respective model used, except that Tc for channel and pipe flow shall be computed using Manning's Equation. Supporting documentation and calculations must be submitted for review and approval

§ 260-306. Riparian corridors.

A. In order to protect and improve water quality, a riparian corridor easement shall be created and recorded as part of any subdivision or land development that encompasses a riparian corridor.

B. As required by 25 Pa. Code Chapter 102, the riparian corridor easement shall be measured to the limit of the one-hundred-year floodplain.

C. Minimum management requirements for riparian corridors.

(1) Existing native vegetation shall be protected and maintained within the riparian corridor easement.

(2) Whenever practicable, invasive vegetation shall be actively removed and the riparian corridor easement shall be planted with native trees, shrubs and other vegetation to create a diverse native plant community appropriate to the intended ecological context of the site.

D. The riparian corridor easement shall be enforceable by the City of Lancaster and shall be recorded in the Lancaster County Recorder of Deeds Office, so that it shall run with the land and shall limit the use of the property located therein. The easement shall allow for the continued private ownership and shall count toward the minimum lot area as required by zoning, unless otherwise specified in the City Zoning Ordinance.

E. Any permitted use within the riparian corridor easement shall be conducted in a manner that will maintain the extent of the existing one-hundred-year floodplain, improve or maintain the stream stability, and preserve and protect the ecological function of the floodplain and shall be in accordance with the provisions of all applicable City codes and ordinances, including but not limited to Chapter 109, Building Construction and Floodplain Management, and Chapter 300, Zoning.

F. The following conditions shall apply when public and/or private recreation trails are permitted within riparian corridors:

(1) Trails shall be for nonmotorized use only.

(2) Trails shall be designed to have the least impact on native plant species and other sensitive environmental features.

G. Septic drainfields and sewage disposal systems shall not be permitted within the riparian corridor easement and shall maintain a minimum distance of 100 feet from the top of stream bank. This provision shall not relieve any person from complying with all other City ordinances governing sewers, sewer systems and sewage disposal.

ARTICLE IV
Information to be Included on or with Stormwater Management Site Plans

§ 260-401. General plan requirements.

A. The SWM site plan shall consist of a narrative and all applicable calculations, maps, plans and supplemental information necessary to demonstrate compliance with this chapter.

B. All landowners of land, or their authorized agent, included in the SWM site plan shall be required to execute all applications and final documents.

C. All SWM site plans shall be prepared by a qualified person.

D. Where the regulated activity constitutes subdivision or land development as hereinabove defined, the SWM site plan shall be submitted with and form an integral part of the plans required under the City Subdivision and Land Development Ordinance (SALDO), and the plan procedure and requirements of Chapter 265 in the City Code shall apply.

§ 260-402. Site plan drafting standards.

A. The plan should be clearly and legibly drawn at a scale of one inch equals 50 feet or larger (i.e., one inch equals 40 feet, one inch equals 30 feet, etc.) and shall be submitted on twenty-four-inch by thirty-six-inch sheets.

B. If the plan is prepared in two or more drawing sheets, a key map showing the location of the sheets and a match line shall be placed on each sheet.

C. Each sheet shall be numbered to show the relationship to the total number of sheets in the plan (e.g., Sheet 1 of 5).

D. A space 4 1/4 inches by 1 3/4 inches shall be provided for the recording certificate for the Office of the Recorder of Deeds of Lancaster County.

§ 260-403. Site plan information.

The following items shall be included in the SWM site plan:

A. Location and identification:

(1) The date of the SWM site plan and latest revision, graphic scale, written scale and North arrow.

(2) The name of the development, the name and address of the owner of the property, and the name of the individual or firm preparing the plan.

(3) The file or project number assigned by the firm that prepared the plan.

(4) Source of title, including deed book volume and page number for the subject property.

(5) Parcel ID number (PIN).

(6) Names of all adjoining property owners with PIN and deed book information.

(7) A legible location map, drawn to a scale of a minimum of one inch equals 2,000 feet, relating the plan to municipal boundaries, at least two intersections of road center line or other identifiable landmarks.

(8) The total tract boundary with distances marked to the nearest hundredth of a foot and bearings to the nearest degree.

(9) Total tract size in acres and square feet to the nearest hundredth of a foot.

(10) Drainage area to each BMP in square feet and acres.

B. Existing features:

(1) In areas of disturbance, contours at intervals of one foot or two feet. In areas of steep slopes (greater than 15%) and areas undisturbed, five-foot contour intervals may be used.

(2) The locations of all existing utilities (including on lot disposal systems and wells) and stormwater management facilities, sanitary sewers, and waterlines and associated easements.

(3) Physical features including flood hazard boundaries, wetlands, sinkholes, streams, lakes, ponds and other water bodies, existing drainagecourses, karst features, areas of native vegetation including trees greater than six inches diameter at breast height, woodlands, other environmentally sensitive areas and the total extent of the upstream area draining through the development site.

(4) An overlay showing soil names, boundaries and hydrologic soil groups.

(5) All existing man-made features within 50 feet of the development site boundary or as determined by the City Engineer.

(6) Municipal, Zoning District, Historic District, Streetscape District and other applicable boundaries lines.

C. Proposed features:

(1) Changes to the land surface and vegetative cover, including final proposed contours at intervals of one foot or two feet in areas of

APPENDIX F – ACRONYMS AND ABBREVIATIONS

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ANSI	American National Standards Institute
ASSE	American Society of Sanitary Engineering
ASTM	American Society for Testing and Materials
BMP	best management practices
CCTV	closed-circuit television
CIP	cast-iron pipe
CN	runoff curve number
CSO	combined sewer overflow
CSS	combined sewer system
DA	drainage area
DBH	diameter at breast height
DPTA	diethylenetriaminepentaacetic acid
E&S	erosion and sedimentation
EDPM	ethylene propylene diene terpolymer
FHWA	Federal Highway Administration
FLL	Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (German Landscape Research, Development, and Construction Society)
GI	green infrastructure
HEC	Hydraulic Engineering Circular
HDPE	high-density polyethylene
HSG	hydrologic soil group
HVAC	heating, ventilation, and air conditioning
IA	impervious area

LOD	limit of disturbance
MEP	maximum extent practicable
MSA	measurement systems analysis
NB	natural basin
NOAA	National Oceanic and Atmospheric Administration
NRCS	National Resource Conservation Service
NRMCA	National Ready Mixed Concrete Association
OSHA	Occupational Safety and Health Administration
PP	polypropylene
PVC	polyvinyl chloride
RCP	reinforced concrete pipe
ROW	ight-of-way
SCS	Soil Conservation Service
SWM	stormwater management
TPO	thermoplastic polyolefin
TSS	total suspended solids
UDFCD	urban drainage and flood control district
USDA	United States Department of Agriculture
UV	ultraviolet
VCP	vitrified clay pipe

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