City of Dublin
OHIO, USA

Stormwater Management Design Manual

INTERIM UPDATE: January 2019

NOTE: This interim update has modified the water quality calculations (WQv), rainfall depth (for WQv calculations), and references for the current Ohio EPA Construction General Permit (OHC000005) to comply with the current Ohio EPA Construction General Permit.

STORMWATER MANAGEMENT DESIGN MANUAL

Prepared for:

City of Dublin, Ohio
Department of Engineering
5800 Shier Rings Road
Dublin, Ohio 43016

Prepared by:

Tetra Tech

TABLE OF CONTENTS

APPENDICES

A. Section 53.070 Exemptions

B. Example Stormwater Approach and Calculations

C. Supplemental Rainfall Information

D. Stormwater Treatment and Control Feasibility Assessment for Redevelopment

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

A. Purpose and Intent

The purpose of this Manual is to set forth the City's standards for stormwater management, and to maintain uniformity in the design standards used for stormwater management. It is a further purpose of this Manual to enable the City to provide effective and efficient review of design data, and to provide applicants with clear guidance in preparing Stormwater Management Plans that further the City's goals for community development and stormwater management.

Stormwater management is an evolving science. The City's goal in preparing this Manual is to enact standards reflecting the most innovative, creative, environmentally effective, and cost-effective practices available. To achieve this goal as stormwater science evolves, this Manual will be revised and updated as necessary to reflect accepted new standard stormwater management practices and control measures (commonly called Best Management Practices or "BMPs", but referred to in this Manual as stormwater control measures).

Through the standards and practices incorporated in this Manual, the City encourages the use of stormwater treatment and engineering methods that allow for groundwater recharge and that manage stormwater as close to its source as possible. The use of Environmentally Sensitive Development (ESD) methods such as conservation design, smart growth, green infrastructure, integrated site design and sustainable development are practices and methods that can help achieve these goals, and are reflected in the standards in this Manual. Specifications for stormwater control measures that use vegetation and soil media to filter, treat or infiltrate stormwater, often referred to as "Low Impact Development" or "LID BMPs," have been incorporated into this Manual. These practices are encouraged to be used in Dublin where suited to site and development conditions, and consistent with the standards in this Manual.

This manual rescinds the previous Manual dated January 2007.

B. Applicability

The provisions and standards of this Manual apply to all publicly- and privately-sponsored projects in the City of Dublin, regardless of the size of the project or the amount of area disturbed, unless exempted under the provisions of Chapter 53.070, Exemptions (See Appendix A, Section 53.070 Exemptions). This includes the alteration, construction, redevelopment, installation, demolition or removal of a structure, impervious surface or drainage facility; clearing, scraping, grubbing, killing or otherwise removing the vegetation from a site; or adding, removing, exposing, excavating, leveling, grading, digging, burrowing, dumping, piling, dredging or otherwise significantly disturbing the soil, mud, sand or rock of a site. Specific thresholds and standards for different types of projects, and standards applicable to specific areas of the City, are enumerated in the Manual.

C. Organization of this Document

Chapter 2, Hydrologic & Hydraulic Design Criteria, addresses the specific design criteria required to design stormwater control measures in terms of the rate, volume and water quality. Climatological information is provided on the rainfall patterns and distribution to be used in preparing an application.

Chapter 3, Special Conditions and Constraints, highlights site conditions that require supplemental protection or that potentially represent a hazard to the public health, safety or welfare are identified and protective measures are incorporated into the design of site improvements and storm water management measures. This section also establishes standards and demonstrations for approval that are consistent with other regulatory requirements and procedures applicable to development within the City of Dublin.

Chapter 4, Flow Conveyance, provides standards and criteria to ensure the safe and effective flow of storm water through flow paths, treatment facilities and the physical storm drainage system in a manner consistent with protection of the public health, safety and welfare; the safety and function of properties,

roads and improvements; and maintaining and improving water and environmental quality in the City of Dublin and its surface waters.

Chapter 5, Stormwater Control Measures, defines the approved stormwater treatment and control measures and practices for use in the City of Dublin. Design guidance and requirements for each type of control measure are presented in a table with accompanying figures.

Chapter 6, Bridge Street District Integration with Stormwater Management, defines and describes the manner in which recommended stormwater treatment and control measures (as defined in Chapter 5) may be used in specific areas of the Bridge Street District. This Chapter is intended to support the general purpose, scope and intent of the Bridge Street District by promoting and facilitating the use of recommended stormwater control measures that are consistent with and suitable for particular street families, right-of-way elements, building types, building sites, and open space types, and which contribute to sound stormwater management in a walkable mixed-use development setting.

Chapter 7, Stormwater Management Plan, provides guidelines, standards and requirements for the orderly development, approval, and implementation of Stormwater Management Plans, including provisions for shared systems and ongoing maintenance. This Chapter sets forth the requirements for preparation and submittal of Stormwater Management Plans, and provides a framework by which property owners and public agencies may propose collectively an overall plan for managing stormwater from multiple properties, where such a management plan will enable greater consistency with the City's adopted plans and policies. It is a further purpose of this Chapter to provide sufficient standards and safeguards for associated plans, approvals and agreements to protect the public interest by ensuring long-term management and maintenance of stormwater management facilities.

Chapter 8, Erosion and Sediment Control, provides standards and guidelines for the preparation of erosion and sediment control plans that protect public health, safety and welfare, and the quality of Dublin's waters from excessive erosion and sedimentation resulting from the construction and operation of development.

2. HYDROLOGIC & HYDRAULIC DESIGN CRITERIA

This Chapter addresses the specific design criteria required to design stormwater control measures in terms of the rate, volume and water quality. Climatological information is provided on the rainfall patterns and distribution to be used in preparing an application under this Chapter.

A. Applicability of Stormwater Requirements

1) Site Development Projects

The stormwater management design for site development projects shall comply with the post-construction water quality requirements of the Ohio EPA's NPDES Construction General Permit for storm water discharges for sites disturbing more than one acre, and with the requirements of this Manual:

a) For new development, use Table 2-1. See Figure 2-1 for graphical representation of the locations listed in Table 2-1. The requirements in Table 2-1 will be met on any new development (building, parking, roadways, site improvements, etc.) on a vacant parcel(s).

b) For redevelopment projects disturbing more than one acre, use Table 2-2 to determine the requirements of stormwater management controls for the site. These developments are ones which modify, expand, add, alter, or change an existing site, including and not limited to the building, parking, roadways and other site improvements.

c) For redevelopment projects disturbing less than one acre, use Table 2-3 to determine the requirements of stormwater management controls for the site.

d) The drainage area tributary to the required stormwater controls should include runoff from outside of the site that naturally flows overland onto the site, unless the City Engineer determines otherwise due to unique or site specific circumstances.

TABLE 2-1 STORMWATER MANAGEMENT REQUIREMENTS BY LOCATION

Location	Quantity	Quality
Outside Bridge Street District	Per Dublin Stormwater Master Plan Rates	0.9 inch event
Historic District Parcels < 1 acre	Not applicable	Not applicable
Historic District Parcels > 1 acre	Not applicable	0.9 inch event
River Corridor	Not applicable	0.9 inch event
Bridge Street District West	Not applicable	1.00 inch event
Bridge Street District East A	Not applicable	0.9 inch event
Bridge Street District East B	Per Dublin Stormwater Master Plan Rates	0.9 inch event

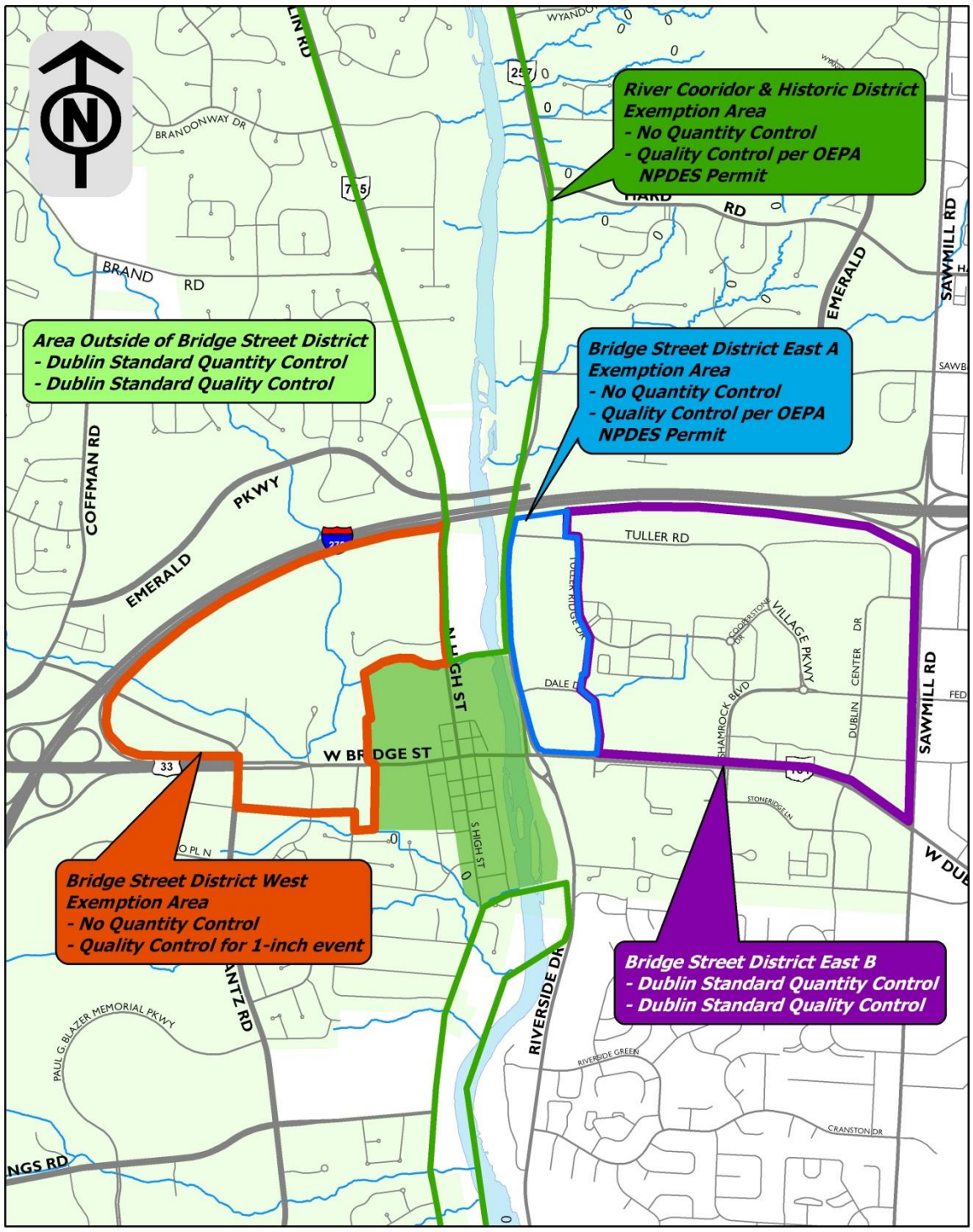


FIGURE 2-1 STORMWATER MANAGEMENT REQUIREMENTS PER LOCATION

TABLE 2-2 REDEVELOPMENT SITES DISTURBING ONE OR MORE ACRES OF LAND

Percent Change of Site Modifications (includes building & site improvements)*	**Quantity Control Level**	**Quality Control Level**	**Additional Requirements**
1 to 25	Stormwater Master Plan rates for the modified area only	OEPA Redevelopment requirements (ie. 20% WQv or reduction of impervious area)	Apply Feasibility Assessment to entire site
26 to 50	Level dependent on location of project for the modified area only; refer to Table 2-1	Provide control for 50% of Standard OEPA requirement (ie. 50% WQv)	None
51 to 100	Entire site must be brought into compliance with the requirements of Table 2-1	Provide control for 75% of Standard OEPA requirement (ie. 75% WQv)	None

*This is calculated based on the percent change of any and all improvements on the property including buildings and pavement. Example: An existing building occupies 55% of a site. It is being torn down and a new building constructed but the parking and rest of site is to remain unchanged, this would be a 55% change of the site and the 75% reduction of water quality volume (WQv) applies.

TABLE 2-3 REDEVELOPMENT SITES DISTURBING LESS THAN ONE ACRE OF LAND

Additional Impervious Area Created (square feet)[1]	**Quantity Control Level**	**Quality Control Level**
Less than 2,000 SF	Apply Feasibility Assessment to entire site	
Greater than 2,000 SF	Level dependent on location of project for the new impervious area only; refer to Table 2-1	Level dependent on location of project for the new impervious area only; refer to Table 2-1

[1] This number is the amount of impervious surface added to the site.

2) Right-of-Way Projects

The stormwater management design for projects within the right-of-way shall comply with the post-construction water quality requirements of the Ohio EPA's NPDES Construction General Permit for construction storm water discharges as follows:

a) For complete street reconstruction, all of the requirements must be met for the entire right-of-way.

b) For projects that increase the total area of impervious surfaces within a designated area, such as adding or widening lanes, adding bike facilities, or adding pedestrian facilities, all of the requirements must be met for the entire right-of-way.

c) For projects limited to roadway resurfacing, post-construction quality controls are not required.

d) The drainage area tributary to the required stormwater controls should include for calculation purposes any runoff from outside of the right-of-way that naturally flows overland into the right-of-way. At a minimum, the tributary area shall be defined as the full right-of-way, unless the City Engineer determines otherwise due to unique or site specific circumstances.

e) For new streets, use of the street right-of-way for stormwater management is limited to the management of the runoff from the street right-of-way and any tributary area as described in (d) above.

3) General Provisions

The stormwater management design for site development projects and projects within the right-of-way shall comply with the following general provisions:

a) No person shall:

i. Construct, maintain, operate, and/or utilize any illicit connection to the storm drainage system.

ii. Cause, allow or facilitate any prohibited discharge.

iii. Act, cause, permit, or suffer any agent, employee, or independent contractor to construct, maintain, operate or utilize any illicit connection, or cause, allow or facilitate any prohibited discharge.

b) Outdoor activity areas within the development site shall be delineated on the Stormwater Management Plan, and the activities that will be conducted within them shall be described in the Plan.

c) Runoff from outdoor activity areas shall not be allowed to co-mingle with runoff from the remainder of the site, and shall be directed to separate treatment systems, as approved by the City Engineer.

d) The site shall be designed to direct runoff from areas other than outdoor activity areas to one or more of the following stormwater control measures as described in Chapter 5:

i. Water Harvesting

ii. Filter Strips

iii. Media Filters

iv. Vegetated Stormwater Control Measures

v. Permeable Pavements

vi. Green Roofs

vii. Basins (Note: Detention/retention basins shall not be allowed in the Bridge Street District without prior approval from the City Engineer.)

viii. Underground Retention/Detention (Note: Underground retention/detention shall not be allowed in the Bridge Street District without prior approval from the City Engineer.)

ix. Prefabricated Devices

x. Other approved stormwater control measures

B. Climatological Information

Rainfall depths for Central Ohio shall be used in conjunction with the appropriate hydrologic routing method or peak flow method to determine design runoff volumes and peak flows. Design rainfall hyetographs shall be developed using the 24-hour rainfall depths from Table 2-4, distributed over a 24-hour period with a NRCS Type II distribution. The 24-hour Type II rainfall distribution represents design rainfall intensities over a time of concentration range typical of a small urban watershed, coupled with wet antecedent conditions at the time of peak rainfall intensity. Refer to Section 2.C. for quantity control requirements and Chapter 4 for flow conveyance requirements.

1) Rainfall Depths

TABLE 2-4 RAINFALL DEPTHS (39.972 N, 83.01 W)

Depths, inches						
1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
2.20	2.63	3.24	3.74	4.44	5.02	5.63

Source: Bonnin, Martin, Lin, Parzybok, Yekta, Riley, *NOAA Atlas 14, Volume 2, Version 3.0*, 2004. and NOAA Precipitation Frequency Data Server http://dipper.nws.noaa.gov/hdsc/pfds/ June 10, 2012

2) Rainfall Distribution

The following are two acceptable methods of generating the NRCS Type II 24-hour design storms. More detail regarding these methods is located in Appendix C.

a) Optimal Rainfall Intensity Equation Coefficients and Time-to-Peak Intensity Ratios found in "Mathematical Formulations of NRCS 24-Hour Design Storms" by David C. Froehlich, Journal of Irrigation and Drainage Engineering, March/April 2009 (Errata 2010)

b) Tabular distribution from Applied Hydrology by Ven Te Chow, David R. Maidment, and Larry W. Mays, 1988.

C. Quantity Control Requirements

The City's Stormwater Master Plan dated February 1999 shall be used to provide design flows and detention requirements for major drainage systems within the City.

For on-site drainage systems, hydrograph routing methods shall be used to design stormwater detention facilities and either hydrograph routing or peak flow methodologies may be used to design stormwater conveyance facilities.

1) Stormwater Control Measures

Stormwater control measures shall be installed on all development projects, unless the applicant demonstrates that the project will not increase the peak rate of runoff, volume, or frequency of the runoff hydrograph of the site prior to development.

Stormwater control measures shall be designed in the following manner:

a) *Studied areas.* Parcels located within drainage sub-basins established in the Stormwater Master Plan, or any subsequent update thereto, shall comply with the runoff release rate for each frequency storm specified in the Stormwater Master Plan. The applicant will need to supply project location information to Engineering Development Group Civil Engineers, who will supply the sub-basin information.

i. *Critical storm controls*. Determine the total volume of runoff from a 1 year, 24 hour storm, occurring over each of the site's drainage areas before and after development. Determine the percent of increase in runoff volume due to development:

Post – Pre /Pre * 100 = Critical Storm

ii. *Select critical storm.* Determine the percent of increase in runoff volume due to development and using this percentage, select the critical storm from the table:

TABLE 2-5 CRITICAL STORM DETERMINATION

If the Percent of Increase in Runoff Volume is		The Critical Storm Runoff Rate Will Be Limited to:
Equal to or Greater than	And less than	
--	10	1 year
10	20	2 year
20	50	5 year
50	100	10 year
100	250	25 year
250	500	50 year
500	--	100 year

iii. *Peak rate of runoff.* The peak rate of runoff from the critical storm occurring over the developed site shall not exceed the allowable peak rate of runoff from a 1 year, 24 hour storm occurring over the same area prior to development, as defined in the Stormwater Master Plan. Storms of less frequent occurrence (longer return period) than the critical storm shall have the allowable peak rate of runoff not greater than the allowable peak rate of runoff for the same storm as documented in the Stormwater Master Plan.

b) *Unstudied areas*. Stormwater control measures designed for parcels located outside drainage sub-basins established with the Stormwater Master Plan, or any subsequent update thereto shall comply to the following minimum design criteria:

i. Development of sites other than single-family residences and other development sites of less than or equal to 2.0 acres shall not release stormwater runoff greater than 0.2 cubic feet per second per acre of development. On-site storage shall be provided to achieve these peak flow rates.

ii. Development sites greater than 2.0 acres (including single-family lots) shall provide runoff controls as defined by the MORPC Stormwater Design Manual.

c) *Dam safety laws apply.* Stormwater detention and retention ponds which are considered by Ohio Department of Natural Resources (ODNR) to be dam structures regulated under the dam safety laws of the State of Ohio shall be designed to safely pass the design flood events as defined by ODNR. Where fill berms are proposed, calculations supporting the stability of the fill berms are to be submitted by a licensed professional engineer with demonstrated experience in geotechnical engineering. The applicant shall design all raised bermed stormwater ponds according to current ODNR dam safety criteria.

d) *Multiple drainage basins.* If the site has multiple drainage basins, the drainage basin divides that exist prior to development shall be used to determine predevelopment rates of discharge for each drainage area of the site.

e) *Fences.* Fenced stormwater facilities are strongly discouraged within the City and shall only be permitted if approved by the City. The City will consider fencing stormwater facilities only where steep slopes that potentially endanger human life are unavoidable. If fencing is required, the design shall conform to the City's fence code (Chapter 153 of the Zoning Code) along the right-of-way boundary around the entire perimeter, including maintenance berms with access for maintenance vehicles. Other designs may be permitted subject to the review and approval of the City Engineer.

f) *Grading requirements.* Areas adjacent to stormwater control measures shall be graded to restrict the entrance of stormwater except at planned locations. Where stormwater control measures,

particularly basins, are located on the project periphery, the developer may be required to provide additional landscaping or screening to adequately protect abutting properties.

g) *Maintenance berms.* The minimum requirement for publically-owned maintenance berms is as follows:

TABLE 2-6 MINIMUM REQUIREMENT FOR MAINTENANCE BERMS

PONDS	MINIMUM MAINTENANCE ACCESSWAY REQUIRED
With perimeter fencing	20 feet around perimeter
Without perimeter fencing	15 feet around perimeter
Access easement	20 feet along a designated corridor between the pond and a public right-of-way (lesser accessways are subject to the approval of the City Engineer)

h) *Water quality requirements.* Stormwater control measures shall also be designed to meet the stormwater runoff quality requirements of Section 2.D.

i) *Headwalls.* Headwalls shall be required at all storm sewer inlets or outlets to and from stormwater management facilities. Stone and/or brick material approved by the City Engineer shall be provided on all visible headwalls and concrete structures. Refer to City of Dublin Standard Construction Drawings (Standard Drawings) for details.

D. Stormwater Runoff Quality Requirements

1) The design water quality volume for all stormwater control measures shall be the runoff from the first .9-inch of rainfall of each and every storm event. Refer to OEPA Permit No.: OHC000005 or current version for values.

2) In addition, stormwater control measures shall be designed to accommodate flows exceeding their design capacity, either by bypassing excess flows, conveying excess flows through the facility without disrupting its stormwater quality control effectiveness, or storing excess flows as necessary to achieve the drainage, flood control, and erosion control objectives of this Chapter.

3) The Rainwater and Land Development Manual (Ohio EPA)may be referenced for additional design information.

4) Methodologies that incorporate infiltration and rainwater re-use and/or harvesting techniques are encouraged.

3. SPECIAL CONDITIONS AND CONSTRAINTS

The purpose of this Chapter is to identify a number of common site conditions that require supplemental protection or planning. Any site conditions that potentially represent a hazard to the public health, safety or welfare or require supplemental protection must be identified by the applicant in the Stormwater Management Plan, and protective measures must be incorporated into the design of site improvements and stormwater control measures. It is a further purpose of this Chapter to establish standards and demonstrations for approval that are consistent with other regulatory requirements and procedures within the City of Dublin.

A. Existing Wetlands

Recognizing that jurisdiction for all activities affecting wetlands, including mitigation, lies with the Ohio EPA and U.S. Army Corps of Engineers (Corps), the City supports the preservation of existing wetlands and values the stormwater benefits these provide. Wetlands have been determined to provide flood and storm control by the hydrologic absorption and storage capacity; pollution treatment by nutrient uptake from wetland plants and the filtering of silt and organic matter by settlement; protection of subsurface water resources by recharging ground water supplies; and wildlife habitat in nesting areas, feeding grounds, and cover for many species including migratory waterfowl, rare, threatened, or endangered wildlife species.

Jurisdictional and isolated wetlands on development sites shall be delineated by a qualified professional as required by the Corps and the Ohio OEPA. Wetland boundaries shall be mapped in an acceptable electronic format and submitted to the City. Copies of all permit applications and any associated wetland mitigation plans shall also be submitted with the Stormwater Management Plan. The City may not approve stormwater management reports or plans prior to receipt of copies of approved Federal (404) and State (401) permits if any such permits are required.

Where wetlands protected under federal or state law are located partially within the Stream Corridor Protection Zone, the Stream Corridor Protection Zone shall be extended to include the full extent of the wetland area plus any setback from the wetland required by a Section 404 permit.

For impacted wetlands that fall outside the Stream Corridor Protection Zone, the City encourages the mitigation of proposed impacts to occur within the limits of the development site but not outside the boundaries of the same HUC-14 subwatershed. To encourage onsite or intra-watershed wetland mitigation, the City will consider the location of mitigation projects within the Stream Corridor Protection Zones of properties that are located adjacent to a tributary stream provided that:

1) Impacts to isolated wetlands and associated mitigation plans are approved/permitted by the Corps and/or OEPA, and

2) Wetlands constructed for Section 404/401 mitigation purposes are not used to serve as a stormwater control measures to treat stormwater runoff.

The stormwater system design for the project shall provide that the predevelopment quantity and quality of stormwater flows directed to any protected wetlands is maintained. Constructed wetlands (including bio-retention basins) shall not be considered subject to these requirements. Existing wetlands shall not be used for stormwater management or stormwater runoff quality treatment of the development site.

B. Floodplain Encroachment

Floodplain encroachment calculations shall be presented in the following format:

1) 100-year HGL: The applicant shall demonstrate that development in a FEMA Special Flood Hazard Area (SFHA) flood plain does not increase the 100-year flood elevations. Show calculations or computer model output that demonstrates the pre-development and post-

development flood elevations. The applicant should include an SFHA permit and the appropriate fee with the Stormwater Management Plan.

2) Compensating storage: The applicant shall demonstrate that any volume of fill placed in the 100-year floodplain is compensated with an equal volume of material removed above the ordinary high water table and below the 100-year flood elevation. The applicant shall show the volume calculation for the fill and the compensating storage.

3) Note: Please refer to Chapter 151, City of Dublin Codified Ordinances for further information regarding floodplains and floodways.

C. Stream Corridor Protection Zones

The Stream Corridor Protection Zone (SCPZ) is that which is described in § 53.200 Establishment of a Stream Corridor Protection Zone. The SCPZ is the area of setback along a stream established to protect the riparian area and stream from the impacts of development, and streamside residents from the impacts of flooding and land loss through erosion. Streams or channels to which these provisions apply are those having a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water in such a way that terrestrial vegetation cannot establish roots within the streambed, including intermittent, ephemeral, and perennial streams; and streams identified by USGS or NRCS maps. Prohibited uses of the SCPZ include construction, disturbance of natural vegetation, and generally any earth-disturbing activity. However, an SCPZ may be used for stormwater management upon approval from the City Engineer and/or all other applicable review authorities. Refer to § 53.200 for more detail regarding the defined width of a SCPZ, permitted uses, and prohibited uses.

D. Karst and Sinkholes

1) Construction in Sinkhole Drainage Areas: The immediate area around a sinkhole should be disturbed as little as possible. The use of mechanized equipment near the sinkhole should be avoided. Sink areas are known to be unstable for construction. Structures placed on soil foundations in sink areas may be subject to both settling and collapse of the sink. Uncontrolled fill placement may present additional settlement hazards. It shall be required that appropriate geotechnical studies be done and measures taken to insure structure foundations are designed to take into account potential sinkhole locations and instability. Such studies shall account for potential foundation problems for both undisturbed sink areas and those previously filled by others.

2) The floodplain line for a sinkhole is defined by the sinkhole lip elevation. Therefore, the storage volume beneath this elevation is the sinkhole floodplain storage volume. *The pre-development floodplain storage volume must be preserved under post development conditions*. If any fill is added in the floodplain outside the no-fill lines, compensating excavation in the floodplain shall be required.

3) The no-fill line shall be established by the contour line or interpolated contour line for the elevation that defines 60% of the floodplain storage volume. The area encompassed by this line shall be defined as a no-fill zone for all construction activities. No construction fill will be allowed in this zone.

E. Contaminated Sites

Direct infiltration on a brownfield site may introduce additional pollutant loads to groundwater and nearby surface waters. Stormwater control measures can be designed to retain, treat and then release stormwater without allowing it to ever come in contact with contaminated soils.

A key component of stormwater management on brownfield sites is the capture, treatment and storage of the stormwater, rather than complete infiltration. Most brownfields that have residual contamination require the use of a cap to prevent water from coming into contact with contaminated areas. Buildings and other impervious surfaces can be strategically located to act as caps over areas with known contamination. Areas with fill caps can include soils and vegetation above the cap in the form of stormwater control measures such as vegetated control measures (see Section 5). If fitted with an underdrain system to release treated stormwater without infiltration, these planted areas can safely allow filtration and evapotranspiration of stormwater. Additional features such as impermeable liners or gravel filter blankets can be coupled with modified stormwater control measures that safely filter stormwater without exposing the water to contaminated soils.

Green roofs are an ideal way to reduce the runoff from building roofs by encouraging evapotranspiration of rainwater. Another option for brownfield sites is the capture and reuse of stormwater for non-potable uses; this can include runoff storage in rain barrels for irrigation of green roofs or landscaped areas, or in cisterns that store rainwater for toilet flushing and other uses.

4. FLOW CONVEYANCE

The purpose of this Chapter is to provide standards and criteria to ensure the safe and effective flow of storm water through flow paths, treatment facilities and the physical storm drainage system in a manner consistent with protection of the public health, safety and welfare; the safety and function of properties, roads and improvements; and maintaining and improving water and environmental quality in the City of Dublin and its surface waters. Refer to Standard Drawings.

A. Storm Sewers

1) Public storm sewers shall be designed such that they do not surcharge from runoff caused by the 5 year, 24 hour storm, and that the hydraulic grade line of the storm sewer stays below the gutter flow line of the overlying roadway, or below the top of drainage structures outside the roadway during a 10 year, 24 hour storm.

2) Private storm sewers shall be designed such that they do not surcharge from runoff caused by the 2 year, 24 hour storm, and that the hydraulic grade line of the storm sewer stays below the gutter flow line of the overlying roadway, or below the top of drainage structures outside the roadway during a 5 year, 24 hour storm. The system shall be designed to meet these requirements when conveying the flows from the contributory area within the proposed development and existing flows from offsite areas that are upstream from the development.

3) Stormwater runoff from offsite areas that discharge to or across a development site shall be conveyed through the stormwater facilities planned for the development site at their existing peak flow rates during each design storm. No Stormwater Management Plan will be approved until it is demonstrated that offsite runoff will be adequately conveyed through the development site in a manner that will not exacerbate upstream or downstream flooding and erosion.

4) The minimum inside diameter of pipe to be used in public storm sewer systems is 12 inches. Smaller pipe sizes may be used in private systems, subject to the approval of the City Engineer.

5) All storm sewers shall be designed and constructed to produce a minimum velocity of 3.0 feet per second (fps) when flowing full. The City Engineer may impose additional hydraulic design criteria for any storm sewer system or portion thereof designed at a supercritical slope and/or with a full-flow velocity in excess of 10 fps.

6) The outlet ends of all storm sewers shall be provided with sufficient energy dissipaters and erosion protection. See Standard Drawings for rock channel protection details; additional measures may be needed depending upon specific site conditions.

7) The following maximum lengths of pipe shall be used when spacing access structures of any type:

TABLE 4-1 STRUCTURE SPACING

PIPE SIZE	STRUCTURE SPACING
12 to 18 inches	300 feet
24 to 36 inches	400 feet
42 inches and larger	500 feet

8) All storm sewer systems shall be designed taking into consideration the tailwater of the receiving facility or waterbody. The tailwater elevation used shall be based on the design storm frequency.

9) The hydraulic grade line for the storm sewer system shall be computed with consideration for the design tailwater on the system defined in the Stormwater Management Plan and the energy

losses associated with entrance into and exit from the system, friction through the system, and turbulence in the individual manholes, catch basins, and junctions within the system.

10) The minimum cover for storm sewers within the right-of-way shall be one foot measured from the top outside of pipe to the bottom of underdrain at the back of curb. Should underdrains not be required, the minimum cover shall be one foot measured from the top outside of pipe to the top of subgrade at the back of curb. Outside the street right-of-way, a minimum two feet of cover shall be provided measured from the top of finished ground surface to the top outside of pipe.

11) All storm sewers shall be backfilled with Item 912 within the right-of-way and the area of influence of pedestrian paths, fire apparatus access roads, and maintenance berms. All others area shall be backfilled with Item 911.

12) The desired maximum distance for overland flow should be 300 feet before entering a storm structure.

13) The desired maximum overland drainage area tributary to the storm structure should be no greater than 1.5 acres.

14) The maximum spacing of curb inlets shall not exceed 300 feet, or that spacing which shall permit a maximum permissible spread. Spread calculations shall be provided with all storm drainage calculations. Maximum permissible spread is 6' from edge of pavement for streets less than 28 feet measured back to back of curb. A 12-foot clear lane shall be maintained for streets wider than 28 feet. A design storm of 5 years shall be used to determine allowable spread.

15) Within a residential subdivision, catch basins shall be installed in the rear lots approximately every third lot. The property shall be graded in such a way to provide that the stormwater can reach the catch basin through a swale or another measure as approved by the City Engineer.

16) The inverts of all curb and gutter inlets, manholes, catch basins, and other structures shall be formed and channelized.

17) Storm sewer structures shall have grates that permit safe crossing by bicycles as approved by the City Engineer.

18) In areas where public safety and welfare concerns (specifically with children) are an issue, the City Engineer may require that any storm sewer outlet greater than 18 inches in diameter accessible from stormwater management facilities or watercourses shall be provided with safety grates, as approved by the City Engineer. See Standard Drawings.

19) Headwalls shall be required at all storm sewer inlets or outlets to and from open channels or lakes unless otherwise approved by City Engineer.

20) Stone and/or brick approved by the City Engineer shall be provided on all visible headwalls and concrete structures, unless this requirement is specifically waived as part of a Stormwater Management Plan. See Standard Drawings.

B. Culverts and Bridges

1) Roadway stream crossings other than bridges shall be designed to convey the stream's flow for the 25-year, 24-hour storm, with a maximum headwater depth that does not cause flooding or significantly pressurize the culvert, as defined by the Ohio Department of Transportation.

2) The minimum inside diameter of pipes to be used for culvert installations under roadways shall be 12 inches. The minimum inside diameter of pipes to be used for driveway crossings shall be 12 inches.

3) The maximum slope allowable shall be a slope that produces a 10-fps velocity within the culvert barrel. Erosion protection and/or energy dissipaters shall be required to properly control entrance and outlet velocities.

4) All culvert installations shall be designed with consideration for the tailwater of the receiving facility or waterbody. The recurrence frequency of the tailwater elevation shall be the same as the culvert design storm frequency.

5) The determination of the required size of a culvert installation can be accomplished by mathematical analysis or by the use of design nomographs.

6) Headwalls shall be required at all culvert inlets or outlets to and from open channels or lakes. Stone and/or brick approved by the City Engineer shall be provided on all visible headwalls and concrete structures unless specifically waived as part of a Stormwater Management Plan. See Standard Drawings.

7) The minimum cover for culverts within the right-of-way shall be one foot measured from the top outside of pipe to the bottom of underdrain at the back of curb. Should underdrains not be required, the minimum cover shall be one foot measured from the top outside of pipe to the top of subgrade at the back of curb. Outside the street right-of-way, a minimum two feet of cover shall be provided measured from the top of finished ground surface to the top outside of pipe. The structural design of culverts and bridges shall be the same as that required by the Ohio Department of Transportation.

8) Bridges shall be designed such that the hydraulic profile through a bridge shall be below the bottom chord of the bridge for either the 100-year, 24-hour storm, or the peak 100-year flood elevation, whichever is more restrictive.

9) 100-year HGL: The applicant shall demonstrate that the hydraulic grade line resulting from the 100-year, 24-hour storm does not encroach on the roadway above the culvert or above the low chord of bridge. The HGL shall be shown graphically on the storm sewer construction plans or on a tabulation spreadsheet.

10) Velocities: The applicant shall tabulate the culvert flow velocities, and demonstrate that the velocities do not exceed 10 feet per second within the culvert barrel.

11) Tailwater and energy loss: The applicant shall list all tailwater assumptions and their source for applicable design storm events, and the energy loss assumptions at the entrance/exit of the structure.

C. Open Channels

1) Where applicable, streams within the City shall be preserved and protected according to the criteria in § 53.200. Requirements for increasing the conveyance capacity, repairing streambank erosion damage, restoring floodplain storage, and/or rehabilitating aquatic or riparian habitat shall be determined by the City Engineer based on the Stormwater Master Plan or other site-specific criteria necessary to protect the public health, safety and welfare or to satisfy pertinent state and federal regulatory requirements.

2) Wherever possible, drainage tributary to streams, wetlands, lakes, and detention facilities shall be maintained by an open channel with landscaped banks designed to carry the 10-year, 24-hour stormwater runoff from upstream contributory areas. The City Engineer may increase the design storm as conditions require.

3) Alterations to streams and other open channels within FEMA floodplains shall be designed according to the requirements of Chapter 151 of the Dublin City Code along with the requirements contained in this Chapter. All open channels shall be designed with one foot of freeboard above the design water surface elevation of the open channel flowing full.

4) Flood relief channels shall be designed to convey the runoff from the 100-year, 24-hour storm, such that a positive discharge of this runoff to an adequate receiving stream or conveyance system results without allowing this runoff to encroach into proposed or existing residential dwellings or places of business.

5) Roadside ditches along existing roadways may be required to be enclosed if ODOT standards for safety and maintenance cannot be satisfied.

6) Capacity: The applicant shall demonstrate that the hydraulic grade line resulting from the 10-year, 24-hour storm does not rise to within one foot of the top of bank.

7) 100-year HGL: The applicant shall demonstrate that the water elevation resulting from the 100-year, 24-hour storm does not encroach into proposed or existing residential dwellings or places of business. The flood elevation shall be shown on the Stormwater Management Plan and associated maps for the project.

5. STORMWATER CONTROL MEASURES

The purpose of this Chapter is to define the stormwater control measures recommended for use in the City of Dublin. Design requirements for each stormwater control measure are presented in a numbered guidance table with an accompanying figure. It is intended that landscape- or vegetation-based stormwater control measures, when designed in accordance with this Manual, be counted towards applicable landscaping requirements for quantity and spacing of plants under the provisions of the Bridge Street District and Sections § 153.130 - § 139 of the Code, recognizing that landscaping required for screening or installation of street trees [other than those in tree boxes per Section 4).d) below] may require landscaped areas or measures in addition to those used for stormwater control.

A. Common Elements

While there are numerous variations and unique site-specific design elements for each stormwater control measure, several common elements exist that have been included in this section rather than repeated within each guidance table. These common elements include energy dissipation, underdrains, pedestrian areas, setbacks, outlets, and vector control considerations. Note that the discussion of the common design elements covered in this section is not intended to be comprehensive; the designer is expected to use sound engineering principles in the design of all elements of the stormwater control measures.

1) Energy Dissipation

Energy dissipation is expected to be incorporated at all inlets and outlets to prevent erosion, scour, or sloughing of the soil. A typical method used to dissipate energy from water flow is constructing a layer of rock for the water to flow over. The specified size, shape, and weight of the rock are a function of the velocity of the water, the geometry of the protected channel or bank, and the magnitude of wave energy. A geotextile blanket also must be placed beneath the rock. Only Rock Type or Riprap Type C or D shall be used within channels. See Standard Drawings. Forebays also may be used for energy dissipation as well as settling out sediment particles. A hard bottom surface is recommended for forebays.

2) Underdrains

Underdrains shall be a minimum of 6-inch Schedule 40 or SDR 35 smooth wall PVC pipe. Collection laterals shall be placed no greater than 10 feet on center with a minimum of 2 pipes for a given collection system. A minimum of 4 rows of 3/8-inch perforations shall be provided around the diameter of the pipe and the perforations shall be placed 6 inches on center within each row for the entire length of the drainage lateral. The underdrains shall be protected from blockage by including a filtering device. A fine aggregate filter layer is preferred over a filter fabric. A cleanout location shall be included and specified at the terminal ends of underdrains, or another appropriate interval in the case of linear stormwater control measures. Designers are encouraged to incorporate a valve at the underdrain outlet that may be opened for overflow and closed to promote greater infiltration and evapotranspiration from the stormwater control measure.

3) Pedestrian Areas

Care should be taken when designing near pedestrian access points so that pedestrians are able to safely exit from a vehicle onto a level surface without risking a large drop, or stepping into water. Designers are to include a 1.5- to 2-foot safety zone between sloped or uneven surfaces and pedestrian access points, such as sidewalks and curbside parking. Vehicle car doors must be able to be opened.

4) Siting of Stormwater Control Measures

Required setback distances of stormwater control measures from buildings, property lines and other site features are noted within each stormwater control measure guidance table. For stormwater control measures other than the retention basin, pocket wetland, stormwater wetland, rain barrel, and cistern

(SCMs which retain water), it is assumed that the entire facility (surface and subsurface) drains within 72 hours. Exceptions to the required distances are allowed only with approval by the City Engineer as part of a Stormwater Management Plan.

5) Outlet

The outlet to a stormwater control measure shall be designed to meet the hydraulic requirements and minimize vandalism, clogging from trash and debris, and the need for maintenance. Access for maintenance shall be provided. The outlet shall connect to the storm drainage system. Stormwater control measure outlet design should consider the characteristics of the contributing drainage area and the anticipated quantity and type of trash and debris. See Standard Drawings for details.

6) Vector Control Considerations

a) Mosquitoes

Stormwater control measures that are designed to temporarily hold water shall drain within 72 hours to prevent the establishment of mosquito colonies. Rain barrels and cisterns shall be covered and include appropriate screens and other features to prevent the entrance of mosquitoes.

b) Goose Population

Canada Geese are attracted to well-trimmed, urban lawns and shallow ponds where they can browse and roost without fear of predators. To deter geese, basins with a permanent pool shall be constructed with a perimeter buffer incorporating naturalized plantings. Turfgrass and rock edging in and around these stormwater control measures are not allowed, not only to discourage nuisance waterfowl but also to enhance the habitat value of these practices.

7) Naturalized Plantings

Naturalized plantings are encouraged to be incorporated into the design of all stormwater control measures involving vegetation.

8) Construction Staging for Vegetated Stormwater Control Measures

The use of vegetation and soil-based treatment systems as outlined in this Chapter requires careful attention to construction staging and phasing. Protection of soils from compaction and disturbance during site preparation and construction, soil amendment, the installation of soil and filter media, and the timing, placement and techniques used in planting, all affect the ultimate efficacy of these stormwater control measures. Therefore a construction and phasing plan must be included in the Stormwater Management Plan for all vegetated stormwater control measures to ensure proper construction, function, and treatment.

B. Stormwater Control Measure Design Guidance

This section is intended to provide guidance for the design of stormwater control measures. A brief description is provided of each stormwater control measure accompanied by a design guidance table and a diagram. The guidance tables and diagrams follow at the end of this chapter.

1) Rainwater Harvesting (Guidance 1 and 2)

Rainwater harvesting is the practice of collecting rainwater and re-using it for purposes such as irrigation and non-potable building uses. With regard to stormwater, the City's standard does not allow rainwater harvesting systems to be used to meet stormwater requirements. However, rainwater harvesting is encouraged as a water conservation and efficiency practice.

Two rainwater harvesting systems are addressed in this Chapter: rain barrels and cisterns. A rain barrel is an above-ground prefabricated storage receptacle with an automatic overflow diversion system that collects and stores stormwater runoff from the roof of a structure that would have been otherwise routed into a storm drain. A cistern is an underground storage component of a rainwater harvesting system, and is typically larger than 80 gallons.

Pretreatment of rainwater prior to entering a storage tank is necessary to keep debris, particularly leaf litter, out of the rainwater harvesting system. Typically this is some type of leaf screen along the gutter or in the downspout. Regular cleaning of these devices is needed to prevent clogging and the buildup of bacteria housed in the leaf decay. It is also recommended that a first-flush diverter be installed to divert the first flow of water, which is typically laden with dust, leaves, twigs, insect bodies, animal feces, and pesticides, to a planted area. Care should be taken to ensure compliance with any potentially applicable plumbing and building codes.

2) Filter Strip (Guidance 3)

Filter strips are bands of dense, permanent vegetation with a uniform slope, primarily designed to provide water quality pretreatment between a runoff source (i.e., impervious area) and another stormwater control measure. The inflow source for a filter strip must be conveyed as sheet flow. Typically this is accomplished by installing a level spreader system immediately upstream of the filter strip. Filter strips are well suited for treating runoff from roads, parking lots, and disconnected downspouts. They may also be used along streams to treat agricultural runoff and may be referred to as buffer strips. Filter strips provide water quality improvement primarily through vegetative filtering and infiltration. Reductions in runoff volume from small storms can be achieved if the soils are sufficiently pervious, sheet flow is maintained along the entire length and width of the strip, and contact time is long enough for infiltration to occur.

3) Media Filter (Guidance 4)

A media filter preceded by a settling basin is a treatment system that is used to remove particulates and solids from stormwater runoff through settling and filtering. The system may be constructed underground in a concrete vault or above ground using earthen berms. Stormwater diverted to the system travels through a settling basin, across a level spreader, and into the media filter. Media is typically sand, peat, or other amended soil. Often, the water quality volume of runoff is temporarily stored above the filter bed. Once the stormwater flows through the filter, it can infiltrate into the native soils or be collected in an underdrain.

4) Vegetated Stormwater Control Measures

The vegetated stormwater control measures include traditional bioretention, bioretention swale, planter box, tree box, and bioretention curb extension. All are included in this category because they use vegetation as an integral part of the system design. It is expected that the growing layer depth for these facilities be tailored to meet the needs of the selected vegetation with a minimum depth of 12 inches.

a) Traditional Bioretention (Guidance 5)

Traditional bioretention describes a shallow stormwater basin or landscaped area that utilizes a soil media and vegetation to capture and treat runoff. It may also be referred to as a rain garden. There are numerous design applications for bioretention. These include use on single-family residential lots, on commercial/industrial sites, as off-line facilities adjacent to parking lots, and along highways and roads. Bioretention areas are designed primarily for the removal of stormwater pollutants from runoff. These facilities may sometimes be used to partially or completely meet quantity control requirements from smaller tributary areas.

b) Bioretention Swale (Guidance 6)

A bioretention swale is a modified swale that uses a soil media to improve water quality, reduce the runoff volume, and modulate the peak runoff rate while also providing conveyance of excess runoff. Bioretention swales are well suited for use within the rights-of-way of linear transportation corridors. They perform the same functions as grassed swales by serving as a conveyance structure and filtering and infiltrating runoff, but because soil media is used, they provide enhanced infiltration, water retention, and pollutant removal. Bioretention swales may be used in conjunction with pretreatment control measures such as filter strips or other sediment capturing devices to prevent sediment from accumulating in the swale.

c) Planter Box (Guidance 7)

A planter box is a variation of traditional bioretention. It performs the same function but is contained within a concrete box which allows it to be incorporated into tight areas such as along a street corridor or attached to a building along the foundation. Planter boxes are often categorized either as flow-through planter boxes or infiltrating planter boxes. Infiltrating planter boxes have an open bottom to allow infiltration into the underlying soils. Flow-through planter boxes are completely lined and have an underdrain system to convey flow that is not taken up by plants to areas that are appropriate for drainage, typically away from building foundations.

d) Tree Box (Guidance 8)

Tree boxes are urban applications of bioretention systems using the water-uptake benefits of a tree. They are generally installed along street corridors with curb inlets. Tree boxes have the ability to be incorporated immediately adjacent to street and sidewalks with the use of a structural soil, modular suspended pavement, or underground retaining wall to keep uncompacted soil in its place. The uncompacted media allows urban trees to thrive, providing shade and an extensive root system for water uptake. For low to moderate flows, stormwater enters through the tree box inlet and filters through the soil. For high flows, stormwater will bypass the tree box if it is full and flow directly to the downstream curb inlet.

e) Bioretention Curb Extension (Guidance 9)

A bioretention curb extension is another variation of traditional bioretention. It performs the same function as traditional bioretention but is contained at least partially within a curb, usually within a street corridor or in a parking lot. Unlike a planter box, curb extensions do not have retaining walls, and therefore comparatively require more space.

5) Permeable Pavements (Guidance 10)

Permeable pavements contain small voids that allow stormwater to drain through the pavement to an aggregate reservoir and then either infiltrate into the soil, or flow through an underdrain to the storm drain network. Permeable pavement includes permeable concrete, permeable asphalt, interlocking concrete pavers, concrete grid pavers, and plastic grid pavers.

Permeable pavement is typically used to replace traditional impervious pavement for most pedestrian and vehicular applications except high-volume/high-speed roadways. Permeable pavements have been used successfully in pedestrian walkways, sidewalks, driveways, parking lots, and low-volume roadways. Several design options are available for using permeable pavements to intercept, contain, filter, and where appropriate infiltrate stormwater on site. Permeable pavements can be installed across an entire street width or an entire parking area. Alternatively, they can be installed in combination with impermeable pavements to infiltrate runoff; several applications use permeable pavement in parking lot lanes or parking stalls to treat runoff from adjacent impermeable pavements.

6) Green Roof (Guidance 11)

Green roofs are used to introduce vegetation onto sections of roof to reduce imperviousness and absorb and filter rainfall. Green roofs consist of a layer of soil media and vegetation that filter, absorb, and retain/detain the rain that falls upon them. Rainfall that infiltrates into the green roof is lost to evaporation or transpiration by plants, or, once the soil has become saturated, percolates through to the drainage system and is discharged through the roof downspouts. Green roofs may cover large sections of a roof while maintaining access for utilities, maintenance, or recreation. Green roofs are most often applied to buildings with flat roofs, but can be installed on roofs with slopes with the use of mesh, stabilization panels, or battens.

7) Basins

The term "basins" includes pocket wetland, retention basin (wet pond), stormwater wetland, and dry extended detention. Common elements of these basins are the inclusion of a forebay and micropool to help settle out sediment. The basin inlet discharges into the forebay while the micropool is used before water leaves the basin through the outlet.

a) Pocket Wetland (Guidance 12)

Pocket wetlands are small constructed shallow marsh systems designed and placed to use the natural processes of wetland vegetation, soils, and their associated biological activity to provide treatment for stormwater runoff. As engineered facilities, stormwater wetlands have less biodiversity than natural wetlands but still require a base flow to support the aquatic vegetation present. Pocket wetlands rely on a high groundwater table to provide a perennial base flow.

Pollutant removal in these systems occurs through the settling of larger solids and coarse organic material and also by uptake in the aquatic vegetation. Wetlands can also be designed to remove ammonia through nitrification/denitrification processes, which may be particularly useful in agricultural settings. Wetlands can be used to enhance the aesthetics of a site and to increase the available habitat.

b) Retention Basin (Guidance 13)

Retention basins are large facilities designed with a permanent pool of water plus additional storage above the level of the permanent pool. During a storm event, water enters the basin and is stored temporarily as it is slowly released to the storm drain network. A safety bench and planted aquatic bench are required around the perimeter of the wet pool. The presence of a mechanical aerator, such as a fountain in the middle of the pond, may be used to make the site more attractive, deter the growth of unwanted vegetation, and make the habitat more suitable for fish.

c) Stormwater Wetland (Guidance 14)

Stormwater wetlands have a similar design and function as a pocket wetland but they depend on flow from the contributing drainage area rather than groundwater flow as their base flow source. Because of this, they tend to require large contributing drainage areas to obtain adequate base flow to function well.

d) Extended Dry Detention (Guidance 15)

Extended dry detention basins are large facilities designed without a permanent pool of water. The outlets are designed such that stormwater runoff is detained for a period of time, typically 24 hours to 72 hours. The temporary storage allows sediment to settle out; overall, however, extended dry detention basins are minimally effective in removing pollutants compared to other stormwater control measures.

8) Underground Retention/Detention (Guidance 16)

Underground retention/detention achieves the capture and temporary storage of stormwater collected from the tributary drainage area. Curb inlets or surface drains lead stormwater to underground vaults or systems of large diameter interconnected storage pipes. The stormwater is then released directly through an outlet pipe back into a stormwater drainage system or allowed to infiltrate to the groundwater table. The outlet system is designed to meet the quantity control requirements.

Underground retention/detention should not be expected to substantially improve water quality unless preceded by a pretreatment practice such as a swale or prefabricated device. Underground retention/detention may be useful for developments where land availability and land costs predicate against the development of surface stormwater control measures and in retrofit and redevelopment settings. Pretreatment is crucial for minimizing maintenance of the storage unit and should be designed to remove sediment, floatables, and oils if prevalent in the drainage area. Where an opening is provided that could allow the entry of personnel, the opening shall be marked, "DANGER- CONFINED SPACE".

9) Prefabricated Devices

Proprietary devices typically consist of catch basin controls or stand-alone vaults that prevent sediment, oils, floatable trash, and debris from being transmitted through the collection system. For instance, several catch basin insert devices are available that use screens, baffles, filter fabrics, and absorbents to capture and retain pollutants within the catch basin. Oil-water separators, sedimentation tanks, gross solids removal screens, and hydrodynamic separators (flow-through devices with a settling or separation unit) are examples of proprietary devices that can be used to remove sediments and other stormwater pollutants. A variety of devices and manufacturers exist, and new products are continuously emerging.

The use of prefabricated devices, other than for retrofit or redevelopment situations where site limitations limit the use of other stormwater control measures, generally is discouraged. Proprietary devices are recommended to be used in conjunction with other control measures as part of a stormwater treatment train. However, these controls are generally considered pretreatment devices, as they typically provide limited treatment when compared to other control measures.

10) Other Approved Stormwater Control Measures

Other stormwater control measures may be recommended to satisfy stormwater management requirements if the Stormwater Management Plan for the site demonstrates to the satisfaction of the City Engineer that these stormwater control measures achieve effluent quality and runoff volume reduction equivalent to recommended stormwater control measures, and can be adequately maintained.

This page is intentionally blank.

Guidance (1) Rain Barrel

1. Siting Setbacks		
Pavement	1	No requirement
Building	2	≤ 1 feet; side or rear of building; if visible from street, it must be screened with landscaping to the top
Property lines/ROW	3	≥ 3 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥ 2 feet above to prevent buoyancy
Septic System/Wells		No requirement
2. Volume		
Surface Area		No requirement
Dimensions		≤ 6 feet above grade including any supporting frame
Bottom slope		Not applicable
Side slopes	4	Not applicable
Freeboard	5	No requirement
3. Vertical Component		
Storage	6	≤ 80 gallons
Growing Layer	7	Not applicable
Filter Layer	8	Not applicable
Drainage Layer	9	Not applicable
Native Material	10	Not applicable
4. Drainage		
Inlet	11	One or more downspouts from roof drainage only; No materials treated with fungicides or herbicides
Underdrain	12	Not applicable
Outlet	13	No requirement
Overflow	14	Required; Must be directed away from the building foundation; Must not cause excessive erosion or water damage, or must be diverted to the public storm sewer or other approved location
Evapotranspiration		No requirement
Infiltration		No requirement
Dewatering		No requirement
5. Composition		
Surface Treatment		Not applicable
Vegetation		Not applicable
Soil Media		Not applicable
Side Slopes		Not applicable
Mulch		Not applicable
6. Pollutant		
Pretreatment	15	Must include a debris excluder prior to entering the storage tank
Sediment Storage		No requirement
7. Maintenance		
Access		Rain barrels shall be covered and protected from unintentional entry by humans, vermin, or insects
Requirements		1) Harvested rainwater may only be used for irrigation and water features; 2) Drain and thoroughly clean at least once annually to avoid freezing in winter temperatures; 3) Rain barrels are not permitted as water quality controls
Aesthetics		1) Plastic rain barrels must be neutral in color, painted to match the body or trim color of the home or match as closely as possible the attached building. Any connector hoses from the downspout to the rain barrel must match the color of the downspout 2) Rain barrels constructed of natural material or designed to appear similar to a wood barrel, planter, stone boulders, or similar may remain as constructed and are not required to match in color the attached building
8. Calculations		None

Notes: Preferably located to the side or rear of residence. No platform or raising structure is permitted to elevate the rain barrel forward of the residence (§ 153.071) Notes: There shall be no direct connection of any rainwater harvesting system and any domestic potable water system except when protected from cross-contamination in accordance with all applicable codes and requirements.

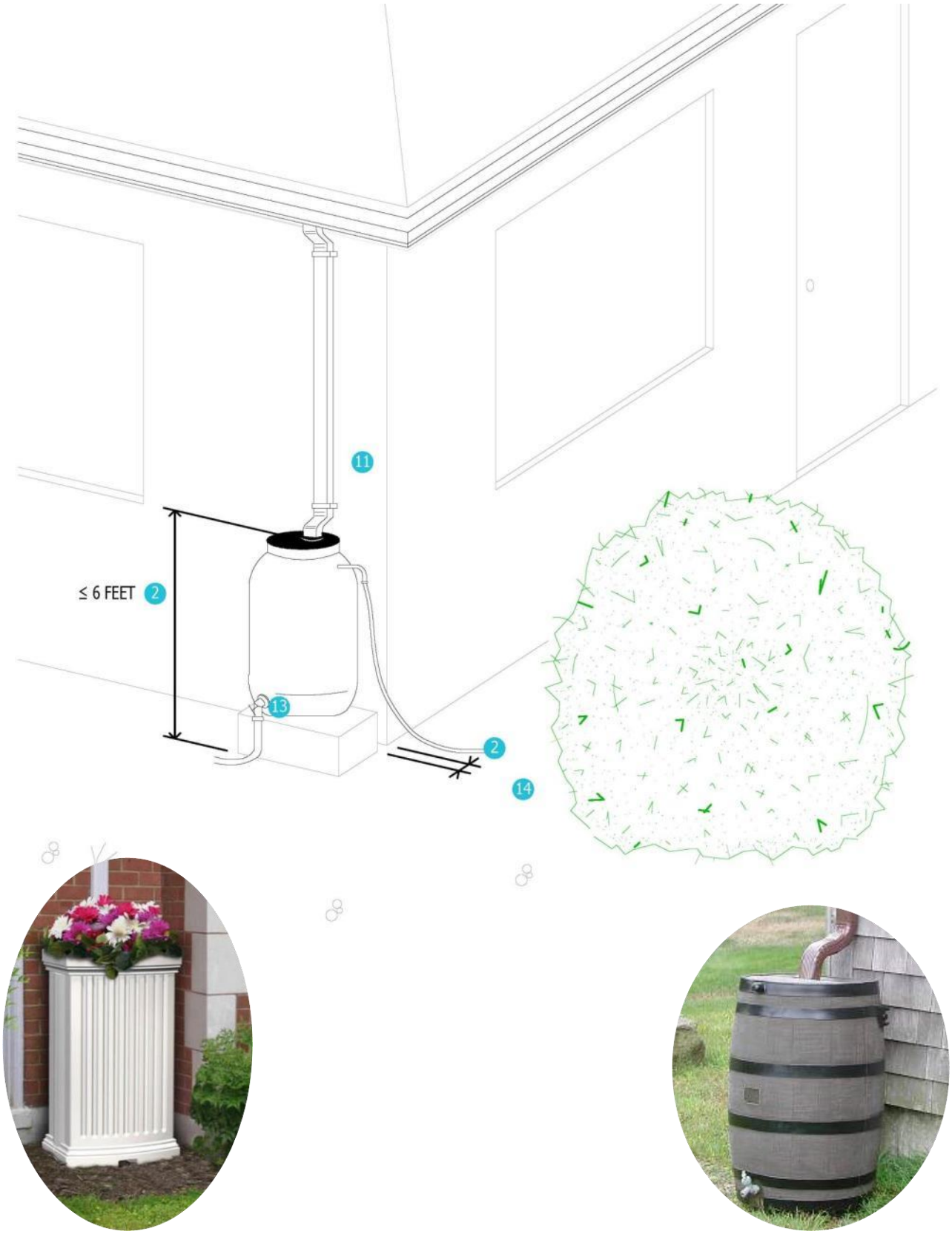


FIGURE 5-1 RAIN BARREL DIAGRAM

Guidance (2) Cistern

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW (3)	≥ 3 feet
Groundwater/Karst/ Bedrock	Bottom of practice to be ≥ 2 feet above to prevent buoyancy
Septic System/Wells	No requirement
2. Volume	
Surface Area	No requirement
Dimensions	No requirement
Bottom slope	Not applicable
Side slopes (4)	Not applicable
Freeboard (5)	No requirement
3. Vertical Component	
Storage (6)	No requirement
Growing Layer (7)	Not applicable
Filter Layer (8)	Not applicable
Drainage Layer (9)	Not applicable
Native Material (10)	Not applicable
4. Drainage	
Inlet (11)	Gutters and downspouts from roof drainage only; No materials treated with fungicides or herbicides
Underdrain (12)	Not applicable
Outlet (13)	Designed to meet hydraulic requirements; minimize vandalism and maintenance.
Overflow (14)	Required; Must be directed away from the building foundation; Must not cause excessive erosion or water damage, or must be diverted to the public storm sewer or other approved location
Evapotranspiration	No requirement
Infiltration	No requirement
Dewatering	No requirement
5. Composition	
Surface Treatment	Not applicable
Vegetation	Not applicable
Soil Media	Not applicable
Side Slopes	Not applicable
Mulch	Not applicable
6. Pollutant	
Pretreatment (15)	Must include a debris excluder prior to entering the storage tank
Sediment Storage	No requirement
7. Maintenance	
Access	Able to be accessed by a vehicle; Cisterns shall include manhole risers a minimum of 8 inches above surrounding grade; Cisterns shall be covered and protected from unintentional entry by humans, vermin, or insects; Manhole covers shall be provided and shall be secured and locked to prevent tampering; Where an opening is provided that could allow the entry of personnel, the opening shall be marked, "DANGER- CONFINED SPACE".
Requirements	1) Harvested rainwater may only be used for irrigation and water features. Other usages may be allowed with City approval 2) Maintenance Plan shall be submitted w/ Stormwater Mgmt. Plan; 3) Cisterns are not permitted as water quality controls without prior approval from City Engineer
8. Calculations	None

Notes: There shall be no direct connection of any rainwater harvesting system and any domestic potable water system except when protected from cross-contamination in accordance with all applicable codes and requirements.

Only below-grade cisterns are permitted.

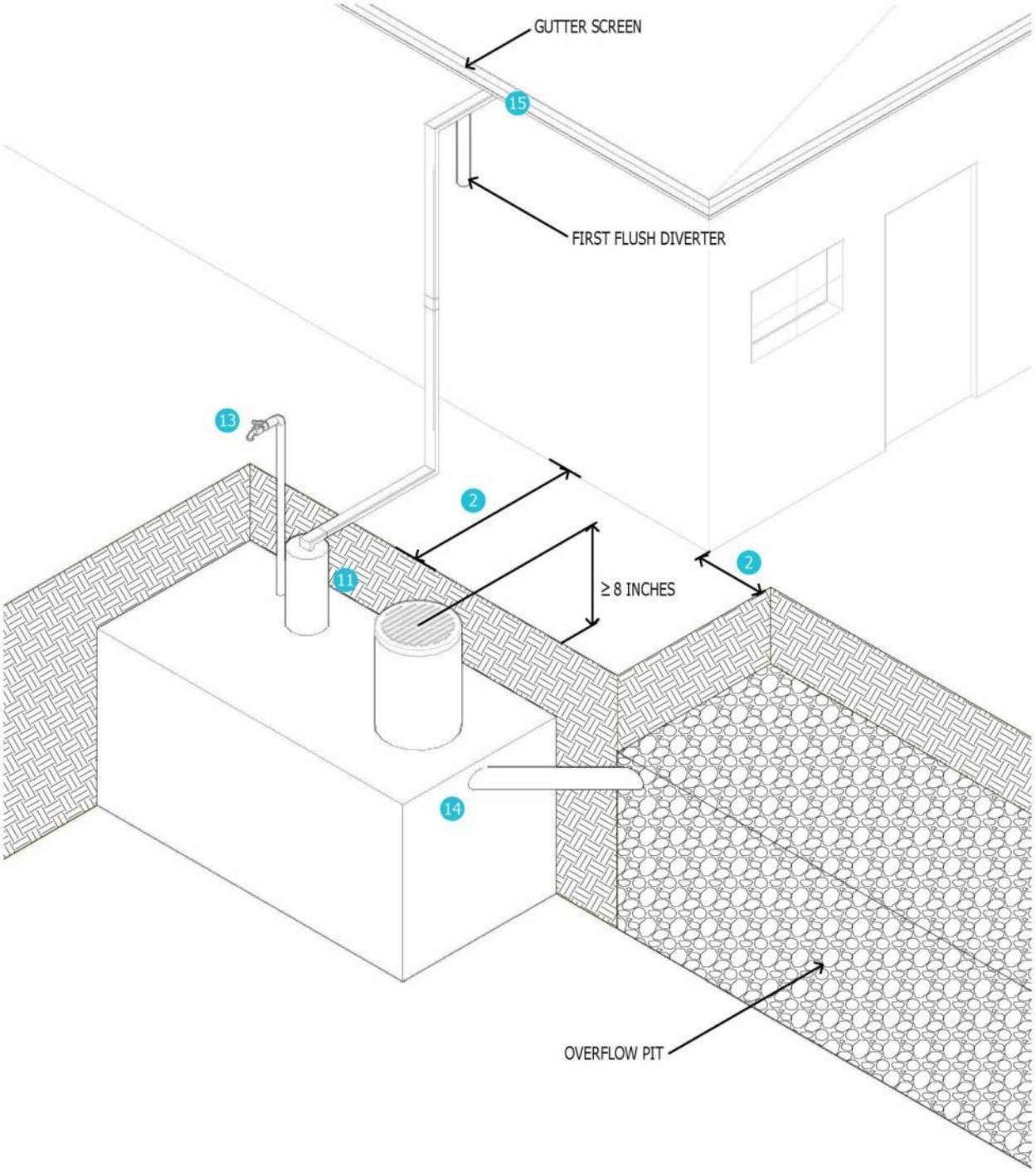


FIGURE 5-2 CISTERN DIAGRAM

Guidance (3) Filter Strip

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW (3)	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock	Bottom of practice to be ≥2 feet above or use liner
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	No requirement
Dimensions	Minimum length of 30 feet; Length must be less than that at which sheet flow concentrates; Depends on surface slope; Width is 10 to 100 feet
Surface slope	Filter Strip (longitudinal): 1% to 5% Blind Swale/Level Spreader: 0%
Side slopes (4)	Not applicable
Freeboard (5)	Not applicable
3. Vertical Component	
Surface Storage (6)	Depth of flow ≤ 3 inches
Growing Layer (7)	≥ 6 inches of soil media
Filter Layer (8)	Not applicable
Drainage Layer (9)	Not applicable
Native Material (10)	Conduct soil analysis to determine if it is suitable soil media
4. Drainage	
Inlet (11)	Blind swale and level spreader required
Underdrain (12)	Beneath blind swale; Drain to bypass
Outlet (13)	Catch basin, swale; receiving stream
Overflow (14)	High flow bypass upstream of blind swale
Evapotranspiration	No requirement
Infiltration	For BSD exemption areas, meet groundwater recharge requirement
Dewatering	≥ 24 hours

5. Composition	
Surface Treatment	Dense vegetation; able to withstand relatively high velocity flows and both wet and dry conditions; usually kept as lawn, 3 to 4 inches in height
Vegetation	Required
Soil Media	Must be able to sustain a grass cover and allow some infiltration
Side slopes	Not applicable
6. Pollutant	
Pretreatment (15)	Sediment forebay or Riprap-lined blind swale
Sediment Storage	Not applicable
7. Maintenance	
Access	Able to be accessed by a vehicle
Requirements	Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations	
Convey Water Quality Vol. (WQv) Hydrograph: $WQ_v = R_v * P * A / 12$ where: WQ_v = water quality volume in acre-feet R_v = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_v = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Determine Design Flow Depth (≤ 1.5 inches): Hydrograph Duration = 2 hours Hydrograph Intensity (in/hr) = WQv*6/A Design Peak Flow Rate = Use Rational Formula Method Geometry = Use Manning's Equation to demonstrate that the flow depth is ≤ 1.5 inches while conveying the WQv hydrograph.	

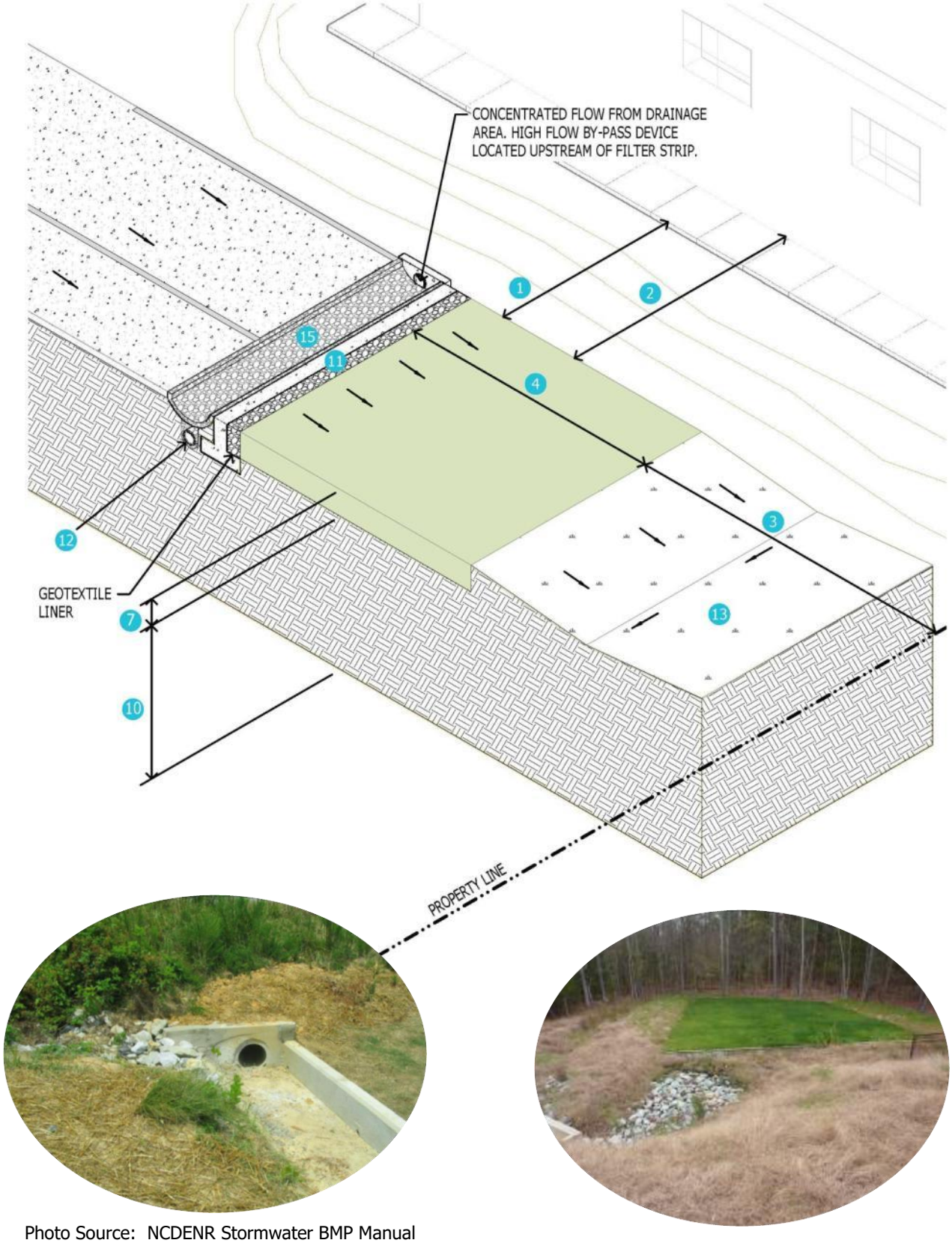
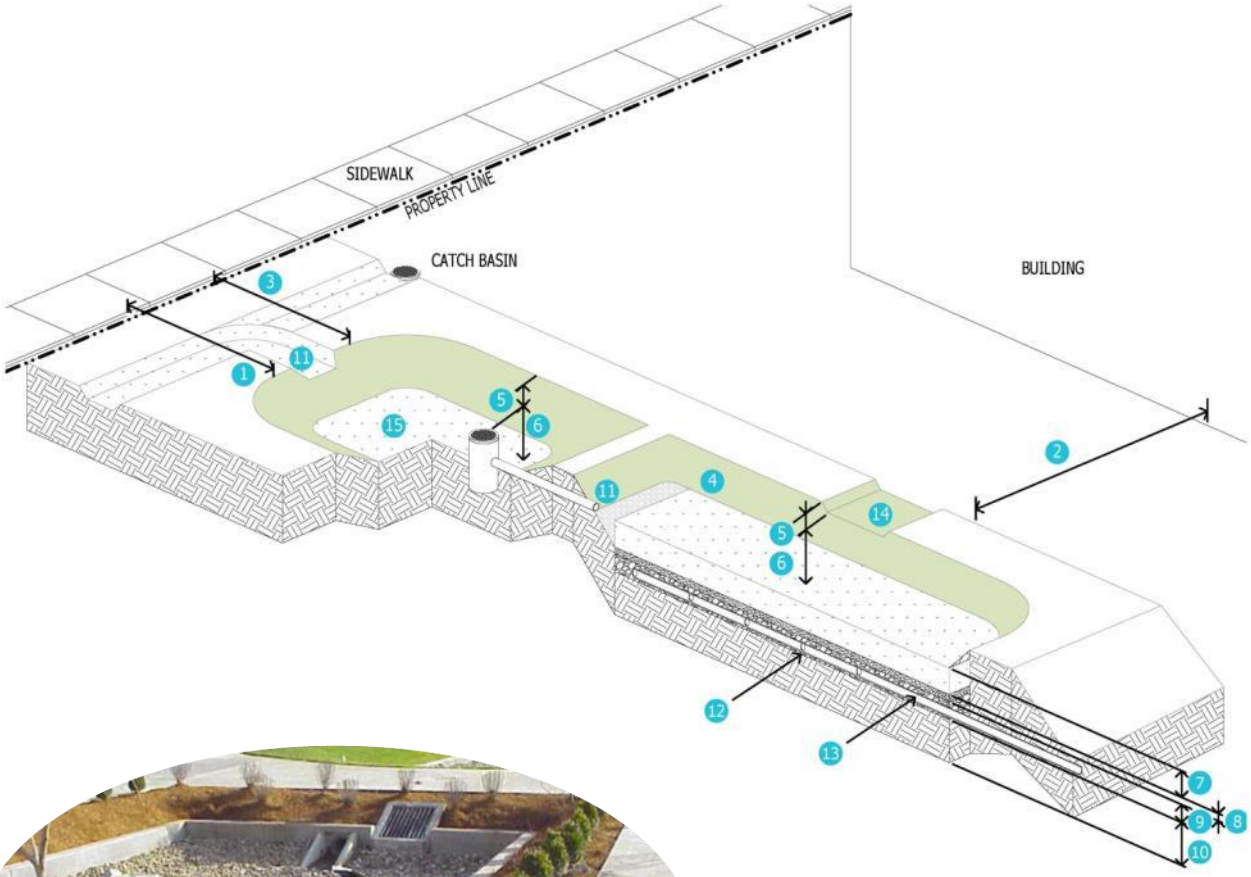


Photo Source: NCDENR Stormwater BMP Manual

FIGURE 5-3 FILTER STRIP DIAGRAM

Guidance (4) Media Filter

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property Lines/ROW (3)	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock	Bottom of practice to be ≥ 2 feet above or use impermeable liner
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	Settling Basin: Min. length to width ratio of 2:1 or use baffles Media Filter: 600 ft^2 per tributary impervious acre
Dimensions	Total system requires 4 to 8 feet of elevation drop
Bottom slope	Settling Basin: No requirement Media Filter: Flat
Side slopes (4)	4H:1V or flatter and vegetated or vertical concrete walls
Freeboard (5)	Settling Basin: ≥ 0.5 foot Media Filter: ≥ 1 foot
3. Vertical Component	
Surface Storage Layer (6)	Settling Basin: 3 to 10 feet Media Filter: 1 to 4 feet
Filter Media Layer (7)	≥ 1.5 feet of sand, peat, amended soil, or other media w/ a diameter of 0.02 to 0.04 inches
Filter Stone Layer (8)	3 to 4 inches of #8 or #78 washed stone
Drainage Layer (9)	≥ 8 inches of clean coarse aggregate AASHTO #4, #5, or equivalent
Native Material (10)	No requirement
4. Drainage	
Inlet (11)	≤ 2 ft/sec into settling basin; Uniformly spread across filter from settling basin to filter
Underdrain (12)	6-inch perforated PVC placed to meet dewatering requirement; cleanout at terminal ends
Outlet (13)	Required
Overflow (14)	Weir; Adhere to ODNR dam safety laws as applicable
Evapotranspiration	No requirement
Infiltration	For BSD exemption areas, meet groundwater recharge requirement
Dewatering	Settling basin releases volume to the filter within 24 hours; Media Filter provides a filtration time of no less than 24 hours and no more than 40 hours
5. Composition	
Surface Treatment	None
Vegetation	Side slopes only (typically grass)
Filter Media	Meets dewatering requirement
Mulch	Not applicable
6. Pollutant	
Pretreatment (15)	Settling basin is required
Sediment Storage	Equal to 20% of water quality volume within settling basin
7. Maintenance	
Access	A stable vehicular access way shall be provided
Requirements	1) Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan 2) Install a fixed vertical sediment depth marker in settling basin
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Settling Basin = WQv +0.2*WQv	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7.	



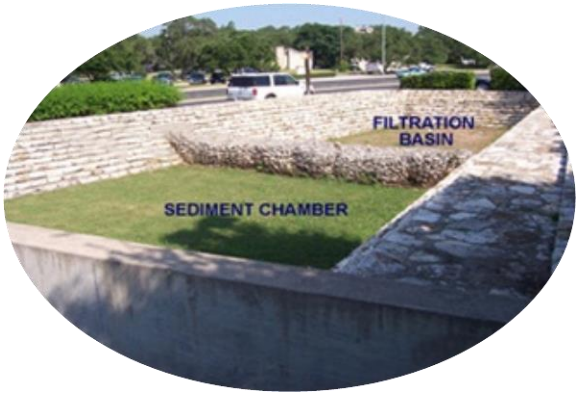


Photo Source: www.austintexas.gov

FIGURE 5-4 MEDIA FILTER DIAGRAM

Guidance (5) Traditional Bioretention

1. Siting Setbacks		
Pavement	1	No requirement
Building	2	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW	3	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥ 2 feet above or use impermeable liner
Septic System/Wells		≥ 50 feet / ≥ 100 feet
2. Volume		
Surface Area		No requirement
Dimensions		No requirement
Bottom slope		Flat
Side slopes	4	2H:1V or flatter
Freeboard	5	6 to 12 inches
3. Vertical Component		
Surface Storage	6	6 to 12 inches
Growing Layer	7	≥ 12 inches soil media; 3 inches of mulch, max
Filter Layer	8	2 to 4 inches of clean medium sand (ASTM c-33) over 2 to 3 inches of #8 or #78 washed stone when drainage layer is used
Drainage Layer	9	Recommended 12 to 30 in. of clean coarse aggregate AASHTO #4, #5, or equivalent
Native Material	10	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage		
Inlet	11	Curb inlet or sheet flow through grass filter strip
Underdrain	12	6-inch perforated PVC placed to meet dewatering requirement if needed; cleanout at terminal ends
Outlet	13	Required
Overflow	14	Catch basin set 6 to 12 inches above soil surface and connected to storm drainage network; Weir in berm placed to minimize property damage
Evapotranspiration		No requirement
Infiltration		For BSD exemption areas, meet groundwater recharge requirement
Dewatering		Between 24 and 56 hours; No more than 1/2 of the WQv is released in less than 1/3 of the minimum drawdown period of 40 hours
5. Composition		
Surface Treatment		Vegetation and mulch
Vegetation		Required
Soil Media		With or without an underdrain, meets dewatering requirement; supports plant growth
Side Slopes		Grass or mulch, no stone
Mulch		Triple-shredded hardwood
6. Pollutant		
Pretreatment	15	Required. May include grass filter strip, stone trench, forebay, sump inlets
Sediment Storage		No requirement
7. Maintenance		
Access		Accessible from a vehicle
Requirements		Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations		
Water Quality Volume (WQv) = WQv = Rv * P * A / 12where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface		
Ponding Area = $WQv*d_s/[k*(h_s+d_s)*t_s]$ d_s=soil media depth k=coefficient of permeability of soil media (ft/day). Use lab values or projected values after settling and use. h_s=average height of water above soil media and mulch, feet t_s=facility drain time (days)		
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7		

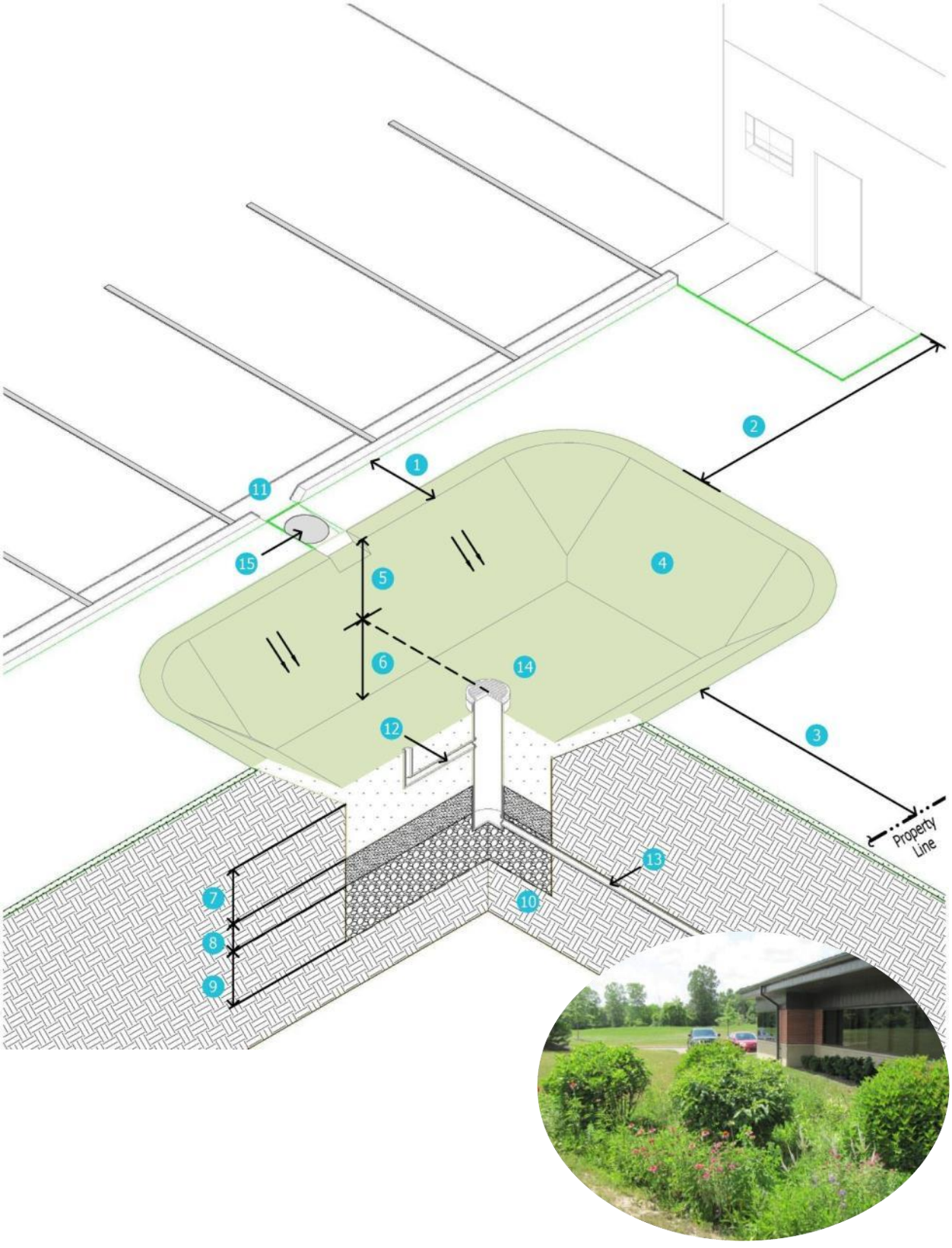


FIGURE 5-5 TRADITIONAL BIORETENTION DIAGRAM

Guidance (6) Bioretention Swale

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW (3)	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock	Bottom of practice to be ≥ 2 feet above or use impermeable liner
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	No requirement
Dimensions	Minimum length of 25 feet
Bottom slope	≥ 1%; Maximum slope is limited to that which does not cause scour
Side slopes (4)	2H:1V or flatter above the surface
Freeboard (5)	6 to 12 inches
3. Vertical Component	
Surface Storage (6)	6 to 12 inches
Growing Layer (7)	≥ 12 inches soil media
Filter Layer (8)	*Optional:* 2 to 4 inches of clean medium sand (ASTM c-33) over 2 to 3 inches of #8 or #78 washed stone
Drainage Layer (9)	*Optional:* 12 to 30 in. of clean coarse aggregate AASHTO #4, #5, or equiv.
Native Material (10)	Test infiltration; ≥1/2 in/hr if designing w/ infiltration
4. Drainage	
Inlet (11)	Curb inlet or sheet flow through grass filter strip
Underdrain (12)	*Optional:* 6-inch perforated PVC; cleanout at terminal ends
Outlet (13)	Required
Overflow (14)	Catch basin set 6 to 12 inches above soil surface and connected to storm drainage network; Weir in berm placed to minimize property damage
Evapotranspiration	No requirement
Infiltration	For BSD exemption areas, meet groundwater recharge requirement
Dewatering	Between 24 and 56 hours; No more than 1/2 of the WQv is released in less than 1/3 of the minimum drawdown period of 24 hours
5. Composition	
Surface Treatment	Vegetation, no mulch
Vegetation	Required
Soil Media	With or w/o an underdrain, meets dewatering requirement; supports plant growth
Side slopes	Grass, no mulch, no stone
6. Pollutant	
Pretreatment (15)	Required. May include grass filter strip or sump inlets
Sediment Storage	No requirement
7. Maintenance	
Access	Able to be accessed by a vehicle; Possibly adjacent to parallel parking for convenience
Requirements	Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Ponding Area = $WQv*d_s/[k*(h_s+d_s)*t_s]$ d_s=soil media depth k=coefficient of permeability of soil media (ft/day). Use lab values or projected values after settling and use. h_s=average height of water above soil media and mulch, feet t_s=facility drain time (days)	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7	
Notes: [1]Use weirs, check dams, or equivalent to detain and treat the water quality volume for a minimum of 24 hours, promote pooling and infiltration, and aid in maintaining non-erosive flow velocities.	

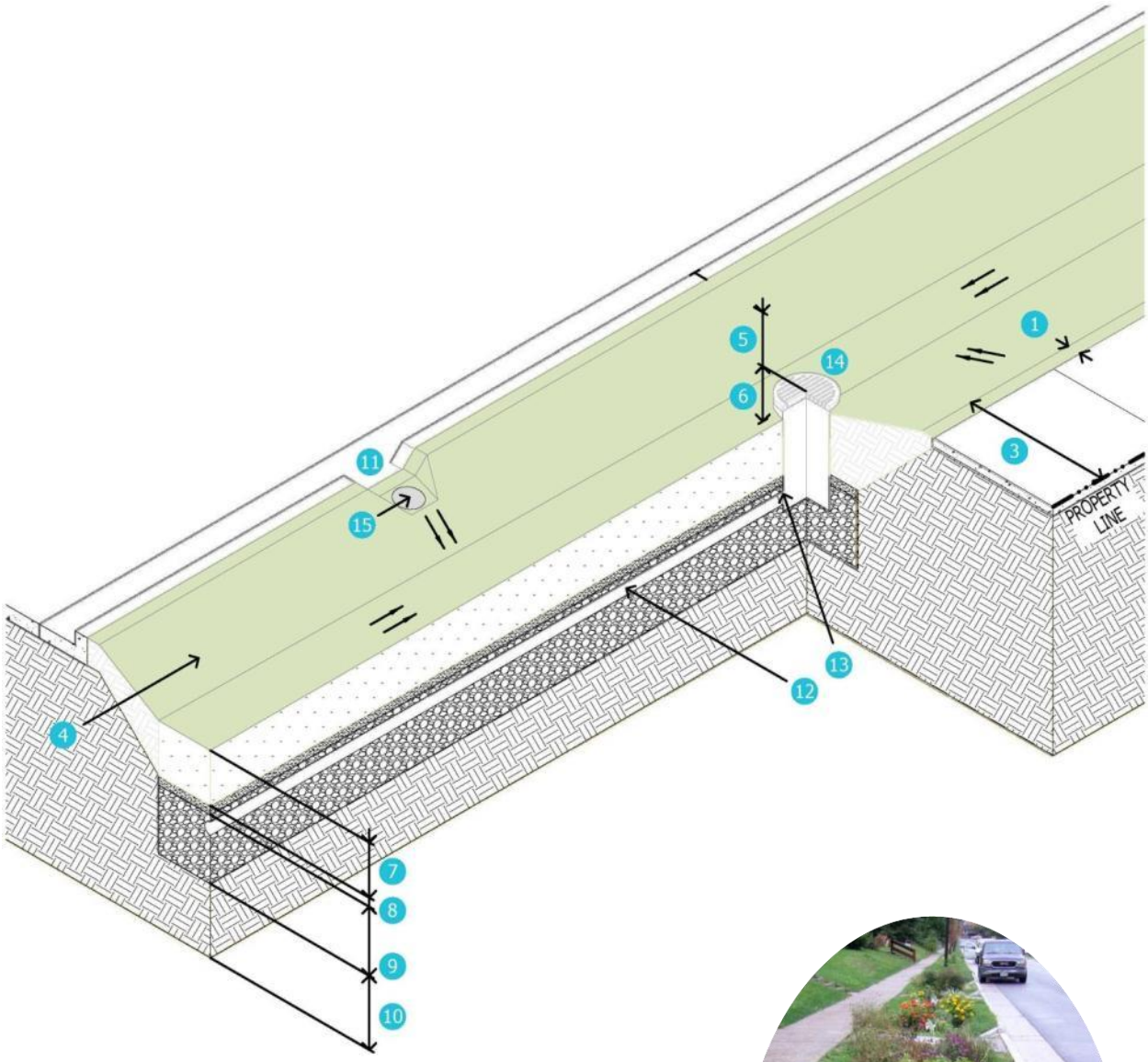


FIGURE 5-6 BIORETENTION SWALE DIAGRAM

Guidance (7) Planter Box

1. Siting Setbacks		
Pavement	1	No requirement
Building	2	No requirement w/ solid or lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW	3	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥2 feet above or use liner
Septic System/Wells		≥ 50 feet / ≥ 100 feet
2. Volume		
Surface Area		No requirement
Dimensions		No requirement
Bottom slope		Flat
Side slopes	4	Vertical retaining wall
Freeboard	5	2 to 6 inches
3. Vertical Component		
Surface Storage	6	6 to 12 inches
Growing Layer	7	≥ 12 inches soil media; 3 inches of mulch, max
Filter Layer	8	*Optional:* 2 to 4 inches of clean medium sand (ASTM c-33) over 2 to 3 inches of #8 or #78 washed stone
Drainage Layer	9	*Optional:* 12 to 30 in. of clean coarse aggregate AASHTO #4, #5, or equivalent
Native Material	10	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage		
Inlet	11	Curb inlet; downspout w/ energy dissipation
Underdrain	12	6-inch perforated PVC placed to meet dewatring-requirement if needed; cleanout at terminal ends
Outlet	13	Required
Overflow	14	Downstream inlet or stand pipe set 4-6 in. above soil
Evapotranspiration		No requirement
Infiltration		For BSD exemption areas, meet groundwater recharge requirement
Dewatering		Between 24 and 56 hours; No more than 1/2 of the WQv is released in less than 1/3 of the minimum drawdown period of 40 hours
5. Composition		
Surface Treatment		Vegetation; Mulch-optional
Vegetation		Required
Soil Media		With or w/o an underdrain, meets dewatering requirement; supports plant growth
Retaining Wall		Coordinate with building materials.
Mulch		Triple-shredded hardwood
6. Pollutant		
Pretreatment	15	Required for street or parking lot runoff; may include sump inlets
Sediment Storage		No requirement
7. Maintenance		
Access		Able to be accessed by a vehicle
Requirements		Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations		
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface		
Ponding Area = $WQv*d_s/[k*(h_s+d_s)*t_s]$ d_s=soil media depth k=coefficient of permeability of soil media (ft/day). Use lab values or projected values after settling and use. h_s=average height of water above soil media and mulch, feet t_s=facility drain time (days)		
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7		

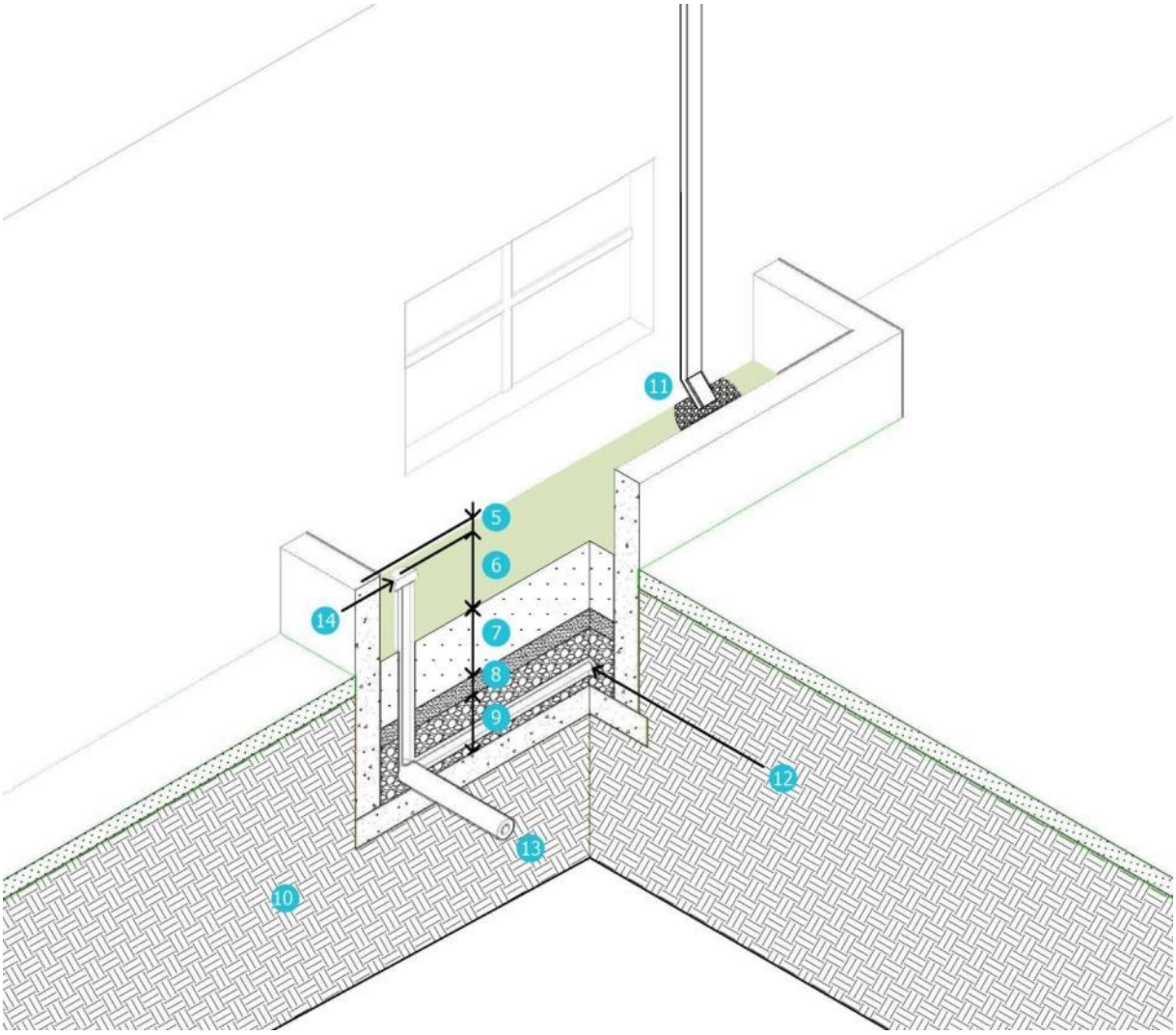


FIGURE 5-7 PLANTER BOX DIAGRAM

Guidance (8) Tree Box

1. Siting Setbacks		
Pavement	1	≥0 ft with structural soil, retaining wall, or modular suspended pavement
Building	2	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW	3	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥2 feet above or use liner
Septic System/Wells		≥ 50 feet / ≥ 100 feet
2. Volume		
Surface Area		Variable
Dimensions		1) ≥1000 ft^3 planting volume for single tree; 2) ≥600 ft^3 planting volume per tree for multiple trees
Bottom slope		Not applicable
Side slopes	4	Not applicable
Freeboard	5	Not applicable
3. Vertical Component		
Surface Storage	6	≤ 6 inches
Growing Layer	7	≥3 feet root zone depth Use: 1) Uncompacted soil w/ retaining wall 2) Structural soil, or 3) Modular suspended pavement
Filter Layer	8	*Optional:* 2 to 4 inches of clean medium sand (ASTM c-33) over 2 to 3 inches of #8 or #78 washed stone
Drainage Layer	9	*Optional:* 12 to 30 inches of clean coarse aggregate AASHTO #4, #5, or equivalent
Native Material	10	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage		
Inlet	11	Curb inlet
Underdrain	12	*Optional:* 6-inch perforated PVC placed to meet dewatering requirement; cleanout at terminal ends
Outlet	13	Required
Overflow	14	Downstream inlet or stand pipe set 4-6 in. above soil
Evapotranspiration		No requirement
Infiltration		For BSD exemption areas, meet groundwater recharge requirement
Dewatering		Between 24 and 56 hours; No more than 1/2 of the WQv is released in less than 1/3 of the minimum drawdown period of 40 hours
5. Composition		
Surface Treatment		Tree approved by City; 2 to 4 in. of Mulch-*optional*
Vegetation		Required
Soil Media		With or w/o an underdrain, meets dewatering requirement; supports plant growth
Retaining Wall		Concrete
Mulch		Triple-shredded hardwood
6. Pollutant		
Pretreatment	15	Required for street or parking lot runoff; may include sump inlets
Sediment Storage		No requirement
7. Maintenance		
Access		Able to be accessed by a vehicle
Requirements		Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations		
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface		
Planting Soil Stormwater Storage = Soil Volume*Water Capacity Factor Water Capacity Factor: silt loam=0.3; loam=0.25; clay loam=0.2; clay=0.15		
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7		

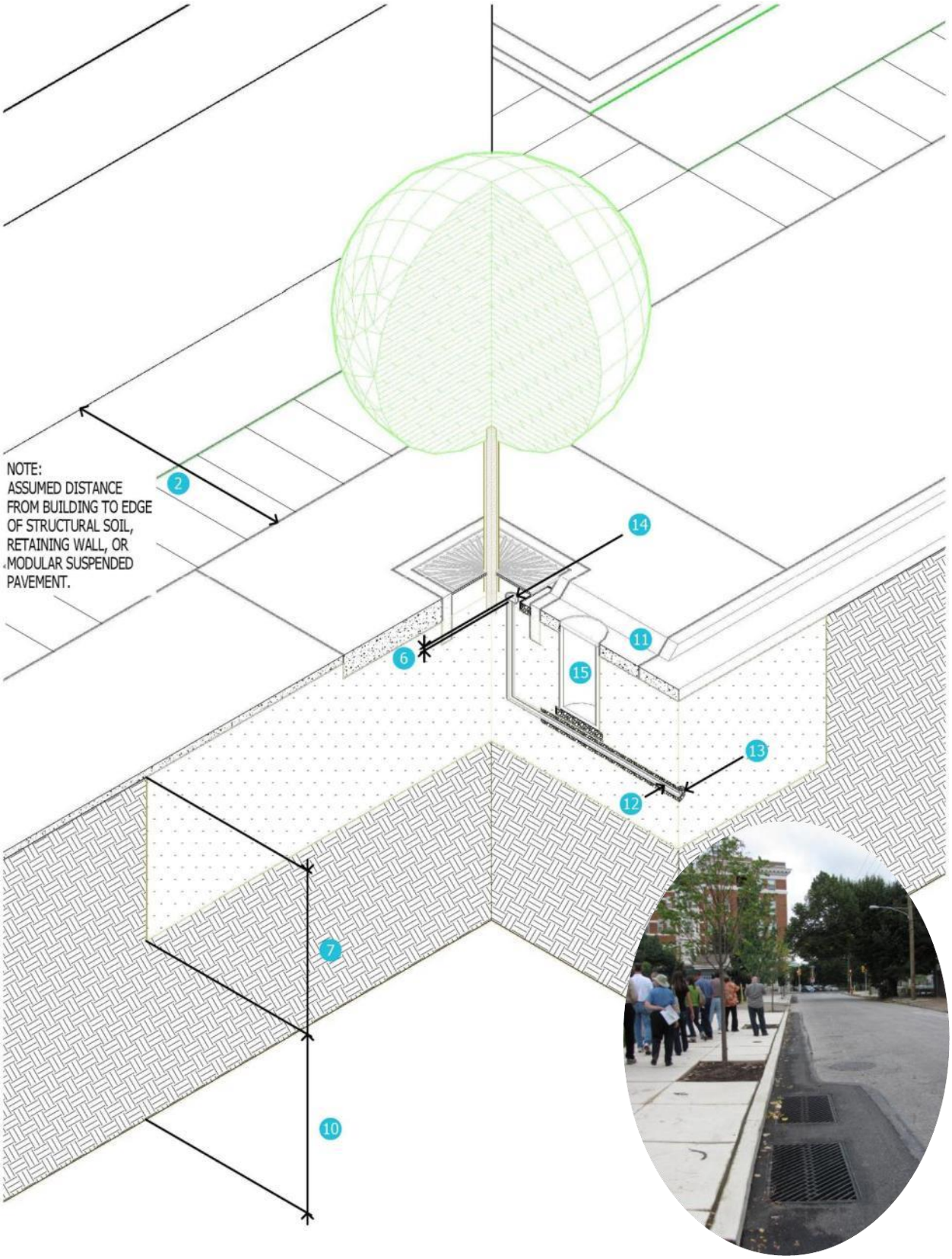


FIGURE 5-8 TREE BOX DIAGRAM

Guidance (9) Bioretention Curb Extension

1. Siting Setbacks		
Pavement	1	No requirement
Building	2	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW	3	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥2 feet above or use liner
Septic System/Wells		≥ 50 feet / ≥ 100 feet
2. Volume		
Surface Area		No requirement
Dimensions		No requirement
Bottom slope		Flat
Side slopes	4	2H:1V or flatter
Freeboard	5	2 to 6 inches
3. Vertical Component		
Surface Storage	6	6 to 12 inches
Growing Layer	7	≥ 12 inches soil media; 3 inches of mulch, max
Filter Layer	8	2 to 4 inches of clean medium sand (ASTM c-33) over 2 to 3 inches of #8 or #78 washed stone
Drainage Layer	9	12 to 30 in. of clean coarse aggregate AASHTO #4, #5, or equivalent
Native Material	10	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage		
Inlet	11	Curb inlet
Underdrain	12	6-inch perforated PVC placed to meet dewatering requirement if needed; cleanout at terminal ends
Outlet	13	Required
Overflow	14	Downstream inlet or stand pipe set 4-6 in. above soil
Evapotranspiration		No requirement
Infiltration		For BSD exemption areas, meet groundwater recharge requirement
Dewatering		Between 24 and 56 hours; No more than 1/2 of the WQv is released in less than 1/3 of the minimum drawdown period of 40 hours
5. Composition		
Surface Treatment		Vegetation and mulch
Vegetation		Required
Soil Media		With or w/o an underdrain, meets dewatering requirement; supports plant growth
Side Slopes		Grass or mulch, no stone
Mulch		Triple-shredded hardwood
6. Pollutant		
Pretreatment	15	Required for street or parking lot runoff; may include sump inlets or forebay
Sediment Storage		No requirement
7. Maintenance		
Access		Able to be accessed by a vehicle
Requirements		Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations		

Water Quality Volume (WQv) = WQ_V = R_V * P * A / 12
where:

WQ_V = water quality volume in acre-feet

R_V = the volumetric runoff coefficient calculated using equation 2
P = 0.9 inch precipitation depth
A = area draining into the BMP in acres

$R_V = 0.05 + 0.9i$ (Equation 2)
where i = fraction of post-construction impervious surface

Ponding Area = $WQv*d_s/[k*(h_s+d_s)*t_s]$

d_s=soil media depth
k=coefficient of permeability of soil media (ft/day). Use lab values or projected values after settling and use.
h_s=average height of water above soil media and mulch, feet
t_s=facility drain time (days)

Quantity Control Requirements = Refer to Chapter 2 and Chapter 7

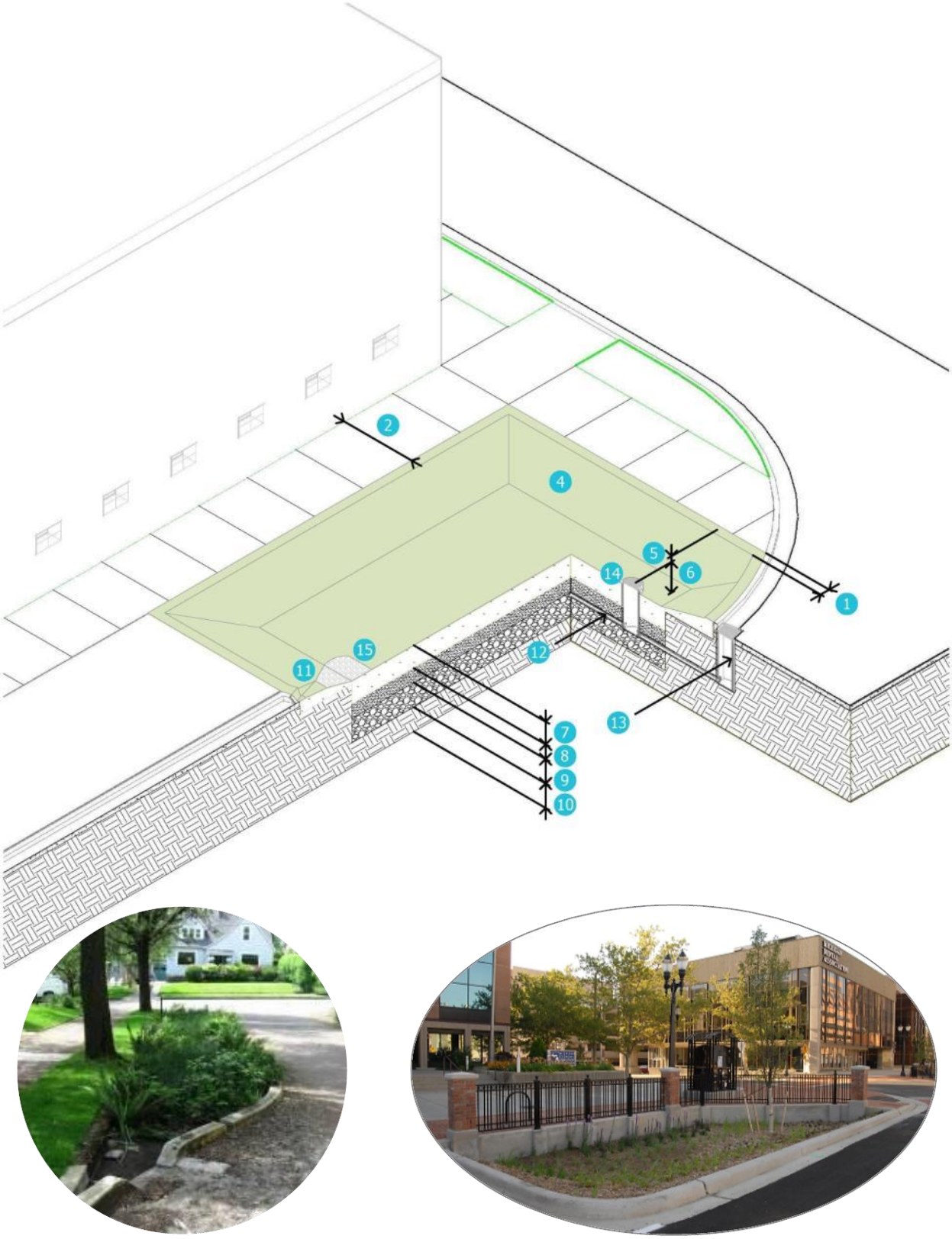


FIGURE 5-9 BIORETENTION CURB EXTENSION DIAGRAM

Guidance (10) Permeable Pavement

1. Siting Setbacks		
Pavement	1	No requirement
Building	2	No requirement with lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property lines/ROW	3	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock		Bottom of practice to be ≥2 feet above or use liner
Septic System/Wells		≥ 50 feet / ≥100 feet
2. Volume		
Surface Area		No requirement
Dimensions		No requirement
Bottom slope		Minimal slope
Side slopes	4	Not applicable
Freeboard	5	Not applicable
3. Vertical Component		
Surface Layer	6	Interlocking Concrete Pavers; Concrete Grid Pavers; Plastic Grid Pavers; Concrete; Asphalt
Growing Layer	7	No requirement
Filter Layer	8	1) Perm. Interlocking Conc. Pavers: 1.5 to 3 inches of #8 or #78 washed stone 2) Concrete and Plastic Grid Pavers: 1 to 1.5 inches of bedding sand 3) Permeable Concrete and Asphalt: None
Base Layer	9	12 to 30 in. of clean aggr. AASHTO #56 or equivalent; thickness depends on strength/storage needed; install geotextile separator where aggregate meets soil
Native Material	10	Compacted as sub-base
4. Drainage		
Inlet	11	Pavement surface
Underdrain	12	6-inch perforated PVC; cleanout at terminal ends
Outlet	13	Required
Overflow	14	Downstream inlet
Evapotranspiration		No requirement
Infiltration		48 hours per OEPA
Dewatering		Less than 24 hours per OEPA
5. Composition		
Surface Treatment		For interlocking or grid-type pavers use fine aggregate, coarse sand, or top soil & grass in openings
Vegetation		Not applicable
Soil Media		Not applicable
Side Slopes		Not applicable
Mulch		Not applicable
6. Pollutant		
Pretreatment	15	Divert runoff from sediment sources away from pavement
Sediment Storage		Not applicable
7. Installation and Maintenance		
Installation		Per manufacturer's recommendation
Load Bearing		1) As directed by City Engineer 2) Designed for projected traffic loads using AASHTO methods
Requirements		Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations		
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface		
Base Layer Storage = assume 40% void space		
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7		

Notes: A reinforced concrete header width is required where permeable pavement meets adjacent non-concrete pavement or soil. Use ODOT Type 6 curb.

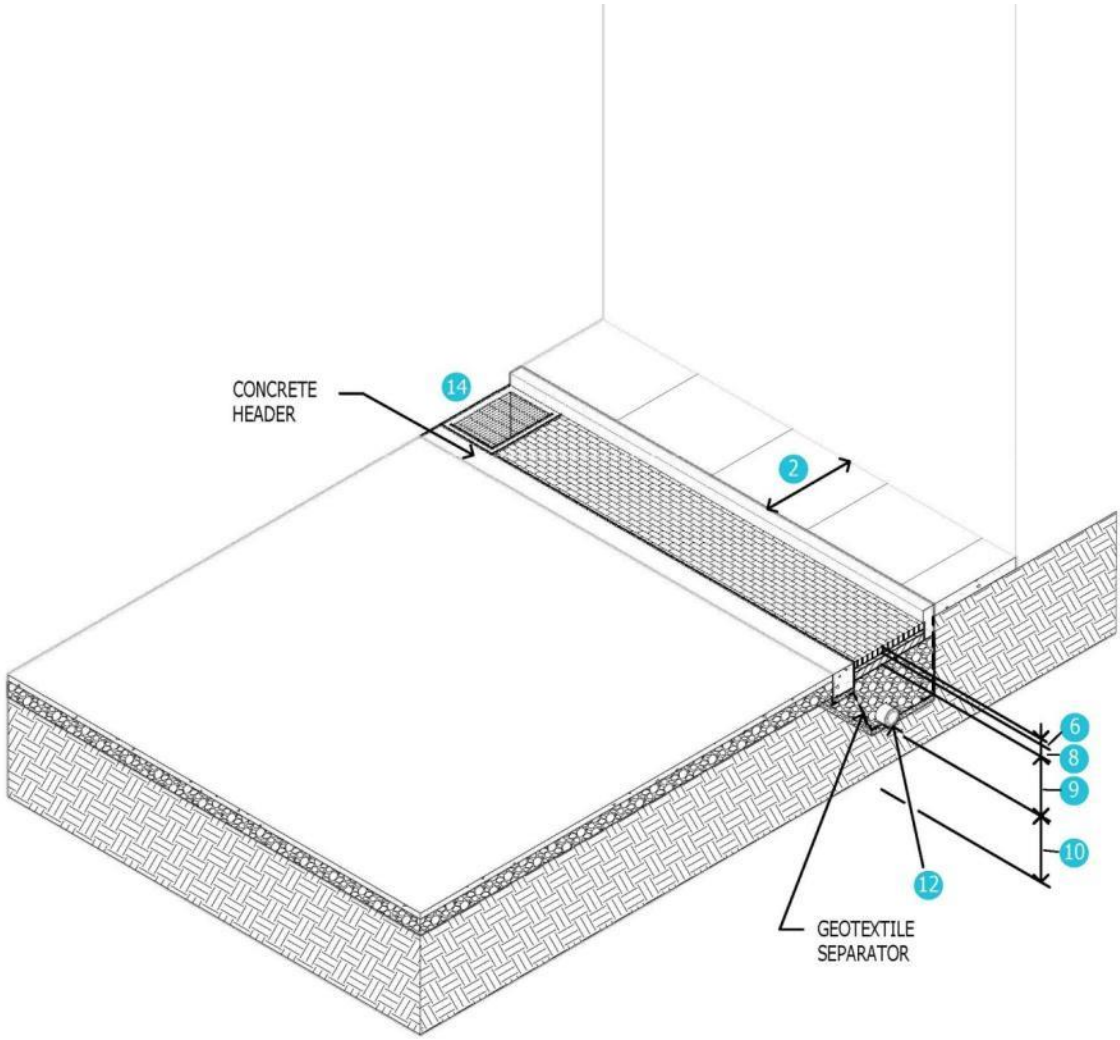


FIGURE 5-10 PERMEABLE PAVEMENT DIAGRAM

Guidance (11) Green Roof

1. Siting Setbacks	
Pavement (1)	Not applicable
Building (2)	Not applicable
Property lines/ROW (3)	Not applicable
Groundwater/Karst/ Bedrock	Not applicable
Septic System/Wells	Not applicable
2. Volume	
Contributing Drainage Area	Roof coverage
Surface Area	Roof coverage
Dimensions	Dependent on green roof use and manufacturer's specs
Bottom slope	Same as pitch of roof; Refer to manufacturer's specs for maximum pitch
Side slopes (4)	Not applicable
Freeboard (5)	Not applicable
3. Vertical Component	
Surface Layer (6)	Wind blanket as needed
Growing Layer (7)	Minimum 2.5-inch thick; Dependent on green roof use and manufacturer's specs
Filter Layer (8)	No requirement
Drainage Layer (9)	Dependent on green roof use and manufacturer's specs
Native Material (10)	Not applicable
4. Drainage	
Inlet (11)	Not applicable
Underdrain (12)	Perforated conduit and/or drainage layer per manufacturer's specs
Outlet (13)	Roof drain
Overflow (14)	Roof drain installed to protect roof from flooding per manufacturer's specs
Evapotranspiration	No requirement
Infiltration	May discharge to infiltrating BMP
Dewatering	≤ 24 hours
5. Composition	
Surface Treatment	Vegetation
Vegetation	Dependent on green roof use and manufacturer's specs
Soil Media	Meets dewatering requirement; supports plant growth
Side Slopes	Not applicable
Mulch	Not applicable
6. Pollutant	
Pretreatment (15)	Not applicable
Sediment Storage	Not applicable
7. Installation and Maintenance	
Installation	Per manufacturer's recommendation
Access	Able to be accessed from the building
Requirements	Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where:	
WQ_V = water quality volume in acre-feet	
R_V = the volumetric runoff coefficient calculated using equation 2	
P = 0.9 inch precipitation depth	
A = area draining into the BMP in acres	
$R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Green Roof Storage = per manufacturer's specs	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7	

Notes: The building roof must be designed to safely support the saturated weight of the green roof.
An irrigation system is optional.

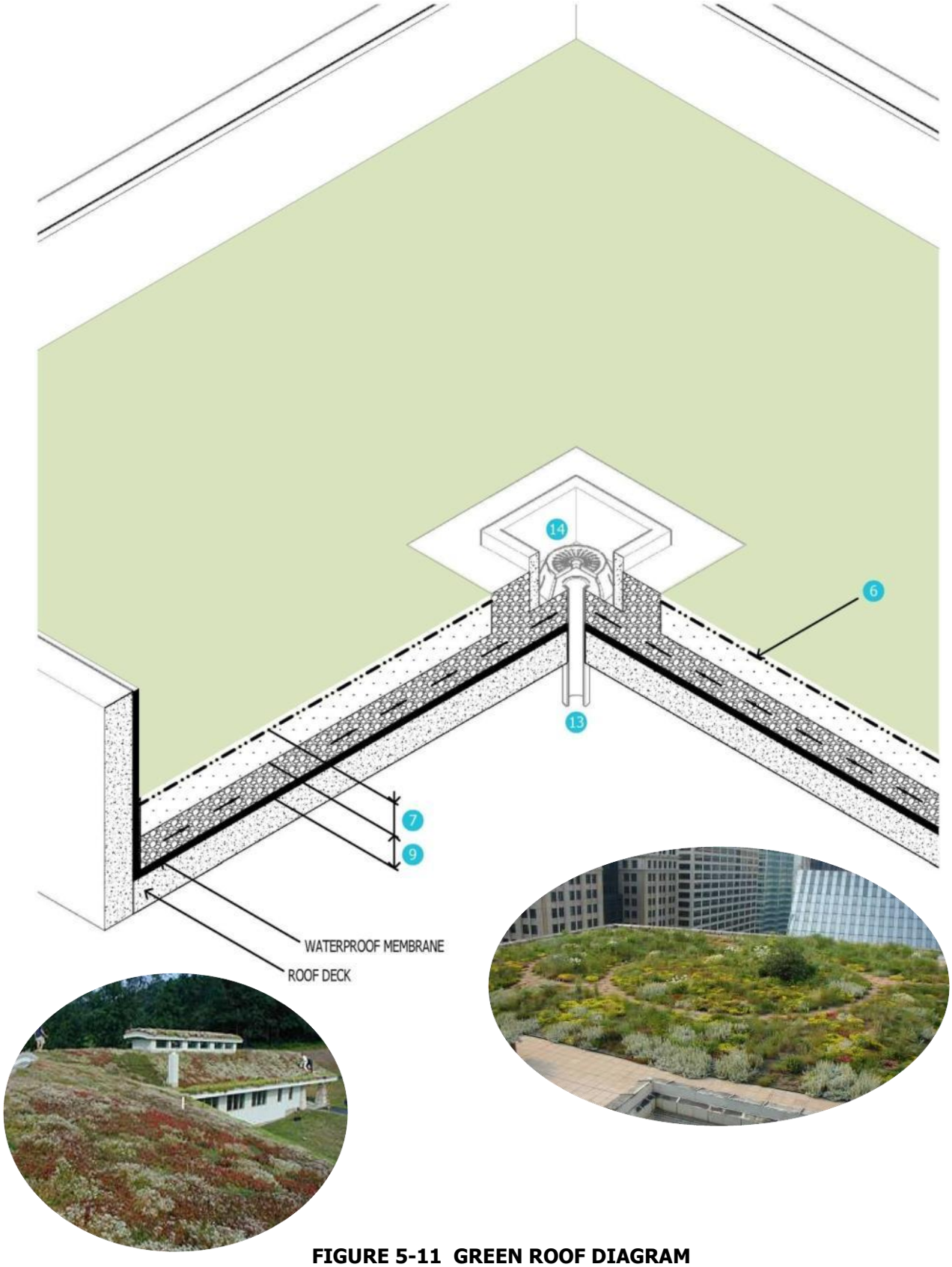


FIGURE 5-11 GREEN ROOF DIAGRAM

Guidance (12) Pocket Wetland

1. Siting Setbacks	
Pavement (1)	≥ 10 feet
Building (2)	Basement: ≥ 50 feet No Basement: ≥ 20 feet
Property lines/ROW (3)	≥ 10 feet / ≥ 50 feet
Groundwater/Karst/ Bedrock	Requires perennial base flow from groundwater
Septic System/Wells	≥ 50 feet/100 feet
2. Volume	
Surface Area	1) Min. 35% of surface area w/ a depth ≤ 6 inches (marsh); 2) 10- to 20% of surface area to be 1.5- to 6-ft deep (pool) 3) provide irregular contours for a natural appearance
Dimensions	Min. flow path of 2L:1W; may use internal berms
Bottom slope	< 8%; 2- to 3- foot elevation drop from inlet to outlet
Side slopes (4)	3H:1V or flatter; deep pool areas require a perimeter safety bench
Freeboard (5)	6 to 12 inches above the 100-year return frequency storm level
3. Vertical Component	
Surface Storage (6)	≤ 3 feet above permanent pool
Permanent Pool and Sediment Storage Volume (7)	See Calculations
Extended Detention Volume (8)	See Calculations
Quantity Control Level (9)	See Calculations
Native Material (10)	Test to ensure low permeability soil and perennial high water table
4. Drainage	
Inlet (11)	Curb inlet with energy dissipation and/or grass swale
Outlet (13)	Required; Bottom drain required
Overflow (14)	Weir; Standpipe
Evapotranspiration	No requirement
Infiltration	Not applicable
Dewatering	24 hours; No more than ½ of the extended detention volume in the first 8 hrs.; Provide method to drain the permanent pool to facilitate maintenance
5. Composition	
Surface Treatment	Vegetation
Vegetation	Wetland vegetation
Soil Media	Typically "C" or "D" soils
Side Slopes	Vegetation
Mulch	None
6. Pollutant	
Pretreatment (15)	Required. May include grass filter strip, swale, sump inlets
Sediment Storage	Equal to 20% of water quality volume
7. Maintenance	
Access	A stable vehicular access way shall be provided to deep pools
Require-ments	1) Designed and maintained to improve water quality; 2) Maintenance Plan shall be submitted w/ Stormwater Management Plan 3) Install a fixed vertical sediment depth marker
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Allocation of WQv: Pool: 25% Marsh: 75% Pool allocation may include forebay and micropool volume.	
Permanent Pool Volume = WQv + groundwater table	
Extended Detention Volume = WQv	
Sediment Storage Volume = 0.2*WQv	
Forebay/Micropool Volume = 0.1 in.*impervious area	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7	
Note: If constructed within navigable waters of the U.S., a Section 404 permit under the Clean Water Act is required along with a state permit.	

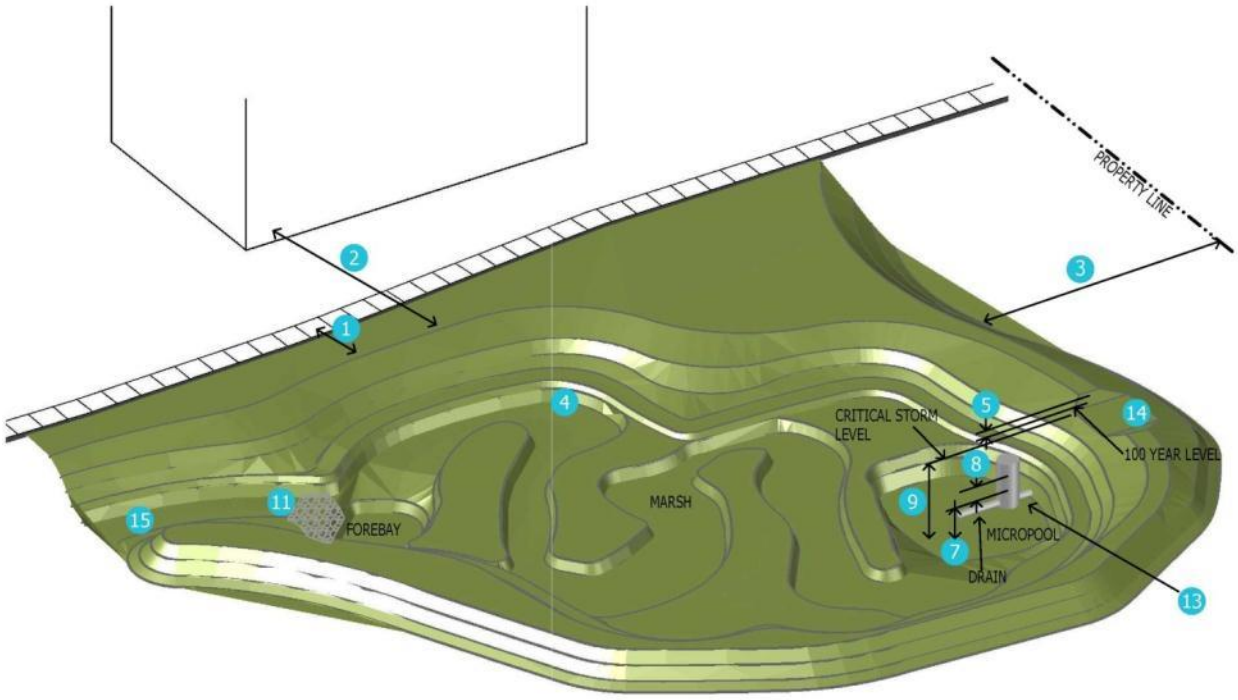


FIGURE 5-12 POCKET WETLAND DIAGRAM

Guidance (13) Retention Basin

1. Siting Setbacks	
Pavement (1)	≥ 10 feet
Building (2)	Basement: ≥ 50 feet No Basement: ≥ 20 feet
Property Lines/ROW (3)	≥ 10 feet / ≥ 50 feet
Groundwater/Karst/ Bedrock	Depending on underlying geology, may need liner to ensure water retention.
Septic System/Wells	≥ 50 feet/ ≥ 100 feet
2. Volume	
Surface Area	Inlet and outlet separated by at least 2 times the width of the pond
Dimensions	Aquatic bench over 25% to 50% of pond surface area with 10:1 side slopes and a max. depth of 18 in.; Min. width of 5 feet
Bottom slope	Flat
Side slopes (4)	4H:1V or flatter above the permanent pool; 2H:1V or flatter below the permanent pool
Freeboard (5)	6 to 12 inches
3. Vertical Component	
Surface Storage (6)	Basin depths in open water areas shall not exceed 12 feet; The mean depth shall be 3 to 6 feet
Permanent Pool and Sediment Storage Volume (7)	See Calculations
Extended Detention Volume (8)	See Calculations
Quantity Control Level (9)	See Calculations
Native Material (10)	Low permeability
4. Drainage	
Inlet (11)	Include forebay or other sediment removal device
Underdrain (12)	None
Outlet (13)	Required; Bottom drain required
Overflow (14)	Weir; Standpipe; Adhere to ODNR dam safety laws as applicable.
Evapotranspiration	No requirement
Infiltration	Not applicable
Dewatering	24 hours; No more than ½ of the extended detention volume in the first 8 hours; Provide method to drain the permanent pool to facilitate maintenance
5. Composition	
Surface Treatment	Open water
Vegetation	Aquatic bench planted with wetland vegetation.
Soil Media	Typically "C" or "D" soils
Side Slopes	Vegetation
Mulch	None
6. Pollutant	
Pretreatment (15)	Forebay; Hard bottom forebays required for facilities maintained by the City
Sediment Storage	Equal to 20% of WQv
7. Maintenance	
Access	A stable vehicular access way shall be provided to forebays and outlets
Requirements	1) Designed and maintained to improve water quality (oxygen levels); 2) Maintenance Plan shall be submitted w/ Stormwater Management Plan; 3) Install a fixed vertical sediment depth marker in forebay
8. Calculations	
Water Quality Volume (WQv) = $WQ_v = R_v * P * A / 12$ where: WQ_v = water quality volume in acre-feet R_v = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_v = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Permanent Pool Volume = WQv	
Extended Detention Volume = WQv	
Sediment Storage Volume = 0.2*WQv	
Forebay Volume = 0.1*WQv	
Flood Control Requirements = Refer to Chapter 2 and Chapter 7.	

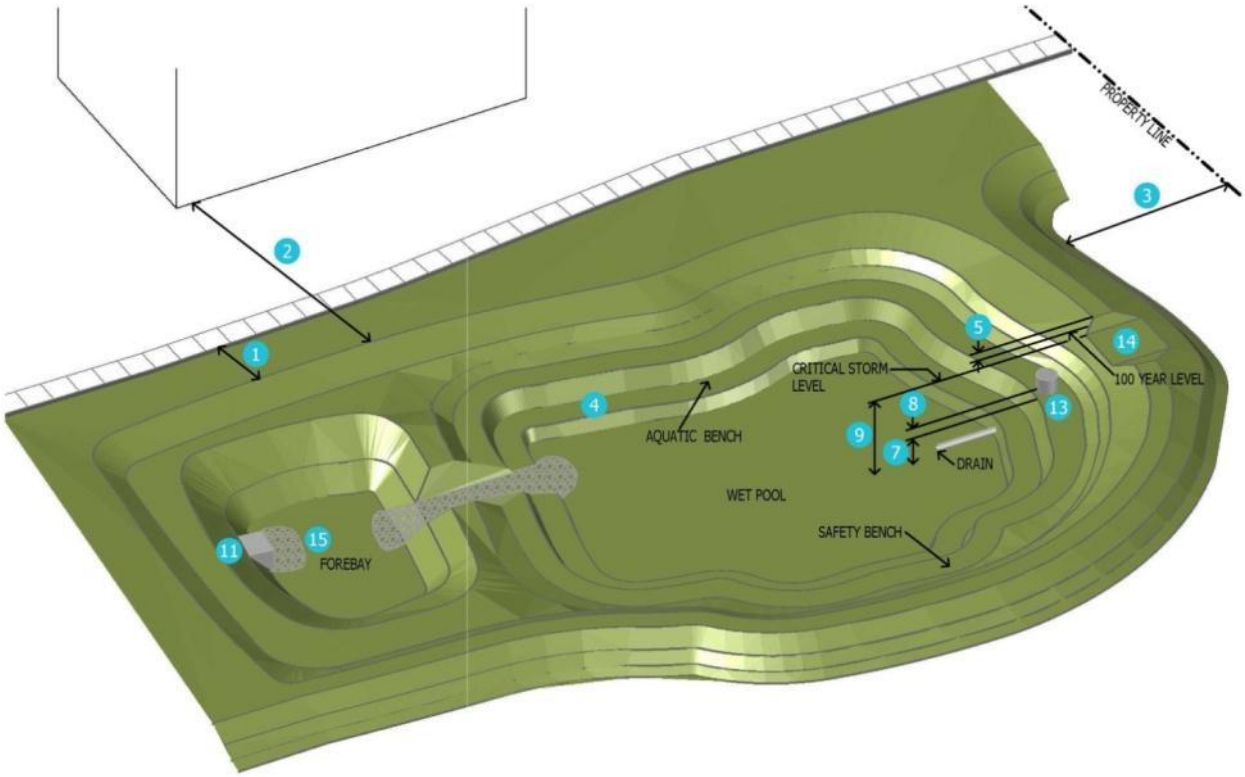


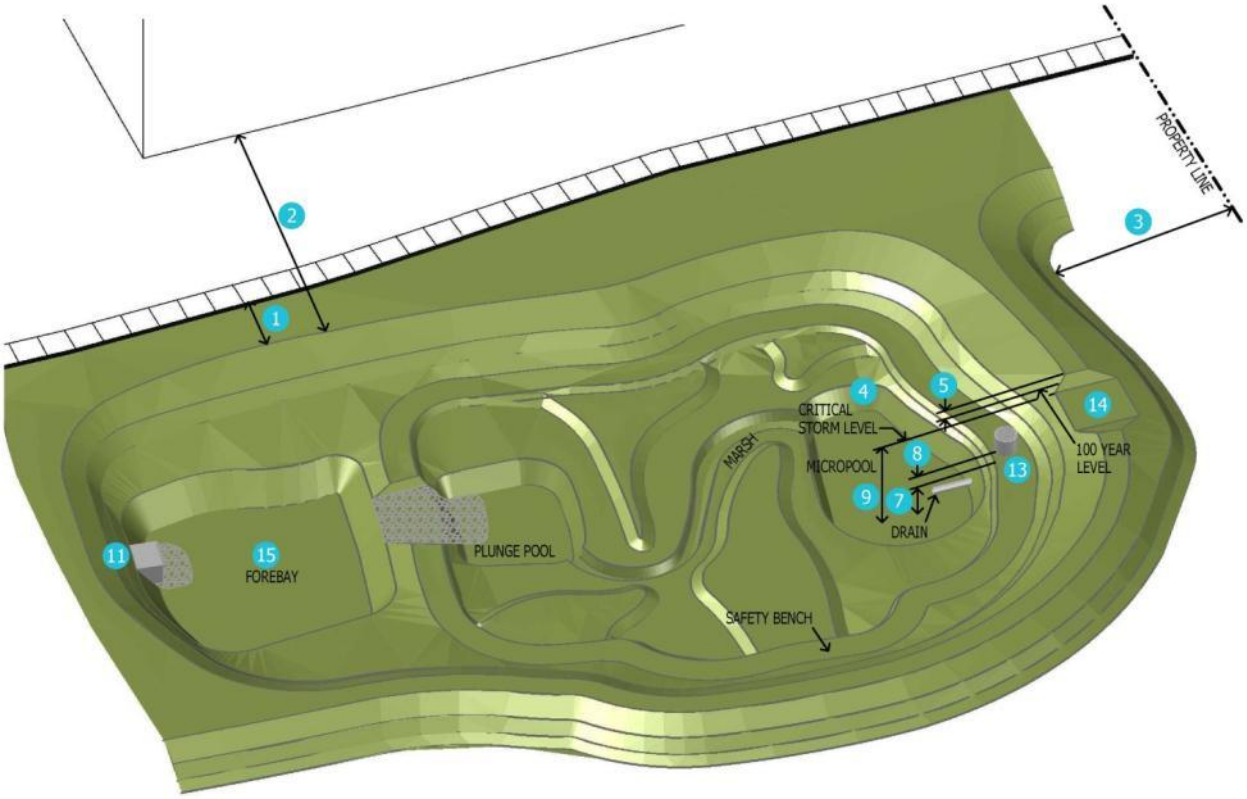
FIGURE 5-13 RETENTION BASIN DIAGRAM

Guidance (14) Stormwater Wetland

1. Siting Setbacks	
Pavement (1)	≥ 10 feet
Building (2)	Basement: ≥ 50 feet No Basement: ≥ 20 feet
Property Lines/ ROW (3)	≥ 10 feet / ≥ 50 feet
Groundwater/Karst/ Bedrock	≥2 feet
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	1) Min. 35% of surface area w/ a depth ≤ 6 inches (marsh); 2) 10- to 20% of surface area to be 1.5- to 6-ft deep (pool) 3) provide irregular contours for a natural appearance
Dimensions	Min. flow path of 2L:1W; may use internal berms
Bottom slope	< 8%; 3- to 5-foot elevation drop from inlet to outlet
Side slopes (4)	3H:1V or flatter; deep pool areas require a perimeter safety bench
Freeboard (5)	6 to 12 inches
3. Vertical Component	
Surface Storage (6)	≤ 3 feet above permanent pool
Permanent Pool and Sediment Storage Volume (7)	See Calculations
Extended Detention Volume (8)	See Calculations
Quantity Control Level (9)	See Calculations
Native Material (10)	Test to ensure low permeability soil and perennial high water table
4. Drainage	
Inlet (11)	Curb inlet with energy dissipation and/or grass swale
Underdrain (12)	None
Outlet (13)	Required; Bottom drain required
Overflow (14)	Weir; Standpipe; Adhere to ODNR dam safety laws as applicable.
Evapotranspiration	No requirement
Infiltration	Not applicable
Dewatering	24 hours; No more than ½ of the extended detention volume in the first 8 hours; Provide method to drain the permanent pool to facilitate maintenance
5. Composition	
Surface Treatment	Vegetation
Vegetation	Wetland vegetation
Soil Media	Typically "C" or "D" soils
Side Slopes	Vegetation
Mulch	None
6. Pollutant	
Pretreatment (15)	Forebay; Hard bottom forebays recommended for maintenance
Sediment Storage	Equal to 20% of water quality volume
7. Maintenance	
Access	A stable vehicular access way shall be provided to deep pools
Require-ments	1) Designed/maintained to improve water quality; 2) Maintenance Plan shall be submitted w/ Stormwater Management Plan 3) Install a fixed vertical sediment depth marker
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Allocation of WQv: Pool: 70% Marsh: 30% Pool allocation may include forebay and micropool	
Permanent Pool Volume = WQv	
Extended Detention Volume = WQv	
Sediment Storage Volume = 0.2*WQv	
Forebay/Micropool Volume = 0.1 in.*impervious area	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7	

Note: If constructed within navigable waters of the U.S., a Section 404 permit under the Clean Water Act is required along with a state permit.

A water balance must be performed to demonstrate that the wetland can withstand a 30-day drought at summer evap. rates without completely drawing down.



Copyright 2000, Center for Watershed Protection

FIGURE 5-14 STORMWATER WETLAND DIAGRAM

Guidance (15) Extended Dry Detention

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	No requirement w/ solid or lined bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property Lines/ROW (3)	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock	None
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	No requirement
Dimensions	Inlet and outlet separated by at least 2 times the width of the pond
Bottom slope	No requirement
Side slopes (4)	4H:1V or flatter and vegetated
Freeboard (5)	6 to 12 inches
3. Vertical Component	
Surface Storage (6)	The mean depth shall be 3 to 6 feet
Sediment Storage Volume (7)	See Calculations
Extended Detention Volume (8)	See Calculations
Quantity Control Level (9)	See Calculations
Native Material (10)	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage	
Inlet (11)	Include forebay or other sediment removal device
Underdrain (12)	No requirement
Outlet (13)	Required; Micropool recommended
Overflow (14)	Weir; Standpipe; Adhere to ODNR dam safety laws as applicable.
Evapotranspiration	No requirement
Infiltration	No requirement
Dewatering	48 hours; No more than ½ of the extended detention volume in the first 16 hours; Provide method to drain pools to facilitate maintenance

5. Composition	
Surface Treatment	Vegetation
Vegetation	Aquatic bench planted with wetland vegetation.
Soil Media	Not applicable
Mulch	Not applicable
6. Pollutant	
Pretreatment (15)	Forebay; Hard bottom forebays required for facilities maintained by the City
Sediment Storage	Equal to 20% of water quality volume
7. Maintenance	
Access	A stable vehicular access way shall be provided to forebays and outlets
Requirements	1) Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan 2) Install a fixed vertical sediment depth marker in forebay

8. Calculations

Water Quality Volume (WQv) = WQ_V = R_V * P * A / 12
where:

WQ_V = water quality volume in acre-feet

R_V = the volumetric runoff coefficient calculated using equation 2
P = 0.9 inch precipitation depth
A = area draining into the BMP in acres

$R_V = 0.05 + 0.9i$ (Equation 2)
where i = fraction of post-construction impervious surface

Extended Detention Volume = WQv

Sediment Storage Volume = 0.2*WQv

Forebay/Micropool Volume (each) = 0.1*WQv

Quantity Control Requirements = Refer to Chapter 2 and Chapter 7.

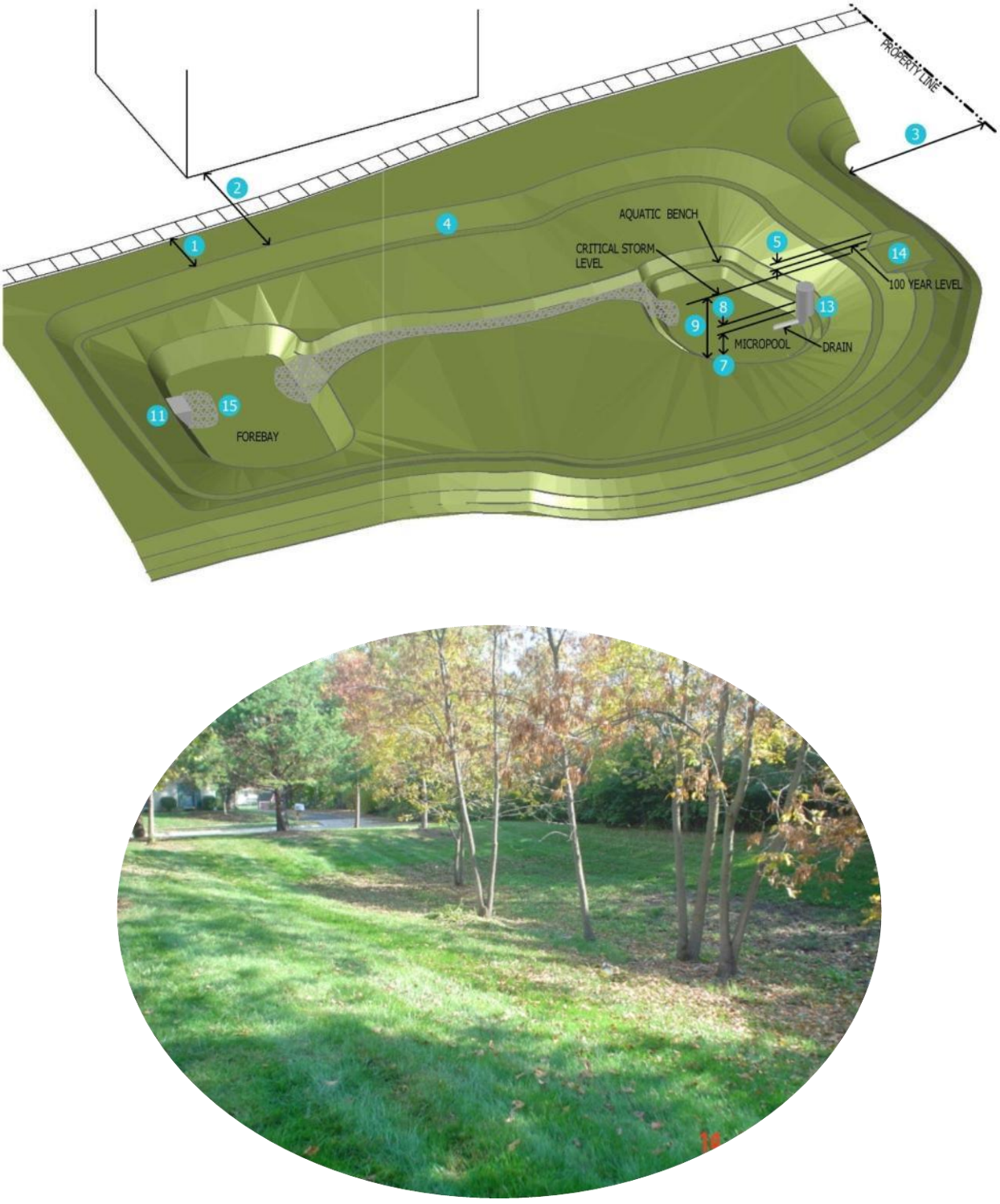


FIGURE 5-15 EXTENDED DRY DETENTION DIAGRAM

Guidance (16) Underground Retention/Detention

1. Siting Setbacks	
Pavement (1)	No requirement
Building (2)	No requirement w/ solid bottom; otherwise, Basement: ≥ 10 feet No Basement: ≥ 5 feet
Property Lines/ROW (3)	≥ 2 feet / ≥0 feet
Groundwater/Karst/ Bedrock	No requirement w/ solid bottom; otherwise, ≥ 2 feet
Septic System/Wells	≥ 50 feet / ≥ 100 feet
2. Volume	
Surface Area	No requirement
Dimensions	No requirement
Bottom slope	Positive slope toward outlet
Side slopes (4)	No requirement
Freeboard (5)	No requirement
3. Vertical Component	
Surface Storage (6)	The mean depth shall be 3 to 6 feet
Sediment Storage Volume (7)	See Calculations
Extended Detention Volume (8)	See Calculations
Quantity Control Level (9)	See Calculations
Native Material (10)	Test infiltration; ≥1/2 in/hr if designing with infiltration
4. Drainage	
Inlet (11)	Include sediment removal device
Underdrain (12)	No requirement
Outlet (13)	Required
Overflow (14)	Back-up aboveground; Weir; Standpipe
Evapotranspiration	No requirement
Infiltration	No requirement
Dewatering	48 hours per OEPA; No more than ½ of the extended detention volume in the first 16 hours

5. Composition	
Surface Treatment	Not applicable
Vegetation	Not applicable
Soil Media	Not applicable
Mulch	Not applicable
6. Pollutant	
Pretreatment (15)	Required; May be swale, prefabricated device, or forebay
Sediment Storage	Equal to 20% of water quality volume
7. Maintenance	
Access	At a minimum, access points are to be installed near each inlet and outlet; Where an opening is provided that could allow the entry of personnel, the opening shall be marked, "DANGER-CONFINED SPACE".
Requirements	1) Designed and maintained to improve water quality; Maintenance Plan shall be submitted w/ Stormwater Management Plan 2) Install a fixed vertical sediment depth marker
8. Calculations	
Water Quality Volume (WQv) = $WQ_V = R_V * P * A / 12$ where: WQ_V = water quality volume in acre-feet R_V = the volumetric runoff coefficient calculated using equation 2 P = 0.9 inch precipitation depth A = area draining into the BMP in acres $R_V = 0.05 + 0.9i$ (Equation 2) where i = fraction of post-construction impervious surface	
Extended Detention Volume = WQv	
Sediment Storage Volume = 0.2*WQv	
Quantity Control Requirements = Refer to Chapter 2 and Chapter 7.	

Notes:
If the facility is designed to infiltrate via a subsurface fluid distribution system, it is likely considered a Class V well and will need a permit. The Class V permitting agency for Ohio is the Ohio EPA.

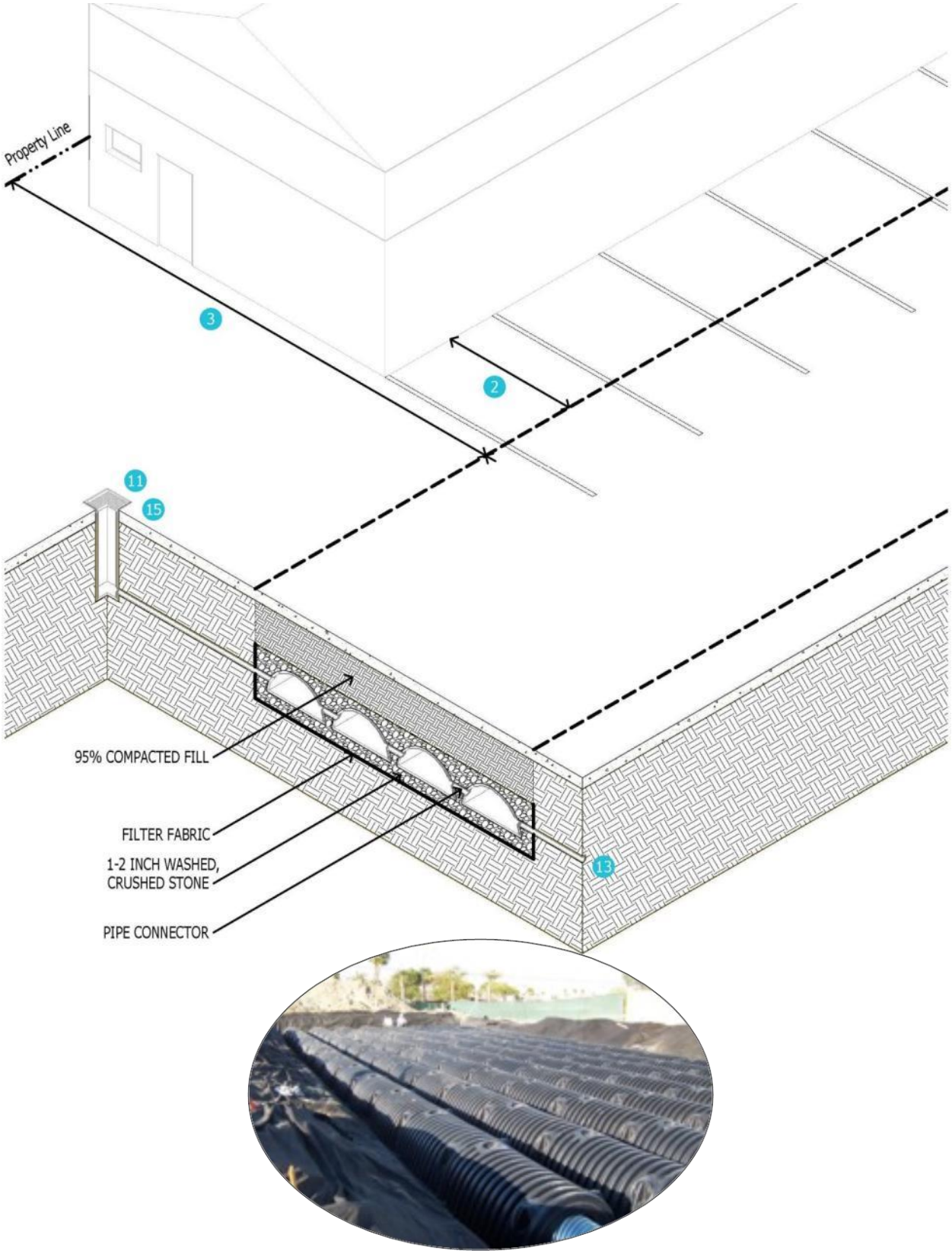


FIGURE 5-16 UNDERGROUND RETENTION/DETENTION

6. BRIDGE STREET DISTRICT INTEGRATION WITH STORMWATER MANAGEMENT

A. Purpose

The purpose of this Chapter is to define and describe the manner in which recommended stormwater control measures as defined in Chapter 5 may be used in specific areas of the Bridge Street District, and to provide flexible and effective standards for the integration of these practices into new development, redevelopment, and public improvement projects within the Bridge Street District. This Chapter is intended to support the General Purpose, Scope and Intent of the Bridge Street District and associated development areas by promoting and facilitating the use of recommended measures that are consistent with and suitable for particular street families, right-of-way elements, building types, building sites, and open space types, and which contribute to sound stormwater management in a walkable mixed-use development setting.

B. General Provisions

For purposes of this Chapter, the term "effective impervious area" shall mean those impervious surfaces from which stormwater runoff is conveyed directly to surface water or the storm drainage system, without an opportunity to be infiltrated or otherwise retained.

From a stormwater management perspective, minimizing the amount of effective impervious area is preferred because it helps to minimize the extent of stormwater infrastructure that must be constructed and maintained, and to reduce water quantity and water quality impacts on receiving waters. Therefore, it is the intent of this Chapter to promote design techniques that reduce the total impervious area and effective impervious area in public rights-of-way and on developed sites, but to do so in the context of creating a walkable, urban mixed-use area and without compromising pedestrian, bicycle and vehicle safety. It is also recognized that minimum widths, areas and structural requirements of impervious surfaces will in many cases be required to meet other standards such as Americans with Disabilities Act (ADA) and emergency vehicle accessibility. Therefore, while an important goal for water quality, the directive to minimize the total area of impervious surfaces and effective impervious area does not in and of itself supersede other planning goals, objectives and standards adopted by the City of Dublin.

FIGURE 6-1 BRIDGE STREET DISTRICT

In presenting the recommended integration of stormwater control measures with development within the Bridge Street District, the tables in this Chapter identify those stormwater control measures that are most

feasible for the District. Common reasons a control measure may *not* be considered "most feasible" may include an inability to contribute to quantity control requirements, the lack of a treatment mechanism, lower cost-effectiveness in terms of cost per volume unit of stormwater controlled, and the need for more space than typically available. Table 6-1 provides guidance for the consideration of recommended stormwater control measures. Note that the information provided in Table 6-1 is not meant to discourage use but rather provide an explanation as to why a recommended stormwater control measure is generally not noted as "most feasible" in the following tables. It is recognized that each development is unique and there are many possible stormwater control measures that might meet the code and design criteria.

TABLE 6-1 STORMWATER CONTROL MEASURE FEASIBILITY

		COMMON REASONS FOR LACK OF FEASIBILITY			
		Inability to Contribute to Quantity Control Requirements	**Limited Treatment Mechanism**	**Not Cost-Effective**	**Need for More Space than Available**
RECOMMENDED STORMWATER CONTROL MEASURES	**Water Harvesting**				
	Rain Barrels	●	●		
	Cisterns	●	●		
	Filter Strips	●			
	Media Filter				
	Vegetated Bioretention				
	Traditional				
	Bioretention Swales				
	Planter Boxes				
	Tree Boxes			●	
	Curb Extension				
	Permeable Pavements				
	Green Roofs			●	
	Basins				
	Pocket Wetland				●
	Stormwater Wetland				●
	Retention Basin		●		
	Extended Dry Detention		●		
	Underground Retention/Detention		●		
	Prefabricated Devices				
	Hydrodynamic Devices	●			
	Inlet Traps	●			
	Gross Solids Removal	●			

C. Lots and Blocks

The section of the Bridge Street District Code (Code) applicable to lot and block layouts (§ 153.060) is intended to promote the establishment of a network of interconnected streets with walkable block sizes and continuous pedestrian-oriented block faces, and to promote multiple modes of transportation through street design and connectivity. Irrespective of lot and block type, stormwater management will be addressed at the site level either on an individual site or project basis or through a cooperative Stormwater Management Plan among multiple properties per the guidance in Section 7.E. For more detailed guidance on stormwater management design in specific street settings, refer to the subsequent sections in Section 6 on Street Types, Buildings Types, Open Space Types, and Site Development Standards.

D. Street Types

This section addresses the requirements and opportunities for incorporating stormwater management within the street right-of-way. Provisions are made for incorporating stormwater control measures into specific street families and street types as defined in § 153.061 and the suitable placement of stormwater control measures within the right-of-way.

1) Right-of-Way Impervious Surfaces

For street projects, opportunities to minimize the total area of impervious surface constructed may include designing with minimum or reduced travel lane, parking lane, pedestrian (sidewalk) and bike facility widths where deemed appropriate by the City Engineer.

2) Recommended Stormwater Control Measures

Street families, as defined in the Code, are comprised of multiple street types, each configured to accommodate specific transportation needs while reinforcing the intended character and function of the applicable street family. Street families, street types, and the street network within the Bridge Street District are defined in § 153.061. The street types within each street family are distinguished by the absence or presence of right-of-way elements such as parking lanes, planting zone medians, curb extensions, and bike facilities. Figure 6-2 illustrates the potential elements of the right-of-way; specific street type configurations will be determined as part of the development review process.

Stormwater shall be managed using one or more of the control measures applicable to that street family as shown in Table 6-2. It is important to note that some control measures may be applicable only to a certain street type within a given street family.

3) Placement of Stormwater Control Measures

The following section provides guidance on the placement of stormwater control measures within the street right-of-way. Refer to Table 6-3 accompanied by Figure 6-2 for appropriate placement of stormwater control measures.

TABLE 6-2 RECOMMENDED STORMWATER CONTROL MEASURES BY STREET FAMILY[1]

		STREET FAMILIES			
		Corridor Connector Streets	**District Connector Streets**	**Neighborhood Streets**	**Alleys & Service Streets**
RECOMMENDED STORMWATER CONTROL MEASURES	**Water Harvesting**				
	Rain Barrels	**NOT APPLICABLE**			
	Cisterns				
	Filter Strips				
	Media Filter	●			
	Vegetated Bioretention				
	Traditional	●			
	Bioretention Swales	●	●	●	
	Planter Boxes	●	●	●	●
	Tree Boxes	●	●	●	
	Curb Extension	●	●	●	●
	Permeable Pavements[2]	●	●	●	●
	Green Roofs	**NOT APPLICABLE**			
	Basins				
	Pocket Wetland				
	Stormwater Wetland				
	Retention Basin	NOT PERMITTED			
	Extended Dry Detention				
	Underground Retention/Detention				
	Prefabricated Devices				
	Hydrodynamic Devices	●	●	●	●
	Inlet Traps	●	●	●	●
	Gross Solids Removal	●	●	●	●

[1] While SCMs with a ● are all permissible for a given street family depending on the street type, the most feasible and cost-effective SCMs are denoted with a ●. A blank cell indicates that the SCM is not suitable.

[2]Within the street right-of-way, the proposed type of permeable pavement must be approved by the City Engineer.

TABLE 6-3 PLACEMENT OF STORMWATER CONTROL MEASURES WITHIN THE STREET RIGHT-OF-WAY

		TYPICAL ELEMENTS OF THE RIGHT-OF-WAY							
		Median	Travel Lane	Parking Lane	Curb/ Gutter	Curb Extension	Bike Facility	Planting Zone	Pedestrian Facility
RECOMMENDED STORMWATER CONTROL MEASURES	**Water Harvesting**								
	Rain Barrels								
	Cisterns								
	Filter Strips	●							
	Media Filter	●							
	Vegetated Bioretention								
	Traditional	●							
	Bioretention Swales	●							
	Planter Boxes								
	Tree Boxes	●						●	
	Curb Extension					●			
	Permeable Pavements		● (alley/ service)	●			●	●	●
	Green Roofs								
	Basins								
	Pocket Wetland								
	Stormwater Wetland								
	Retention Basin	NOT PERMITTED							
	Extended Dry Detention								
	Underground Retention/Detention								
	Prefabricated Devices[1]								
	Hydrodynamic Devices	●			●	●	●		●
	Inlet Traps	●			●				
	Gross Solids Removal	●			●	●	●		●

[1] With verification that no other suitable location exists, Hydrodynamic Devices and Gross Solids Removal may be located within the travel lane and parking lane with prior approval by the City Engineer.

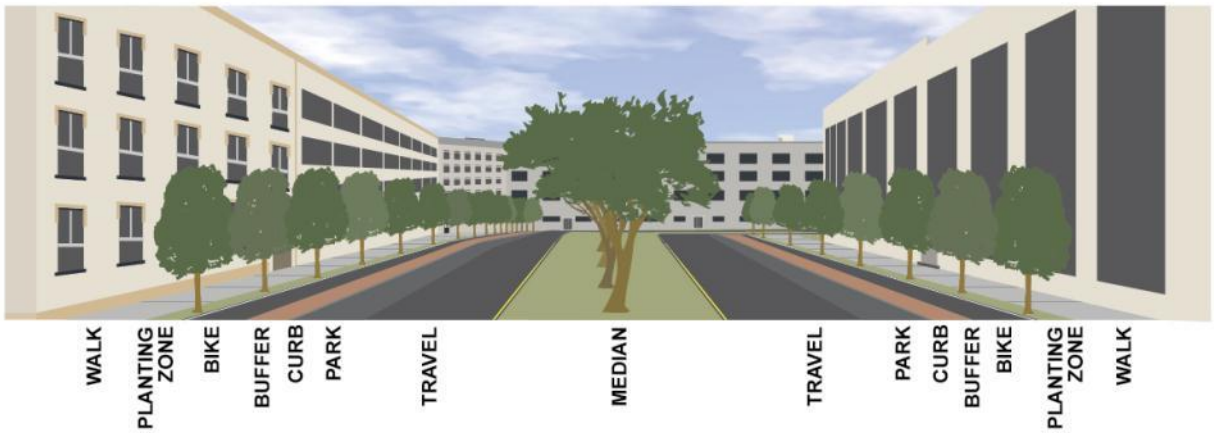


FIGURE 6-2 POTENTIAL ELEMENTS OF THE TYPICAL STREET RIGHT-OF-WAY

E. Building Types

This section addresses the requirements and opportunities for incorporating stormwater management within a Bridge Street District development site and the suitable placement of stormwater control measures within that site. There are thirteen defined building types within the code and stormwater management for each type is addressed in this section.

1) Building Type and Impervious Surfaces

Applicants are encouraged to use available opportunities to reduce effective impervious surface related to buildings (e.g., minimizing building and parking lot footprints, promoting disconnection of rooftops and other impervious surfaces from directly discharging into the stormwater drainage system). The Stormwater Treatment and Control Feasibility Assessment for Redevelopment in Appendix D offers guidance on site techniques that are potentially applicable in new development settings as well as for redevelopment. Applicable design techniques may include, as appropriate:

- designing for the minimum number of parking stalls, incorporating compact parking spaces, and maximizing the use of shared parking arrangements or other methods to reduce surface parking;
- using permeable surfacing for all or portions of parking areas, walkways, and driveways as appropriate; and
- minimizing the extent and length of interior driveway networks without compromising circulation and connectivity requirements.

2) Permitted Stormwater Control Measures

The Code defines various building types, with each having specific requirements as defined in § 153.062. While keeping within the building type requirements, a stormwater management system meeting the applicable requirements shall be incorporated into the site design. Figure 6-3 illustrates the elements of a typical site layout. Stormwater shall be managed using one or more of the control measures applicable to each building type as shown in Table 6-4. Note that some control measures are more appropriate for certain building types than others. Refer to Table 6-5 for appropriate placement of control measures within the site.

3) Placement of Stormwater Control Measures

The following provides guidance on placement of stormwater control measures within a building site. Refer to Table 6-3 accompanied by Figure 6-3 for appropriate placement of stormwater control measures.

TABLE 6-4 RECOMMENDED STORMWATER CONTROL MEASURES BY BUILDING TYPE[1]

RECOMMENDED STORMWATER CONTROL MEASURES	BUILDING TYPES												
	Single Family Detached	Single Family Attached	Apartment	Loft	Corridor	Mixed Use	Commercial Center	Large Format Commercial	Historic Mixed Use	Historic Cottage Commercial	Civic	Parking Structure	Podium Apartment
Water Harvesting													
Rain Barrels	●	●											
Cisterns	●	●	●	●	●	●	●	●	●	●	●	●	●
Filter Strips	●	●	●	●	●	●	●	●	●	●	●	●	●
Media Filter		●	●	●	●	●	●	●	●	●	●	●	●
Vegetated Bioretention													
Traditional	●	●	●	●	●	●	●	●	●	●	●	●	●
Bioretention Swales	●	●	●	●	●	●	●	●	●	●	●	●	●
Planter Boxes	●	●	●	●	●	●	●	●	●	●	●	●	●
Tree Boxes		●	●	●	●	●	●	●	●	●	●		●
Curb Extension		●	●	●	●	●	●	●	●	●	●		●
Permeable Pavements	●	●	●	●	●	●	●	●	●	●	●	●	●
Green Roofs		●	●	●	●	●	●	●			●	●	●
Basins													
Pocket Wetland		●	●	●	●	●	●	●	●	●	●	●	●
Stormwater Wetland		●	●	●	●	●	●	●	●	●	●	●	●
Retention Basin	NOT PERMITTED												
Extended Dry Detention													
Underground Retention/Detention		●	●	●	●	●	●	●	●	●	●	●	●
Prefabricated Devices													
Hydrodynamic Devices		●	●	●	●	●	●	●	●	●	●	●	●
Inlet Traps		●		●	●	●	●	●	●	●	●		
Gross Solids Removal		●	●	●	●	●	●	●	●	●	●	●	●

[1] While SCMs with a ● are all permissible for a given building type depending on the details of that development, the most feasible and cost-effective SCMs are denoted with a ●. A blank cell indicates that the SCM is not suitable.

TABLE 6-5 PLACEMENT OF STORMWATER CONTROL MEASURES WITHIN A BUILDING SITE

		TYPICAL ELEMENTS OF A BUILDING SITE					
		Side Yard	**Rear Yard**	**Required Building Zone (RBZ)[1]**	**Roof**	**Attached to Building**	**Surface Parking Lot**
RECOMMENDED STORMWATER CONTROL MEASURES	**Water Harvesting**						
	Rain Barrels[3]	●	●	●		●	
	Cisterns	●	●	●	●		
	Filter Strips	●	●	●			●
	Media Filter	●	●	●			●
	Vegetated Bioretention						
	Traditional	●	●	●			●
	Bioretention Swales	●	●	●			●
	Planter Boxes			●		●	
	Tree Boxes			●			●
	Curb Extension						●
	Permeable Pavements[2]	●	●	●			●
	Green Roofs				●		
	Basins						
	Pocket Wetland	●	●				●
	Stormwater Wetland	●	●				●
	Retention Basin	NOT PERMITTED					
	Extended Dry Detention						
	Underground Retention/Detention	●	●				●
	Prefabricated Devices						
	Hydrodynamic Devices	●	●	●			●
	Inlet Traps	●	●	●			●
	Gross Solids Removal	●	●	●			●

[1] Filter Strips, Traditional Bioretention, Bioretention Swale, Planter Boxes, and Tree Boxes are permissible in landscape RBZ treatments as described in § 153.065(D)(6).
[2] Permeable Pavements are permissible in the side yard and rear yard subject to parking location (as applicable) and setback requirements of § 153.062(N)(1)(C).
[3] Rain Barrels are permissible in the side yard and rear yard subject to setback requirements of § 153.071(B)(1)(f).

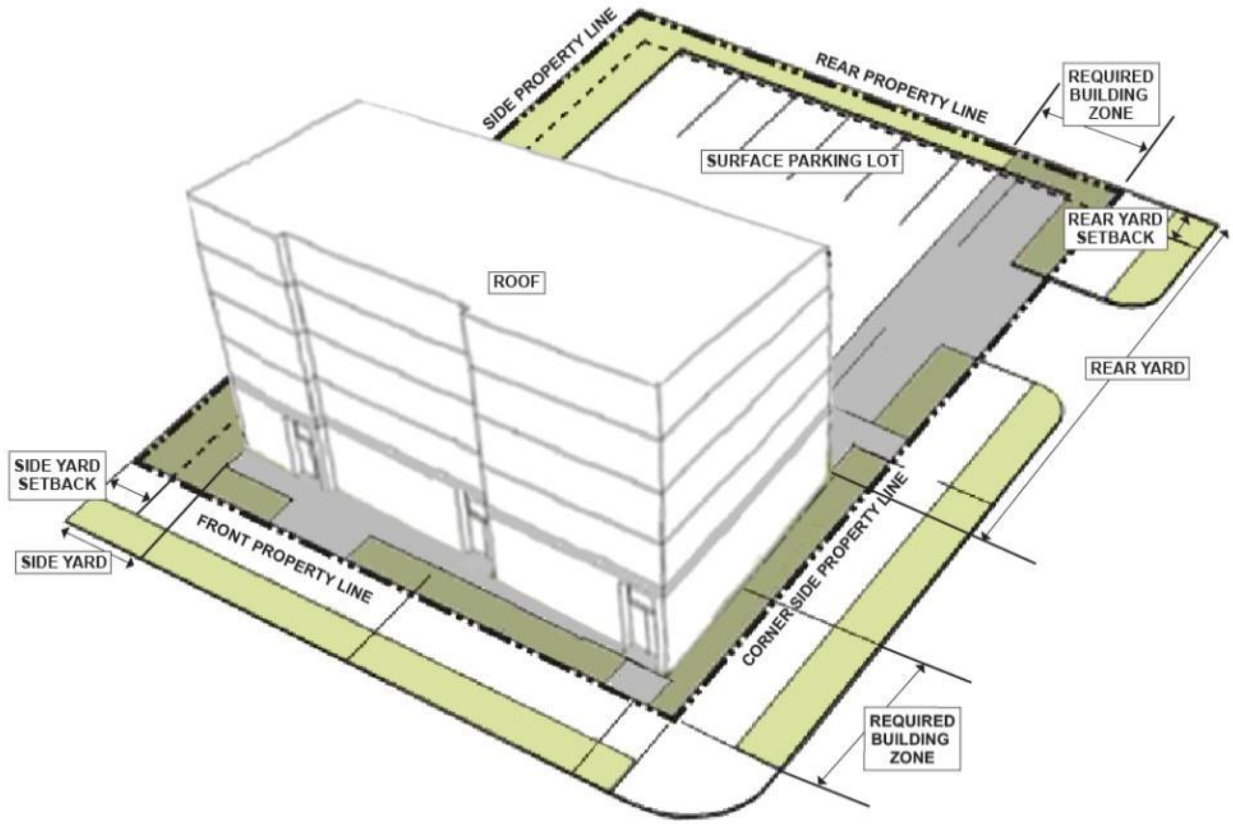


FIGURE 6-3 POTENTIAL ELEMENTS OF A BUILDING SITE

F. Neighborhood Standards

The section of the Code applicable to neighborhood standards (§ 153.063) is intended to promote the creation of signature places in the City consistent with the Bridge Street Corridor Vision Report. The neighborhood standards guide the development of streets, buildings, and open spaces, although not to the extent that precise location is dictated. Guidance on specific allowable stormwater control measures is provided within this Section for the fundamental elements of neighborhood districts including street family, building type, and open space. However, detailed stormwater control measure correlation with neighborhood districts is not presented. By following the guidance on allowable stormwater control measures by element (street family, etc.) the overall placement of stormwater control measures should be consistent with the objectives of the Code.

G. Open Space Types

This section addresses the requirements and opportunities for incorporating stormwater management within open space as defined in § 153.064, Open Space Types. The Code include provisions for incorporating one or more of the defined open space types within a site development as a function of neighborhood district and building type. The intent is to create a variety of functional, well-designed open spaces carefully distributed throughout the Bridge Street District to enhance the quality of life for residents, businesses, and visitors.

There are seven defined open space types within the Code and stormwater management for each is addressed in this section, including recommended stormwater BMPs for each open space type and the suitable placement of stormwater BMPs within the open space.

1) Open Space and Impervious Surfaces

Including open space within a development provides an opportunity to decrease the effective impervious surface of a site or project by directing runoff from impervious surfaces such as roofs, parking lots, and sidewalk into an open space area. Care should be taken during construction and maintenance activities to maintain soil permeability by keeping heavy equipment out of the designated open space as much as possible.

2) Recommended Stormwater BMPs

The Code defines various open space types and presents the requirements for each in § 153.064. While staying within the open space type requirements, a stormwater management system meeting the applicable requirements of a site development project shall be incorporated into the site design. Stormwater shall be managed using one or more of the stormwater control measures applicable to each open space type as shown in Table 6-6.

3) Placement of Stormwater Control Measures

The permitted stormwater control measures may be placed anywhere within the open space as long as it follows the guidance in Chapter 5 for siting.

TABLE 6-6 RECOMMENDED STORMWATER CONTROL MEASURES IN EACH OPEN SPACE TYPE[1]

		OPEN SPACE TYPE						
		Pocket Plaza	**Pocket Park**	**Green**	**Square**	**Plaza**	**Park**	**Greenway**
RECOMMENDED STORMWATER CONTROL MEASURES	**Water Harvesting**							
	Rain Barrels	●	●	●	●	●	●	●
	Cisterns	●	●	●	●	●	●	●
	Filter Strips		●	●	●		●	●
	Media Filter		●	●	●		●	●
	Vegetated Bioretention							
	Traditional		●	●	●		●	●
	Bioretention Swales		●	●	●		●	●
	Planter Boxes	●	●	●	●	●	●	●
	Tree Boxes	●	●	●	●	●	●	●
	Curb Extension	●	●	●	●	●	●	●
	Permeable Pavements	●	●	●	●	●	●	●
	Green Roofs	●	●	●	●	●	●	●
	Basins							
	Pocket Wetland			●			●	●
	Stormwater Wetland			●			●	●
	Retention Basin	NOT PERMITTED						
	Extended Dry Detention							
	Underground Retention/Detention	●	●	●	●	●	●	●
	Prefabricated Devices							
	Hydrodynamic Devices	●	●	●	●	●	●	●
	Inlet Traps	●	●	●	●	●	●	●
	Gross Solids Removal	●	●	●	●	●	●	●

[1] While SCMs with a ● are all permissible for a given open space type depending on the details of that development, the most feasible and cost-effective SCMs are denoted with a ●. A blank cell indicates that the SCM is not suitable.

H. Site Development Standards

An important aspect of this Manual is to promote the integration of stormwater control measures into the design of each site and its site development features, as defined in Section § 153.065 of the Code. The provisions below for integrating stormwater control measures with site development features is intended to maximize water quality treatment through recommended stormwater control measures, eliminate the future use of retention/detention ponds, and create multi-functional landscapes in the Bridge Street District.

This Section describes the recommended approaches and opportunities for integrating stormwater management with specific required site features, including parking and loading, landscaping area and street tree requirements, and Required Building Zones (RBZs); and for the coordination of stormwater management with site features such as fencing, walls and screening, exterior lighting, utility undergrounding, and signs.

1) Parking

The use of permeable pavement and surfacing, bioretention, and other stormwater control measures for surface parking as listed in Table 6-5 is encouraged. Stormwater control measures meeting the standards in this Manual may be incorporated into parking areas, drive aisles, landscaped islands, required pedestrian walkways, landscaped edges, and turn-around or other access areas, except for driveway aprons as provided in § 153.065(B)(c)(5). Specific design standards and review guidance on design standards for parking are listed in Table 6-7 Below:

TABLE 6-7 PARKING AND STORMWATER STANDARDS

Code Sections (153.065)	Code Provision	Stormwater Control Measure Objectives and Standards
(B)(1)(a)(4)(a)	Parking areas that cannot be finished due to weather or other conditions shall be 'adequately surfaced' to accommodate stormwater	Surfacing of parking areas with permeable pavement shall follow City Standard Construction Drawings and shall be designed for projected traffic loads using AASHTO methods.
B(1)(b)(2)	Surfacing of off-site parking	Same as for on-site parking
B(6)(b)(1) and (2)	Surfacing of parking areas	Surfacing of parking areas with permeable pavement shall follow City Standard Construction Drawings and shall be designed for projected traffic loads using AASHTO methods.
B(6)(c)(5)	Driveway aprons connecting parking lots to public roadways may not be constructed with permeable materials.	
B(6)(d)(1)	Raised or rolled concrete curbs or wheel stops at least five inches high shall be installed where necessary to prevent vehicle conflicts with abutting landscape areas, sidewalks, streets, buildings or lot lines. The minimum distance from a curb or wheel stop to a property line or protected area shall be two and one-half feet.	Breaks in curbing shall be designed to enable flow to be directed into landscaped areas or stormwater control measures that are designed and installed to manage stormwater runoff. The design and location of curb breaks should not convey sheet flow or concentrated drainage into landscaped areas that would be damaged or dislodged by the flow. Energy dissipation measures that may be incorporated into curb breaks are described in Section 5(a), Common Elements.
B(6)(d)(2)	If a curb is located at the edge of a landscaped area, planted areas shall be installed at a lower grade than the parking lot pavement and curbing shall have openings or gaps allowing drainage from the pavement to	

Code Sections (153.065)	Code Provision	Stormwater Control Measure Objectives and Standards
	enter and percolate through the landscaped areas.	
B(8)(a)(5)	All permeable paving materials shall be maintained in an unbroken condition and shall be regularly swept and vacuumed to prevent blockages of sand, sediment, or other materials that would impair their permeability to water as originally designed.	Maintenance standards or a maintenance plan will be submitted with the Stormwater Management Plan. Where a proprietary product is used, the manufacturer's specifications shall be submitted with the Stormwater Management Plan.

2) Landscaping

The integration, co-location and integrated design of stormwater control measures indicated in Table 6-2 through Table 6-6 with required landscaping areas is strongly encouraged in order to promote high-density development patterns, maximize the utility, aesthetic and environmental function of landscaped areas in the City and District. This Manual provides for the review of stormwater control measures in required landscape areas, including landscape planting plans, plant and ground cover materials, and landscaped buffers in a holistic manner that provides guidance on appropriate waivers and other discretionary approvals under Section § 153.065(D) and the applicable provisions of Section § 153.132 through § 153.148.

a) Interpretation of Code and Manual Landscaping Requirements for Stormwater Features

Stormwater features counting towards required landscaping. Any approved Filter Strips, Vegetated Bioretention, Traditional Bioretention Swales, Planter Boxes, Tree Boxes and surrounding planted areas, planted Curb Extensions, and Constructed Wetlands that are designed and approved in accordance with the standards in this Manual shall be considered 'rain gardens' or 'vegetated site features created to meet stormwater management requirements' as described in section § 153.065(D)(2)(f) of the Code (at right).

In evaluating potentially conflicting landscape requirements applicable to the same area under the provisions of section § 153.065D(2)(i), if the area in question has been designed as a Filter Strip, Vegetated Bioretention, Traditional Bioretention Swale, Planter Box, Tree Box and surrounding planted area, planted Curb Extension, or Constructed Wetland, consideration shall be given to the design requirements of the specific stormwater practice in determining the amount of required landscaping so that stormwater management objectives are not compromised or adversely affected by specific plant material, quantity or spacing requirements.

§ 153.065(D)(2)(f)

Areas included in rain gardens or vegetated site features created to meet stormwater management requirements may be counted towards any landscaping required by § 153.065(D)(4) - (6) if landscaped to meet the requirements.

§ 153.065(D)(2)(i)

If two or more conflicting landscape requirements apply to the same area, the one requiring the most landscaping shall apply.

TABLE 6-8 LANDSCAPING AND STORMWATER CODE PROVISIONS

Code Sections (153.065)	Code Provision	Stormwater Control Measure Objectives and Standards
D(1)	Unless otherwise specified, these requirements should not be interpreted as requiring regular, symmetrical or standardized intervals of vegetation within landscape areas. Required landscaping should be creatively and architecturally designed to add visual interest and preserve natural integrity, as appropriate to the character of the surrounding area.	A plan sheet showing the integration of stormwater treatment features with required landscaping shall be submitted with the application package at each stage of plan review. For Basic Plan Review and Development Plan Review, general locations for landscaping and stormwater treatment, and the general approach to stormwater treatment, shall be indicated on the plan. Site Plan Review submittals shall include details of all proposed plant materials for stormwater treatment and landscaping areas. Sheets shall include a landscape plan with detail, a grading and drainage plan, and a combined plan showing the integration of these features.
D(2)(b)	Each application for development or redevelopment shall include a landscape plan showing compliance with the provisions of § 153.065(D).	
D(2)(e)	In all areas where landscaping is required, a minimum of 80% of the surface area of any landscape bed shall be covered within four years after installation by living materials, rather than bark, mulch, gravel or other non-living materials. Areas included in rain gardens or other vegetated site features to meet stormwater management requirements are excluded from this requirement with prior approval from the Director	Landscaping and surface area coverage shall be consistent with the standards for each stormwater control measure per Section 5 of this Chapter.

3) Perimeter Landscape Buffering

Perimeter Landscape Buffering areas represent a potential area of opportunity for the integration of recommended stormwater control measures. § 153.065(D)(4) states: "The buffering is intended to obscure the higher-intensity land use from view and block potential negative impacts related to noise, lighting levels, and activity through the use of denser landscape screening and/or a fence or wall visually softened by clustered plantings, creatively and architecturally designed, as appropriate to the character of the surrounding area." The integration of stormwater control measures specified for perimeter landscape buffering areas is encouraged, provided the primary visual and buffering functions of the Perimeter Landscape Buffer are achieved.

4) Street Trees and Tree Preservation

a) Purpose

The integration of trees as functional components of a site or area Stormwater Management Plan is strongly encouraged. Street trees are recognized in this Manual as an integral and essential feature of stormwater management, aesthetic enhancement and environmental protection in the City of Dublin and the Bridge Street District. The intent of this Section is to provide guidance for determining where deviation from the strict dimensional and numeric requirements for street trees, including but not limited to standards for tree protection, removal, replacement, spacing, and tree lawn planting areas, supports the integration of recommended stormwater treatment measures with high quality site design supporting the City's goals for the District.

b) Tree and Stormwater Standards

This section of the Manual is intended to provide guidance on specific technical issues related to the incorporation of trees into specific stormwater control measures, and overall Stormwater Management Plans. The standards in this Manual are intended to provide guidance for varying the calculation of street tree planter box requirements, spacing, removal and replacement, species and calipers in service of an integrated overall street tree and Stormwater Management Plan.

In the event an application is made to modify an approved stormwater system that affects any tree, shrub or tree radius for which approval is required pursuant to § 153.065(D)(3), verification to the City Engineer that the amended Stormwater Management Plan meets the standards and requirements of this Manual shall be provided in addition to the required City Forester approvals.

TABLE 6-9 TREE PRESERVATION AND STORMWATER STANDARDS

Code Sections (153.065)	**Code Provision**	**Stormwater Control Measure Objectives and Standards**
D(2)(b)	The siting of buildings shall avoid the removal of desirable trees in good or fair condition where alternatives consistent with the provisions of § 153.062 are available	In the event tree removal represents the only feasible option for siting a recommended stormwater treatment measure rather than a wet pond, consideration shall be given to options for replacement that accommodate the recommended method.
D(2)(c)	Protected trees, as defined in this Chapter, removed from any portion of a lot consistent with an approved Site Plan Review shall be replaced in accordance with § 153.146 except as provided by § 153.065(D)(9)	
D(2)(d)	Existing trees which are incorporated into the landscape plan shall be protected during construction as required by § 153.145	Standards for protecting trees and soils during construction shall be observed; areas of the site where soils are to be protected from compaction during construction shall be indicated on the tree preservation plan and grading plan or an equivalent per the provisions of Section § 153.140.

7. STORMWATER MANAGEMENT PLAN

The purpose of this Chapter is to provide guidelines, standards and requirements for the orderly development, approval, and implementation of Stormwater Management Plans, including provisions for shared systems and ongoing maintenance, that will enable development consistent with the vision for the City. This Chapter sets forth the requirements for preparation and submittal of Stormwater Management Plans, and provides a framework by which property owners and public agencies may propose collectively an overall plan for managing stormwater from multiple properties, where such a management plan will enable greater consistency with the City of Dublin's adopted plans and policies. It is a further purpose of this Chapter to provide sufficient standards and safeguards for associated plans, approvals and agreements to protect the public interest by ensuring long-term management and maintenance of stormwater management facilities.

A. General Requirements

1) A Stormwater Management Plan shall be prepared by the applicant for each proposed development activity and approved by the City Engineer in accordance with § 53.120 if the plan demonstrates that the proposed development activity has been planned and designed, and shall be implemented and maintained, to meet the performance criteria described herein.

2) For concept plans in stormwater management areas, possible methods of management and applicable Stream Corridor Protection Zones shall be included and represented.

3) Subdivision Development - Preliminary stormwater management plans (drawings and calculations) shall be submitted with preliminary development plans and preliminary plats for planning commission review. Stream corridor protection plans shall also be determined at this time. With submission of final development plan and plats, updated stormwater management plans shall be submitted. Stormwater Management shall be approved prior to approval of public improvement plans by the City Engineer.

4) Commercial sites – Preliminary stormwater management plans (drawings and calculations) shall be submitted with preliminary development plans and updated preliminary stormwater management plans with final development plans for planning commission or Administrative Review Team review. Stream corridor protection plans shall also be determined at this time. Stormwater Management plans shall be approved prior to approval of the private site improvements by the City Engineer and issuance of the building permit.

5) If applicable, the feasibility assessments shall be submitted with first submission of any documents to the City for review.

6) This Stormwater Management Plan shall be part of the overall submitted improvement plan and not a separate submittal. Supporting calculations for each design storm specified in § 53.090 hereof shall be submitted (hard copy and electronic copy) and will contain, at a minimum, a runoff hydrograph for the undeveloped and developed site, stage-storage calculations for the stormwater control measure, stage-discharge calculations for the outlet structure, and a runoff hydrograph after routing through the proposed stormwater control measure. All routing calculations shall account for tailwater conditions of the receiving facility, and shall be submitted to the City.

7) The stormwater management plan shall be a bound report containing all pertinent stormwater calculations for detention/retention basins, storm sewers, culverts, open channels, and other stormwater management system features, including stormwater control measures specified in this Manual. The report shall be signed and sealed by a Professional Engineer registered in the

state of Ohio. A stormwater management map shall be included in a sleeve page or pocket of the plan. The construction plans shall be submitted with the report, but not attached to it. The plan shall contain divider pages with labeled tabs that clearly identify the calculations contained in each section.

8) Stormwater Pollution Prevention Plans (SWP3) as required by OEPA shall be submitted to the City prior to the start of construction.

B. Map Content

The project engineer shall include in the construction plans a master stormwater management map showing all existing and proposed features, including trees and, where integrated with the stormwater management design, landscaping. The map is to be prepared on a 22-inch by 34-inch sheet on a scale not to exceed 1-inch equal's 400-feet (1"=400'). The map shall be based on state plane coordinate system. Listed below are the features that are to be included on the map.

1) Existing and proposed contours at one-foot intervals.

2) North arrow and scale.

3) Pre-development and post-development sub-basins overlaid on the same map including on and offsite contributory area. The acreages shall be shown.

4) Downstream receiving waterway of drainage system.

5) Pre-development and post-development overland flow paths to and from the management basins.

6) Soil type by sub-basin including hydrologic soil group designation of A, B, C or D.

7) Hydrologic boundaries, including all areas flowing to the proposed project.

8) Project boundaries and area.

9) Sufficient topographical information with elevations to verify the location of all ridges, streams, etc. (one-foot contour intervals within the project's boundaries and for proposed offsite improvements).

10) High water data or critical flood elevations on existing structures upstream of, within, and downstream of the project.

11) Notes indicating sources of high water data and critical flood elevations.

12) Notes pertaining to existing standing water, areas of heavy seepage, springs, wetlands, streams, and hydrologically sensitive areas.

13) Existing stormwater management features (ditches, pipes, roadways, ponds, and control measures). Existing stormwater management features are to be shown a minimum of 1,000

feet downstream of the proposed development unless the ultimate outfall system is a lesser distance.

14) Subdivision layouts with horizontal and vertical controls.

15) Proposed and existing stormwater management features, including locations of inlets, swales, pipes, detention/retention facilities, control measures, ponding areas, and all works.

16) Delineation and area of pre-development and post-development sub-basins.

17) Delineate retention/detention facilities and ingress/egress areas for facilities maintenance.

18) General type of soils by sub-basin and location of soil borings.

19) 10-, 25-, and 100-year flood elevations for any areas in or within 100 feet of the property. The source of these elevations shall also be shown on the plans.

20) Description of current ground cover, land use, and landscaping, and an estimate of the impervious area and percent imperviousness created by the construction activity by sub-basin.

21) Delineated stream corridor protection zone along any streams within or adjacent to the site.

C. Calculations

Stormwater calculations (hard copy and original copy) shall be signed and sealed by a professional engineer registered in the State of Ohio indicating that the plan has been prepared in accordance with the regulations of the Manual, and in accordance with good engineering practices and principles for all stormwater works, including design high water elevations for all applicable storm events. Software/models that utilize this methodology and technique and which are deemed acceptable to the City include but are not limited to SWMM, TR-55, PONDPAK, HEC-1, etc. The City will not accept methodologies that do not perform dynamic routing of hydrographs, which include but are not limited to the Bowstring Methodology, Mass Diagram Analysis, etc. The calculations shall include the following:

1) If quantity control is required;
   a) Pre- and post-development stormwater flows and stages for the stormwater control measures for all design storm frequencies pertinent to the project based upon the requirements of the stormwater regulations, including, but not limited to, the following:
   b) Critical Storm Calculation: Show the calculation of the total volume of runoff from a 1-year, 24-hour storm, before and after development for the entire site. Show the calculation of percent increase in runoff volume, and reference Table 2-5 to determine the critical storm.
   c) On-Site and Off-Site Area Allocation(s): Contact Engineering Development Group Civil Engineers for the applicable Stormwater Master Plan peak flow rates. Show the allocation of on-site and off-site area contributory to the facility for each Stormwater Master Plan sub-basin as shown in Table 7-1:

TABLE 7-1 EXAMPLE SUB-BASIN ON-SITE AND OFF-SITE AREA ALLOCATIONS

Sub-Basin Identifier #	On-Site Area (acre)	Off-Site Area (acre)	Total (acre)
2150	4.9	3.5	8.4
2030	0.2	0.0	0.2
2020	1.4	0.0	1.4
Total (acre)	6.5	3.5	10.0

d) Pre-development runoff hydrograph, post-development runoff hydrograph to each stormwater control measure, and the routed post-development hydrograph discharged from each stormwater control measure.

e) Pre-development and post-development runoff volumes.

f) Stage-area-storage calculations for each stormwater control measure.

g) Stage-discharge calculations for the outfall control structure, including tailwater assumptions.

h) *Release rate calculation*: Calculate the maximum release rate for each design storm using the critical storm criteria and referencing Appendix C of the Stormwater Master Plan and the Area Allocation table. Include a summary of the release rates as shown in Table 7-2:

TABLE 7-2 STORMWATER MANAGEMENT SUMMARY TABLE

	1-year	2 year	5 year	10 year	25 year	50 year	100 year
Predeveloped Q							
Postdeveloped Q							
Allowable Release							
Actual Release							
Control Measure Depth/Elev							

i) Show the calculation that is used to determine the maximum release rate for each storm.

j) Stormwater control measure volumes and recovery calculations. Show calculations or model output that demonstrates the storage and release of the water quality and quantity volumes over the time period specified in Chapter 5.

k) Show the calculation adding together the volume required for quantity control and quality control. Stormwater control measure shall be sized to contain both volumes.

l) Soil storage or curve number calculations per sub-basin, including impervious calculations.

m) Time of concentration calculations per sub-basin.

n) 100-year floodplain compensating calculations, if applicable.

o) Storm sewer, culvert, open channel and stormwater control measure tabulations, including, but not limited to, the following:

   i. Location and type of structures.

   ii. Length of facility and dimensions, including diameter, height, and/or width for pipes.

   iii. Cross-sections for-open channels.

   iv. Sub-basin areas tributary to each structure.

   v. Runoff coefficients or curve numbers per sub-basin for both the pre-construction and post-construction site conditions.

   vi. Time of concentration to the inlet of each structure.

   vii. Stormwater flow to and from the stormwater structure or junction point.

   viii. Hydraulic gradient for the applicable storm event, including losses through structures with friction and local loss coefficients.

   ix. Estimated receiving water elevation with sources of information, if available.

x. Velocities for all facilities and details for provisions to control erosion.

p) Construction plans including, but not limited to, the following:

i. Overall project plan of roads, lots, and stormwater control measures.

ii. Staging and sequencing of construction of stormwater control measures.

iii. Cross-section of stormwater control measures.

iv. Typical swale, ditch, or canal sections.

v. Drainage rights-of-way.

vi. Road plan and profile with groundwater elevation shown in profile.

vii. Overall project grading plan (at 1-foot contours) and individual lot grading plans.

viii. Density of the project.

2) If quantity control is not required:

Refer to Chapter 2 for an explanation of when quantity control is not required.

a) Stormwater control measure volumes and recovery calculations. Show calculations or model output that demonstrates the storage and release of the water quality volume over the time period specified in Chapter 5.

b) 100-year floodplain compensating calculations, if applicable.

c) Storm sewer, culvert, open channel and stormwater control measure tabulations, including, but not limited to, the following:

i. Location and type of structures.

ii. Length of stormwater control measure and dimensions, including diameter, height, and/or width for pipes.

iii. Cross-sections for-open channels.

iv. Sub-basin areas tributary to each structure.

v. Runoff coefficients per sub-basin for both the pre-construction and post-construction site conditions.

vi. Time of concentration to the inlet of each structure.

vii. Stormwater flow to and from the stormwater structure or junction point.

viii. Hydraulic gradient for the applicable storm event, including losses through structures with friction and local loss coefficients.

ix. Estimated receiving water elevation with sources of information, if available.

x. Velocities for all facilities and details for provisions to control erosion.

d) Construction plans including, but not limited to, the following:

i. Overall project plan of roads, lots, and stormwater control measures.

ii. Staging and sequencing of construction of stormwater control measures.

iii. Cross-section of stormwater control measures.

iv. Typical swale, ditch, or canal sections.

v. Drainage rights-of-way.

vi. Road plan and profile with groundwater elevation shown in profile.

vii. Overall project grading plan (at 1-foot contours) and individual lot grading plans.

viii. Density of the project.

D. Maintenance Plans

Maintenance Plans shall be submitted to the City prior to occupancy or acceptance of public improvements. The maintenance plan shall contain:

1) A designated entity for stormwater inspection and maintenance responsibilities;

2) The routine and non-routine maintenance tasks to be undertaken;

3) A schedule for inspection and maintenance;

4) Any necessary legally binding maintenance easements and agreements; and

5) A map showing all access and maintenance easements.

E. Shared Systems Allowed

The City of Dublin finds that enabling the coordination of shared stormwater treatment facilities between two or more properties may be desirable in cases where shared systems promote greater efficiency in land use, support the design goals of the Bridge Street District, reduce the total area of land consumed by stormwater treatment areas, or enable greater use of recommended treatment approaches, including vegetation-based control measures.

1) Design Standards Apply

All design standards and requirements in this Manual shall apply to the design, approval and construction of shared stormwater treatment facilities.

2) Consent of All Property Owners Required

Any group of two or more property owners may apply for approval of a shared system. The record owner of each property whose improvements would discharge into the proposed system, or whose land would be utilized for any component of the treatment system, including surface or underground conveyance or discharge, shall be required to sign the application for a Stormwater Management Plan that involves a shared system.

3) Use of the Public Right-of-Way Prohibited

Use of the public right-of-way to meet water quality and quantity requirements, as described in Chapter 2, in conjunction with a shared system solely serving privately-owned properties, is prohibited.

4) Allocation of Capacity in the Shared System.

The allocation of capacity in the shared stormwater system, described in terms of the amount of impervious area discharging to the system from each property and any rights-of-way, shall be stated in the Stormwater Management Plan application and incorporated into the written approval of the Stormwater Management Plan and associated development(s).

In the event of an application to amend any approval for a property or properties party to the shared stormwater system that would increase or decrease the system capacity used by one or more property owners, a revised Stormwater Management Plan application shall be submitted stating the proposed change in the allocation of capacity, and all property owners party to the Stormwater Management Plan shall sign the application indicating consent to the change.

At the time of application for a Stormwater Management Plan, a shared stormwater treatment system may be designed for a greater capacity than would be required to treat the existing and proposed development(s) utilizing the system. In the event such an application is made, the applicants shall state clearly the total design capacity required to manage runoff from existing and proposed development, and the capacity proposed to be constructed that would serve future development. At such time as additional development is proposed to utilize the system, amendment of the Stormwater Management Plan shall be required in conjunction with other development approvals.

5) Recording of Agreement and Required Terms and Conditions

A binding agreement in a form suitable to the City Attorney shall be recorded in the land records prior to issuance of any permit to construct the system and associated improvements. Such an agreement shall, at a minimum:

a) State that the property owners consent to the terms and conditions of the Stormwater Management Plan and conditions of development approval relevant to the shared system;

b) Bind the parties to make the land available for, and maintain the system as intended per its approved design, in perpetuity, unless the land development permits attached thereto are amended by the applicable City or State authorities upon the written consent of all property owners using the shared system;

c) Stipulate the terms and conditions under which the parties shall be responsible for maintenance of the system, and the penalties and remedies in the event one or more parties damages the system or otherwise violates the terms of the agreement; and

d) Authorize the City, upon written notice to the property owners, to enter, repair and maintain the system and recover all associated costs in the event the system deteriorates in the sole judgment of the City Engineer to the point of posing a threat to surface waters, public improvements, health, safety or property.

8. EROSION AND SEDIMENT CONTROL

A. Purpose

It is the purpose of this Section to provide standards and guidelines for the preparation of erosion and sediment control plans that protect public health, safety and welfare, and the quality of Dublin's waters from excessive erosion and sedimentation resulting from the construction and operation of development.

B. Applicability

When required by this regulation, a soil erosion and sediment control plan shall be prepared for the earth disturbance activities. Furthermore, in accordance with the appropriate requirements of § 53.310, the plan shall be prepared, submitted to the City, and approved by the City, prior to any earth- disturbance.

The plan shall serve as a basis for all subsequent grading and stabilization and be incorporated as part of the final construction drawings.

C. Plan Content

1) Any person seeking approval of an earth disturbance proposal shall, on a map rendered from a base derived from the site Stormwater Management Plan or site grading plan, at a scale not to exceed 1" – 100', provide the following information:
   a) A description of the nature and type of the construction activity (e.g., low density residential, shopping mall, highway, etc.)
   b) Total area of the site and the area of the site that is expected to be disturbed (i.e., grubbing, clearing, excavation, filling or grading, including off-site borrow areas).
   c) Existing data describing the soil and, if available, the quality of any discharge from the site.
   d) A description of prior land uses at the site.
   e) An implementation schedule which describes the sequence of major construction operations (i.e., grubbing, excavating, grading, utilities and infrastructure installation) and the implementation of erosion, sediment and storm water management practices or facilities to be employed during each operation of the sequence.
   f) The name and/or location of the immediate receiving stream or surface water(s) and the first subsequent named receiving water(s) and the aerial extent and description of wetlands or other special aquatic sites at or near the site which will be disturbed or which will receive discharges from disturbed areas of the project.

2) For subdivided developments where the Stormwater Management Plan does not call for a centralized sediment control capable of controlling multiple individual lots, a detail drawing of a typical individual lot showing standard individual lot erosion and sediment control practices. This does not remove the responsibility to designate specific erosion and sediment control practices in the Stormwater Management Plan for critical areas such as steep slopes, stream banks, drainage ways and stream corridor protection zones.

3) Location and description of any storm water discharges associated with dedicated, on-site asphalt and concrete plants covered by this permit and the best management practices to address pollutants in these storm water discharges.

4) A description of the intended maintenance plan with associated frequencies shall be required for the site.

5) Site map showing:
   a) Limits of earth-disturbing activity of the site including associated off-site borrow or spoil areas that are not addressed by a separate NOI and associated Stormwater Management Plan.
   b) Soils types for all areas of the site, including locations of unstable or highly erodible soils.
   c) Existing and proposed contours.
   d) A delineation of drainage watersheds expected during and after major grading activities as well as the size of each drainage watershed, in acres.
   e) Surface water locations including springs, wetlands, streams, lakes, water wells, etc., on or within 200 feet of the site, including the boundaries of wetlands or stream channels and first subsequent named receiving water(s) the permittee intends to fill or relocate for which the permittee is seeking approval from the Army Corps of Engineers and/or Ohio EPA.
   f) Existing and planned locations of buildings, roads, parking facilities and utilities.
   g) The location of all erosion and sediment control practices, including the location of areas likely to require temporary stabilization during the course of site development.
   h) Sediment and storm water management basins noting their sediment settling volume and contributing drainage area.
   i) Permanent storm water management practices to be used to control pollutants in storm water after construction operations have been completed.
   j) Areas designated for the storage or disposal of solid, sanitary and toxic wastes, including dumpster areas, areas designated for cement truck washout, vehicle fueling, and lay down areas.
   k) The location of designated construction entrances where the vehicles will access the construction site.
   l) The location of any in-stream activities including stream crossings.

6) Additionally, the plan, as part of the overall Stormwater Management Plan, shall provide space for signatures of City of Dublin officials. These signature blocks shall be placed on the Stormwater Management Plan drawings.

7) Statement identifying the name, address, and telephone number of the person(s) preparing the plan, the owner of the property where the grading is proposed and the developer and/or person responsible for the development area.

8) A statement indicating that the owner will notify the City forty-eight (48) hours before commencing any earth-disturbing activity. At the time this notice is given, the owner shall identify the site manager.

9) The City Engineer may waive specific requirements for plan detail or may require additional information to show that work will conform to basic requirements of this regulation.

D. Calculations

Any person seeking approval of an Erosion and Sediment Control Plan (ESCP) shall submit design computations and applicable assumptions for all structural measures for erosion and sediment control. Volume and velocity of flow shall be provided for all surface water conveyance. This information shall also be provided for surface water outlets. Specific guidance for Erosion and Sediment Control Plan calculations referenced in § 53.320.

E. Standards and Criteria

1) Non-Structural Preservation Methods

The ESCP must make use of practices that preserve the existing natural condition as much as feasible. No construction shall be allowed within the Stream Corridor Protection Zone defined by these regulations unless explicitly allowed under Section § 53.210. In addition, construction operations shall be phased in order to minimize the amount of disturbed land at any one time. Within zones designated for active construction, tree preservation areas under § 153.140 through § 153.148, soil preservation areas, or other protective clearing or grubbing practices shall be designated.

2) Timing of Sediment-Control Practices

Sediment control practices shall be functional throughout earth-disturbing activities. Sediment ponds (including sediment basins and traps) and perimeter controls intended to trap sediment shall be implemented as the first step of grading and within seven days from the start of grubbing. They shall continue to function until the upslope development area is re-stabilized.

3) Stabilization

Disturbed areas must be stabilized as specified in the sections that follow.

PERMANENT STABILIZATION	
Area requiring permanent stabilization	**When to implement controls**
Any areas that will lie dormant for one year or more	Within seven days of the most recent disturbance
Any areas within 50 feet of a stream and at final grade	Within two days of reaching final grade
Any other areas at final grade	Within seven days of reaching final grade within that area

TEMPORARY STABILIZATION	
Area requiring temporary stabilization	**When to implement controls**
Any disturbed areas within 50 feet of a stream and not at final grade	Within two days of the most recent disturbance if the area will remain idle for more than 14 days
For all construction activities, any disturbed areas that will be dormant for more than 14 days but less than one year, and not within 50 feet of a stream	Within seven days of the most recent disturbance within the area For residential subdivisions, disturbed areas must be stabilized at least seven days prior to transfer of permit coverage for the individual lot(s).
Disturbed areas that will be idle over winter	Prior to the onset of winter weather

Where vegetative stabilization techniques may cause structural instability or are otherwise unobtainable, alternative stabilization techniques must be employed.

4) Construction Access Routes

Measures shall be taken to prevent soil transport onto surfaces or onto public roads where runoff is not checked by sediment controls. Off-site tracking of sediments and dust generator shall be minimized, as required under the City's Ordinance, § 97.38.

5) Sloughing and Dumping

No soil, rock, debris, or any other material shall be dumped or placed into a stream or into such proximity that it may readily slough, slip, or erode into a stream, unless such dumping or placing is authorized by the City Engineer and when applicable, the U.S. Army Corps of Engineers, for such purposes as, but not limited to, construction of bridges, culverts, and erosion control structures.

Unstable soils that, in the opinion of the City Engineer, are prone to slipping or landsliding shall not be graded, excavated, filled or have loads imposed upon them unless the work is done in accordance with a qualified professional engineer's recommendations to correct, eliminate, or adequately address the problems.

6) Cut and Fill Slopes

Cut and fill slopes shall be designed and constructed in a manner that will minimize erosion. Consideration shall be given to the length and steepness of the slope, soil type, upslope drainage area, groundwater conditions, and slope stabilization.

7) Stabilization of Outfalls and Channels

Outfalls and constructed or modified channels shall be designed and constructed to withstand the expected velocity of flow from a post-development, five-year frequency storm without eroding.

8) Establishment of Permanent Vegetation

Permanent vegetation shall not be considered established until ground cover is achieved which, in the opinion of the City Engineer, provides adequate cover with a density of at least 70% and is mature enough to control soil erosion satisfactorily and to survive adverse weather.

9) Sediment Deposition

Sediment deposition caused by accelerated stormwater runoff over a development site or by accelerated erosion due to the sloughing or sliding of surface soil that has been exposed by grading, dumping, stockpiling or any other excavation-related earth disturbances shall be retarded and confined to within the boundaries of the development site, during site development.

10) Sediment Control Practices During Construction

The ESCP shall include a description of structural practices that shall store runoff during construction, allowing sediments to settle and/or diverting flows away from exposed soils or otherwise limiting runoff from exposed areas. Structural practices shall be used to control erosion and trap sediment from a site remaining disturbed for more than 14 days. Such practices may include, among others: sediment settling ponds, silt fences, earth diversion dikes or channels which direct runoff to a sediment settling pond and storm drain inlet protection. All sediment control practices must be capable of ponding runoff in order to be considered functional. Earth diversion dikes or channels alone are not considered a sediment control practice unless those are used in conjunction with a sediment settling pond. The ESCP must contain detailed drawings for all structural practices.

11) Timing

Sediment control structures shall be functional throughout the course of earth-disturbing activity. Sediment basins and perimeter sediment barriers shall be implemented prior to grading and within seven days from the start of grubbing. They shall continue to function until the up slope development area is restabilized according to requirements in Section § 53.320(C)(1) As construction progresses and the topography is altered, appropriate controls must be constructed or existing controls altered to address the changing drainage patterns.

12) Sediment Settling Ponds

Concentrated storm water runoff and runoff from drainage areas, which exceed the design capacity of silt fence or inlet protection, shall pass through a sediment settling pond. For common drainage locations that serve an area with 10 or more acres disturbed at one time, a temporary sediment settling pond must be provided until final stabilization of the site. The permittee may request approval from Ohio EPA to use alternative controls if it can demonstrate the alternative controls are equivalent in

effectiveness to a sediment settling pond. It is recommended that smaller sediment basins and/or sediment traps be used for drainage locations serving less than 10 acres.

The sediment settling pond shall be sized to provide at least 67 cubic yards of storage per acre of total contributing drainage area. When determining the total contributing drainage area, off-site areas and areas which remain undisturbed by construction activity must be included unless runoff from these areas is diverted away from the sediment settling pond and is not co-mingled with sediment-laden runoff. The depth of the sediment settling pond must be less than or equal to five feet. The configuration between inlets and the outlet of the basin must provide at least two units of length for each one unit of width (> 2:1 length:width ratio). Sediment must be removed from the sediment settling pond when the design capacity has been reduced by 40 percent (This is typically reached when sediment occupies one-half of the basin depth). When designing sediment settling ponds, the permittee must consider public safety, especially as it relates to children, as a design factor. Alternative sediment controls must be used where site limitations would preclude a safe design. The use of a combination of sediment and erosion control measures in order to achieve maximum pollutant removal is encouraged.

13) Silt Fence and Diversions

Sheet flow runoff from denuded areas shall be intercepted by silt fence or diversions to protect adjacent properties, streams, and stream corridor protective zones from sediment transported via sheet flow. Where intended to provide sediment control, silt fence shall be placed on a level contour. The use of other sediment barriers designed to control sheet flow runoff shall be at the discretion of the City Engineer. The relationship between the maximum drainage areas to silt fence for a particular slope range is shown in the following:

SILT FENCE CRITERIA	
Maximum drainage area (in acres) to 100 linear feet of silt fence	Range of slope for a particular drainage area (by percent)
0.5	< 2%
0.25	> 2% but < 20%
0.125	> 20% but < 50%

Stormwater diversion practices shall be used to keep runoff away from disturbed areas and steep slopes where practicable. Such devices, which include swales, dikes or berms, may receive storm water runoff from areas up to 10 acres.

14) Inlet Protection

Inlet protection control measures shall minimize sediment laden water entering active storm drain systems, unless the storm drain system drains to a sediment settling pond. Sediment shall be removed from the storm sewer, to the extent possible, prior to final approval.

15) Other Controls

Non-Sediment Pollutant Controls. No solid (other than sediment) or liquid waste, including building materials, shall be discharged in storm water runoff. The permittee must implement all necessary control measures to prevent the discharge of non-sediment pollutants to the stormwater management system of the site or surface waters of the state. Under no circumstance shall concrete trucks wash out directly into an open channel, storm sewer or surface waters of the state. No exposure of storm water to waste materials is recommended.

16) Compliance with Other Requirements

The Stormwater Management Plan shall be consistent with applicable State and/or local waste disposal, sanitary sewer or septic system regulations, including provisions prohibiting waste disposal by open burning and shall provide for the proper disposal of contaminated soils to the extent these are located within the permitted area.

17) Trench and Ground Water Control

There shall be no turbid discharges resulting from dewatering activities. If trench or ground water contains sediment, it must pass through a sediment settling pond or other equally effective sediment control device, prior to being discharged from the construction site. Alternatively, sediment may be removed by settling in place or by dewatering into a sump pit, filter bag or comparable practice. Ground water dewatering which does not contain sediment or other pollutants is not required to be treated prior to discharge. However, care must be taken when discharging ground water to ensure that it does not become pollutant-laden by traversing over disturbed soils or other pollutant sources.

18) Disposition of Temporary Practices

All temporary erosion and sediment control practices shall be disposed of within thirty days after final site stabilization is achieved or after the temporary practices are no longer needed, unless otherwise authorized by the City Engineer. Trapped sediment shall be removed or permanently stabilized to prevent further erosion.

19) Maintenance

All temporary and permanent erosion and sediment control practices shall be designed and constructed to minimize maintenance requirements. They shall be maintained and repaired as needed to assure continued performance of their intended function. The person or entity responsible for continued maintenance of permanent and temporary erosion controls shall be identified on the Stormwater Management Plan to the satisfaction of the City.

9. REFERENCES

A. Books, Manuals and Reports

Bonnin, Martin, Lin, Parzybok, Yekta, Riley. 2004. *NOAA Atlas 14, Volume 2, Version 3.0*

Chow, V. T., Maidment, D. R., Mays, L. W. 1988. *Applied Hydrology.*

England, G. and Stein, S. 2007. *Stormwater BMPs: Selection, Maintenance, and Monitoring*. Santa Barbara, CA: ForesterPress

Froehlich, D.C. (March/April 2009, Errata 2010). Mathematical Formulations of NRCS 24-Hour Design Storms. *Journal of Irrigation and Drainage Engineering.* ASCE. Vol. 135, No. 2, pp. 241-247

North Carolina Department of Environment and Natural Resources. March 2010. *Stormwater BMP Manual: Chapter 8 Level Spreader – Vegetative Filter Strip System.*

North Carolina Division of Water Quality. 2007. *Stormwater Best Management Practices Manual.*

Texas Water Development Board. 2005. *The Texas Manual on Rainwater Harvesting, Third Edition.*

B. Web Sites

NOAA Precipitation Frequency Data Server http://dipper.nws.noaa.gov/hdsc/pfds/ June 10, 2012

APPENDIX A
Section 53.070 EXEMPTIONS

§ 53.070 Exemptions

With the approval of the City Engineer, the following activities may be exempted from on-site stormwater runoff control. An exemption shall apply only to the requirement for on-site stormwater detention or retention facilities. All other design elements such as the storm sewer system, road culverts, erosion and sedimentation control, and runoff quality shall not be exempted.

(A) *Emergency exemption.* Emergency maintenance work performed for the protection of public health and welfare, however, if the earth-disturbing activity would have required an approved erosion and sediment control plan, if the activity were not an emergency, then the land area disturbed shall be shaped and stabilized in accordance with the requirements of the city.

(B) *Maintenance exemption.* Any maintenance to an existing system made in accordance with plans and specifications approved by the City Engineer.

(C) *Development-related exemptions.* The applicant shall provide to the City Engineer in writing a request for exemption which shall include a scaled site map, property tax number, and street address if applicable.

(1) Single-family or duplex exemption. Single-family or duplex residential construction on a single lot that is not part of a larger common plan of development.

(2) Any construction which adds less than 500 square feet through expansion of a building, structure or pavement which results in new impervious area on a project site.

(3) It is conceivable that development situations not automatically subject to exemption may exist such that development will have none of the harmful effects of sediment deposition. Such development situations, subject to city concurrence, are eligible for a waiver from this regulation. Waiver requests shall be made in writing to the City Engineer and shall include sufficient detail to support that granting a wavier will not be detrimental to abutting properties or to watercourses, public waters, or to the sewer system.

(D) *Scioto River Corridor Exemption.* Parcels that are located between State Route 745 (Dublin Road) and State Route 257 (Riverside Drive) which are directly tributary to the Scioto River.

(E) Regular farming activities on land intended for such use, except when these activities involve practices which increase storm water runoff and exacerbate erosion and sedimentation.

(F) Tilling, planting or harvesting of agricultural, horticultural, or forest crops that employ soil conservations related to agriculture as follows: construction of terraces, terrace outlets, check dams, desilting basins, dikes, ponds, ditches, strip cropping, lister furrowing, contour cultivating, contour furrowing, and land drainage and land irrigation which does not cause an increase in stormwater runoff and does not exacerbate erosion and sedimentation.

(G) Minor earth-disturbing activities such as home gardens and individual home landscaping, repairs, service connections and maintenance work.

(H) Installation, maintenance or repair of any underground public utility lines when such activity occurs on an existing hard surfaced road, street or sidewalk (provided the earth-disturbing activity is confined to the area of the road, street or sidewalk that is hard surfaced), and does not involve dewatering operations that produce sediment-laden effluent discharging to surface-lands and/or surface-waters.

(I) Septic tank lines or drainage fields unless included in an overall plan for earth-disturbing activity relating to the construction of the building to be served by the septic tank system.

(J) Repair or rebuilding of the tracks within the right-of-way of a railroad company.

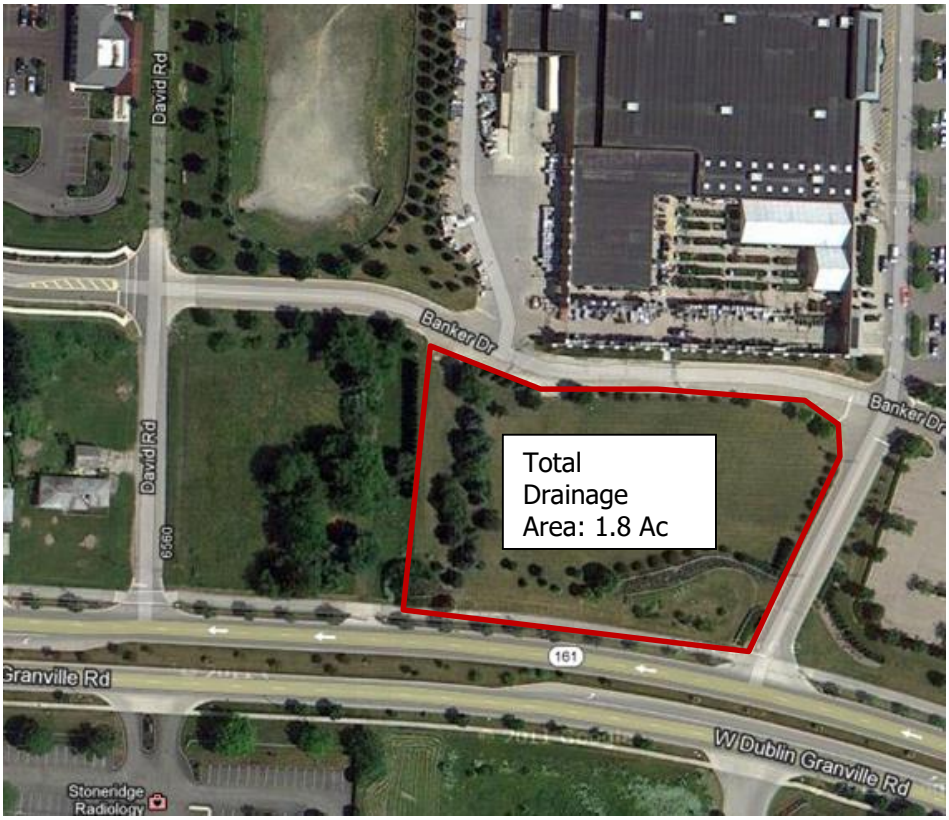
(K) *Stream Corridor Protection Zone.* Stream corridor protection zones are not required if a preliminary plan has already been approved for a site at the time this chapter is passed.

(L) *Historic Dublin.* Development within this area, as defined in the Zoning Code, shall be exempt from compliance with the city's stormwater quantity regulations but shall be held in compliance with the city's storm water quality regulations, described in § 53.090, if the construction activities disturb one or more acres of total land.

(Ord. 48-05, passed 9-6-05)

APPENDIX B
EXAMPLE STORMWATER APPROACH AND CALCULATIONS

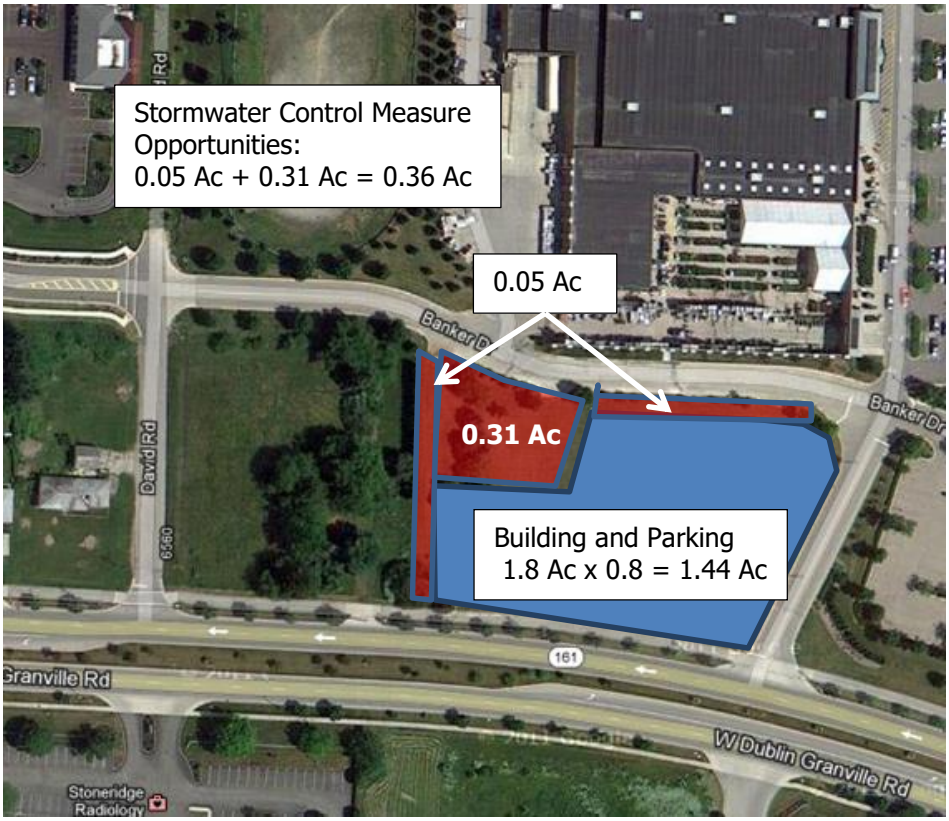
EXAMPLE 1: NEW DEVELOPMENT



Pre-Development Data
Site Area = Total Drainage Area (A) = 1.8 Ac
Impervious Area = 0%
Soils Type "D" http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Land Use = Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >50%)
Curve Number = 80 (NEH Part 630, Chapter 9, Table 9-1 and Table 9-5)

Compute Time of Concentration: (NEH Part 630, Chapter 15, Velocity Method)
Sheet Flow: 300 feet at 0.019 ft/ft, Dense grasses
Shallow Concentrated Flow: 105 feet at 0.019 ft/ft, Grassed waterways
Tc = 0.66 hours



Post-Development Data

Site Area = Total Drainage Area (A) = 1.8 Ac
Building Type: Corridor Building
Impervious Area = 80% = 1.44 Ac (maximum for Corridor Building)
Pervious Area:
Assume 5-foot side yard and rear yard = 0.05 Ac
Assume "Green Space" = 0.31 Ac
Soils Type "D" http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Land Use = Urban | Commercial and Business (est. 85% imperv.)
Curve Number = 95 (NEH Part 630, Chapter 9, Table 9-1 and Table 9-5)

Compute Time of Concentration: (NEH Part 630, Chapter 15, Velocity Method)
Sheet Flow: 65 feet at 0.019 ft/ft dense grasses
Tc = 0.19 hours

Critical Storm Calculation

This example uses a unit hydrograph approach as described in the National Engineering Handbook (NEH) Part 630, Chapter 16, Hydrographs. Per City standards, a NRCS Type II 24-hour design storm is used. The curve number method is used to estimate runoff volume per NEH Part 630, Chapter 10, Estimation of Direct Runoff from Storm Rainfall.

Pre-development: 1-year, 24-hour storm runoff volume = 4,538 CF
Post-Development: 1 year, 24 hour storm runoff volume = 10,645 CF

(Post – Pre)/Pre x 100 = Percent of Increase in Runoff Volume = Critical Storm
(10,645 – 4,538)/4,538 x 100 = 135%
Critical Storm = 25-year storm

TABLE B-1 CRITICAL STORM DETERMINATION

If the Percent of Increase in Runoff Volume is		The Critical Storm Runoff Rate Will Be Limited to:
Equal to or Greater than	And less than	
--	10	1 year
10	20	2 year
20	50	5 year
50	100	10 year
100	250	25 year
250	500	50 year
500	--	100 year

On-Site and Off-Site Area Allocation

Supply project location information to Engineering Development Group Civil Engineers, and they will supply the sub-basin information.

Supplied Information:
Studied Area = East Unconsolidated Watersheds Sub-Basin 2600

TABLE B-2 EXCERPT FROM CITY OF DUBLIN STORMWATER MASTER PLAN

	Design Storm (CFS/Ac)						
Sub-basin	1	2	5	10	25	50	100
2600	0.1	0.2	0.3	0.4	0.6	0.8	1.1

Allowable release rate for the critical storm is 0.1 CFS x 1.8 Ac = 0.18 CFS

Show the allocation of on-site and off-site area contributory to the facility for each applicable Stormwater Master Plan sub-basin as follows:

TABLE B-3 ON-SITE AND OFF-SITE AREA ALLOCATION

Sub-Basin Identifier #	On-Site Area (acre)	Off-Site Area (acre)	Total (acre)
2600	1.8	0	1.8

Total (acre)	1.8	0	1.8

Stormwater Control Measure (SCM) Design

This section describes several stormwater management alternatives that could be used to meet the water quality and quantity requirements as described in Chapter 2. The three alternatives are provided explicitly for these example calculations and are not to imply a requirement for submittal of design alternatives.

Alternative 1: Traditional Bioretention

***Please note that the following example is utilizing the previous method of calculating water quality volume that would not be applicable today.**

Available construction area: 0.36 acres = 15,682 SF
Water Quality Volume (WQv): C*(P/12)*A = (1.6)*(0.75/12)*1.8 = 0.18 (ac-ft) = **7,841 CF**

C=runoff quality coefficient (Refer to OEPA Permit No.: OHC000003 for values) or use
$C=0.858i^3-0.78i^2+0.774i+0.04 = 1.6$
where i=fraction of post-const. impervious surface = 0.8
P=0.75 Precipitation depth, inches
A=area tributary to the basin, acres

In this example, storage volume is calculated assuming vertical movement of water within the bioretention facility is ignored. Hence the time required for the water to filter through a soil or aggregate layer is ignored. Infiltration rates are only used at the bottom of the bioretention facility to release the water back into the native soil. The facility is sized to control the allowable peak rate of runoff from the critical storm and the less frequent storm events. Allowable peak rates are included in Table B-4. Following the determination of the size of the bioretention facility to meet the peak rate of runoff requirements, a cross-check is performed to ensure that the facility volume is at least as great as the water quality volume.

Model Results Summary: (see results tables and graphs below)
Bioretention surface area required: 11,449 SF (98 ft x 98 ft)
Bioretention total water storage volume: 19,905 CF
Surface Storage: 10 inches (3H:1V side slope)
Growing Layer: 24 inches (1H:1V side slope)
Drainage Layer: 30 inches (Vertical side slope)
Orifice 1 Offset: 3 inches from bottom of storage layer
Orifice 1 Area: 0.015 SF (1.7-inch diameter)
Orifice 2 Offset: 63.5 inches from bottom of storage layer
Orifice 2 Area: 0.5 SF (9.6-inch diameter)
Evapotranspiration: 0.1 inches/day
Infiltration through bottom of SCM: 0.06 inches/hr

TABLE B-4 TRADITIONAL BIORETENTION STORMWATER DATA

	1-year	2 year	5 year	10 year	25 year	50 year	100 year
Predeveloped Q (cfs)	0.86	1.26	1.88	2.42	3.21	3.89	4.62
Postdeveloped Q (cfs)	3.74	4.64	5.88	6.92	8.35	9.54	10.8
Allowable Release (cfs)	0.18	0.18	0.18	0.18	0.18	1.44	1.98
Actual Release (cfs)	0.08	0.09	0.10	0.10	0.11	0.49	1.96
Surface Water Dewater Time (hr)	Before end of storm	Before end of storm	1.5	8.5	18	20.4	20.5
Total Dewater Time (hr)	25.1	31.2	39.4	46.3	56	58.3	58.4

EXAMPLE CALCULATIONS

Stormwater Control Measure 1

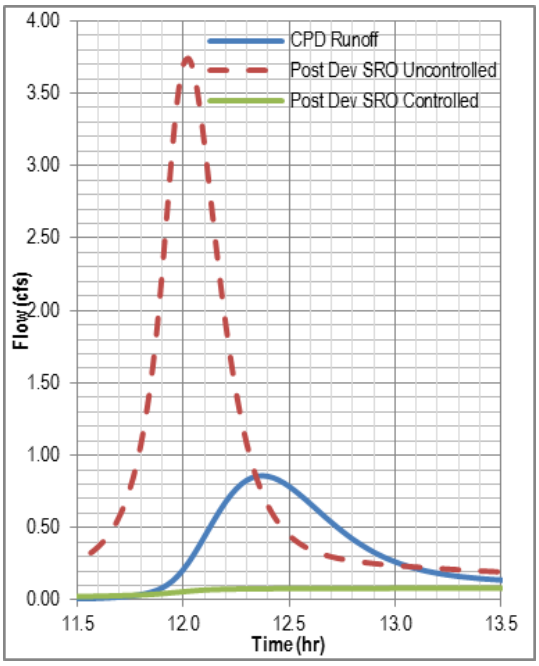
Practice Type	Bioretention
Drainage Area (ac)	1.8
Discharge To	Offsite
Len:Width (xL:1W)	1

	Allowed	Area (sf)
Evaporation	Yes	11449
Infiltration (through bottom)	Yes	9604

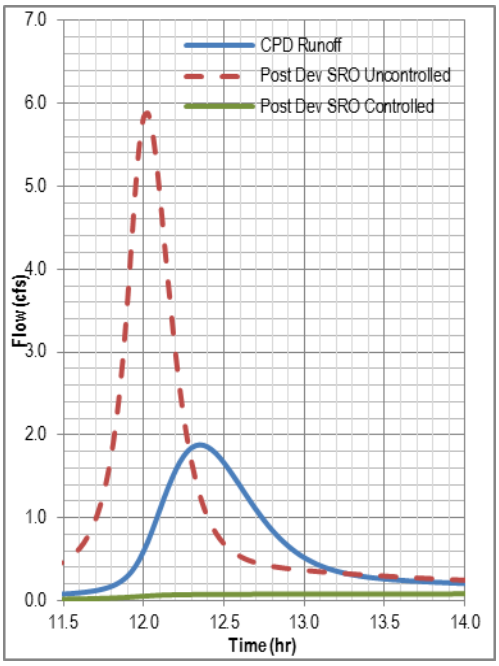
	Cross Section Media	Layer (in)	Side Slope xH:1V	Width (ft)	Len (ft)	Surface Area (sf)	Void Ratio	Total Vol (cf)	Water Storage Vol (cf)
Top				107.0	107.0	11,449			
	NA		0	107.0	107.0	11,449	100%	0	0
	NA		0	107.0	107.0	11,449	100%	0	0
	Surface Storage	10	3	102.0	102.0	10,404	100%	9,102	9,102
	Planting Soil Sandy Loam	24	1	98.0	98.0	9,604	30%	20,003	6,001
Bottom	Planting Soil Sandy Clay Loam	30	0	98.0	98.0	9,604	20%	24,010	4,802
	Total	**64**					**Total**	**53,115**	**19,905**

Outlet Type	Orifice	Orifice	None	None	None
Offset from bottom (in)	3	63.5			
coefficient c	0.6	3			
Area (sf) or Length (ft)	0.01	0.5			
Volume below the offset (cf)	480.2	19429	NA	NA	NA

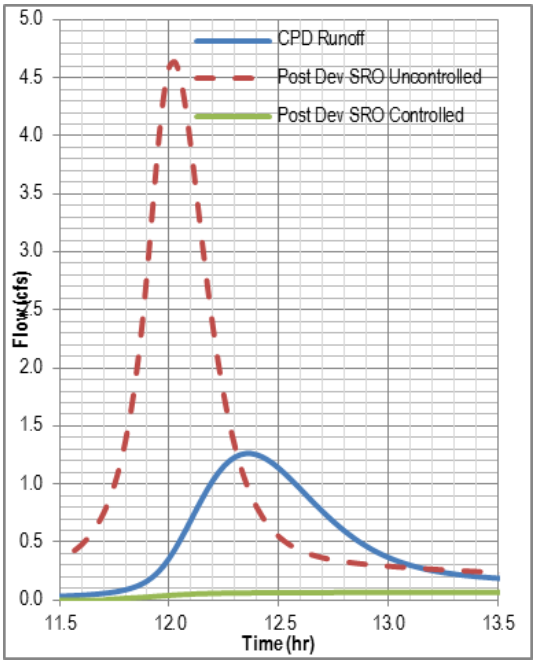
Surface Storage (in)	10



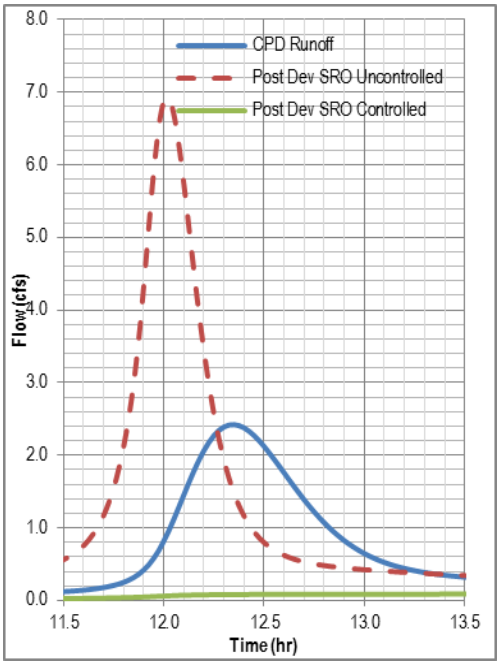
1-year 24-hour Runoff Hydrographs



5-year 24-hour Runoff Hydrographs



2-year 24-hour Runoff Hydrographs

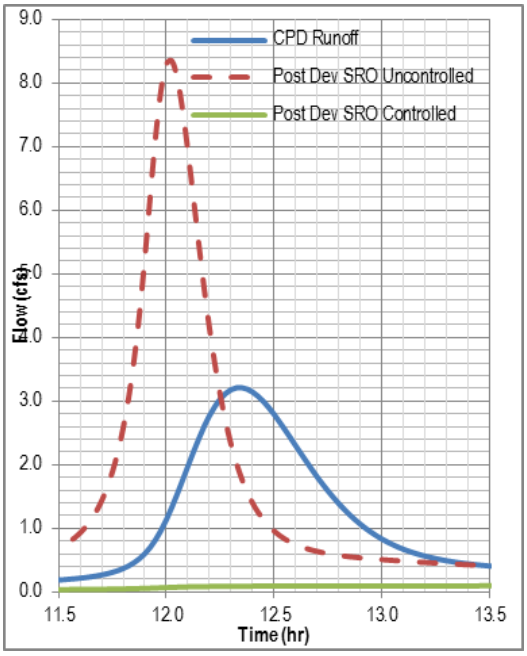


10-year 24-hour Runoff Hydrographs

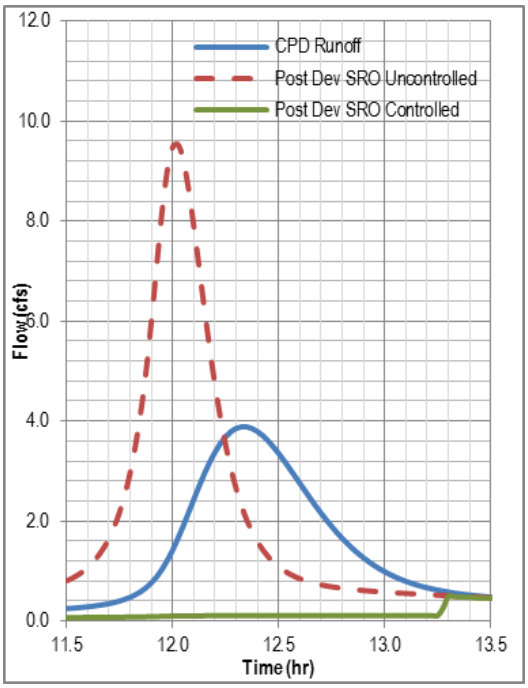
TOTAL SYSTEM RESULTS

	Recurrence Interval	1-year	2-year	5-year	10-year
PEAK FLOW	CPD Runoff (cfs)	0.86	1.26	1.88	2.42
	Post Dev SRO Uncontrolled (cfs)	3.74	4.64	5.88	6.92
	Post Dev SRO Controlled (cfs)	**0.08**	**0.09**	**0.10**	**0.10**
	Difference CPD - Post Dev (cfs)	0.8	1.2	1.8	2.3
	Criteria	Qpost<= 0.18 cfs	Qpost<= 0.18 cfs	Qpost<= 0.18 cfs	Qpost<= 0.18 cfs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**	**Yes**
VOLUME	CPD Runoff (cf)	4,538	6,449	9,362	11,950
	Post Dev Runoff (cf)	10,645	13,337	17,138	20,331
	ET (cf)	215	242	277	306
	Infiltration (cf)	2,541	2,877	3,312	3,673
	Outflow (cf)	7,889	10,218	13,548	16,352
	Remaining Storage (cf)	0	0	0	0
	Continuity	0.00%	0.00%	0.00%	0.00%
	Criteria	Okay	Okay	Okay	Okay
	Criteria Met (Y/N)	NA	NA	NA	NA
DEWATER TIME[1]	Surface Water Dewater Time (hr)	-24.0	-24.0	1.0	8.8
	Criteria	<= 24 hrs	<= 24 hrs	<= 24 hrs	<= 24 hrs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**	**Yes**
	Complete Drainage Dewater Time (hr)	32.7	40.8	51.0	58.9
	Criteria	<= 72 hrs	<= 72 hrs	<= 72 hrs	<= 72 hrs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**	**Yes**

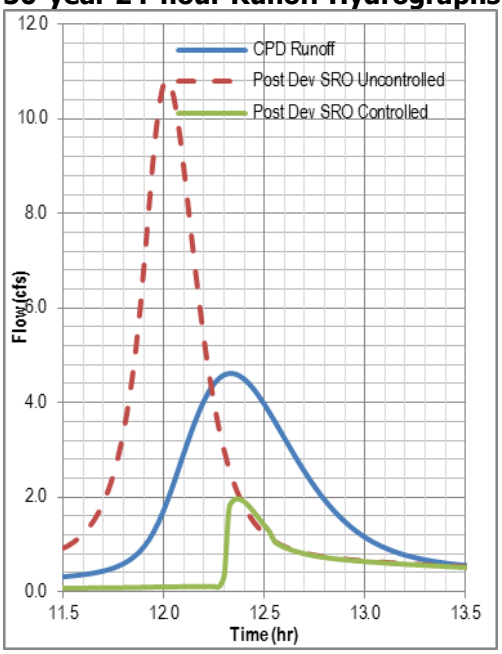
[1]Duration since the end of the rainfall event. Rainfall events are set at 24 hours. Negative values mean that the dewatering is completed before the rainfall ends.



25-year 24-hour Runoff Hydrographs



50-year 24-hour Runoff Hydrographs



100-year 24-hour Runoff Hydrographs

TOTAL SYSTEM RESULTS

	Recurrence Interval	25-year	50-year	100-year
PEAK FLOW	CPD Runoff (cfs)	3.21	3.89	4.62
	Post Dev SRO Uncontrolled (cfs)	8.35	9.54	10.80
	Post Dev SRO Controlled (cfs)	**0.11**	**0.49**	**1.96**
	Difference CPD - Post Dev (cfs)	3.1	3.4	2.7
	Criteria	Qpost<= 0.18 cfs	Qpost<= 1.44 cfs	Qpost<= 1.98 cfs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**
VOLUME	CPD Runoff (cf)	15,750	19,016	22,595
	Post Dev Runoff (cf)	24,828	28,568	32,577
	ET (cf)	346	356	357
	Infiltration (cf)	4,159	4,286	4,302
	Outflow (cf)	20,323	23,926	27,917
	Remaining Storage (cf)	0	0	0
	Continuity	0.00%	0.00%	0.00%
	Criteria	Okay	Okay	Okay
	Criteria Met (Y/N)	NA	NA	NA
DEWATER TIME[1]	Surface Water Dewater Time (hr)	19.0	21.8	21.9
	Criteria	<= 24 hrs	<= 24 hrs	<= 24 hrs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**
	Complete Drainage Dewater Time (hr)	69.1	71.9	72.0
	Criteria	<= 72 hrs	<= 72 hrs	<= 72 hrs
	Criteria Met (Y/N)	**Yes**	**Yes**	**Yes**

[1]Duration since the end of the rainfall event. Rainfall events are set at 24 hours. Negative values mean that the dewatering is completed before the rainfall ends.

Alternative 2: Permeable Pavement

Available construction area: (1.8 ac*0.9) – (1.8 ac*0.8) = 0.18 ac = 7,841 SF (This is the additional 10% of semi-pervious coverage allowed for a Corridor Building Type.)

***Please note that the following example is utilizing the previous method of calculating water quality volume that would not be applicable today.**

Water Quality Volume (WQv): C*(P/12)*A = (1.6)*(0.75/12)*1.8 = 0.18 (ac-ft) = **7,841 CF**

C=runoff quality coefficient (Refer to OEPA Permit No.: OHC000003 for values) or use
$C=0.858i^3-0.78i^2+0.774i+0.04 = 1.6$
where i=fraction of post-const. impervious surface = 0.8
P=0.75 Precipitation depth, inches
A=area tributary to the basin, acres

In this example, permeable pavement storage volume is calculated assuming vertical movement of water within the permeable pavement facility is ignored. Hence the time required for the water to filter through a soil or aggregate layer is ignored. Infiltration rates are only used at the bottom of the facility to release the water back into the native soil. The facility is sized to control the allowable peak rate of runoff from the critical storm and the less frequent storm events. Allowable peak rates are included in Table B-5. Following the determination of the size of the permeable pavement facility to meet the peak rate of runoff requirements, a cross-check is performed to ensure that the facility volume is at least as great as the water quality volume.

Initially, the available storage is calculated within the additional 10% of semi-pervious coverage, which is allowed per the Corridor Building within §153.062(O)(5).

In this case, the semi-pervious area is not large enough to meet the requirements, so it is assumed that semi-pervious coverage will extend into the area reserved for surface parking (assuming this development will have surface parking).

To meet the requirements, the permeable pavement storage must equal 18,818 SF. The design will require an extra 18,818 SF – 7,841 SF = 10,977 SF of permeable pavement beyond the additional 10% of semi-pervious space allowed. (~96 parking spaces)

Model Results Summary:
Permeable Pavement total water storage: 18,818 CF
Surface Storage: 0 inches
Growing Layer: 0 inches
Drainage Layer: 30 inches (vertical side slopes)
Orifice 1 Offset: 0 inches from bottom of storage layer
Orifice 1 Area: 0.025 SF (2.1-inch diameter)
Orifice 2 Offset: 28 inches from bottom of storage layer
Orifice 2 Area: 0.27 SF (7-inch diameter)
Infiltration through bottom of SCM: 0.06 inches/hr

TABLE B-5 PERMEABLE PAVEMENT STORMWATER DATA

	1-year	2 year	5 year	10 year	25 year	50 year	100 year
Predeveloped Q (cfs)	0.86	1.26	1.88	2.42	3.21	3.89	4.62
Postdeveloped Q (cfs)	3.74	4.64	5.88	6.92	8.35	9.54	10.8
Allowable Release (cfs)	0.18	0.18	0.18	0.18	0.18	1.44	1.98
Actual Release (cfs)	0.11	0.13	0.14	0.16	0.18	0.46	1.76
Surface Water Dewater Time (hr)	NA	NA	NA	NA	NA	NA	NA
Total Dewater Time (hr)	14.8	18.7	23.8	27.8	32.9	34.8	35.4

Stormwater calculations must be included per Chapter 7. See Alternative 1 for example calculations.

Alternative 3: Planter Box (attached to building)

Available construction area: Assume 4-foot width around 450 feet of building perimeter = 1,800 SF
***Please note that the following example is utilizing the previous method of calculating water quality volume that would not be applicable today.**

Water Quality Volume (WQv): C*(P/12)*A = (1.6)*(0.75/12)*1.8 = 0.18 (ac-ft) = **7,841 CF**
C=runoff quality coefficient (Refer to OEPA Permit No.: OHC000003 for values) or use
$C=0.858i^3-0.78i^2+0.774i+0.04 = 1.6$
where i=fraction of post-const. impervious surface = 0.8
P=0.75 Precipitation depth, inches
A=area tributary to the basin, acres

In this example, planter box storage volume is calculated assuming vertical movement of water within the planter box facility is ignored. Hence the time required for the water to filter through a soil or aggregate layer is ignored. With a planter box attached to a building, infiltration to the underlying soil is not allowed. The facility is sized to control the allowable peak rate of runoff from the critical storm and the less frequent storm events. Allowable peak rates are included in Table B-6. Following the determination of the size of the facility to meet the peak rate of runoff requirements, a cross-check is performed to ensure that the facility volume is at least as great as the water quality volume.

Initially, the available storage is calculated within the planter box.

In this case, the planter box alone is not enough to meet the requirements, so for this example, bioretention will be added to the site. It is assumed that runoff from the impervious area will first discharge to the planter box, which will overflow to a bioretention area.

Model Results Summary:
Planter Box surface area available: 1,800 SF
Planter Box total water storage: 4,410 CF
Drainage Area: 1.44 Ac
Surface Storage: 12 inches (vertical side slope)
Growing Layer: 18 inches (vertical side slope)
Drainage Layer: 30 inches (vertical side slope)
Orifice Offset: 0 inches from bottom of storage layer
Orifice Area: 0.09 SF (4-inch diameter)
Evapotranspiration: 0.1 inches/day
Infiltration through bottom of BMP: Not allowed

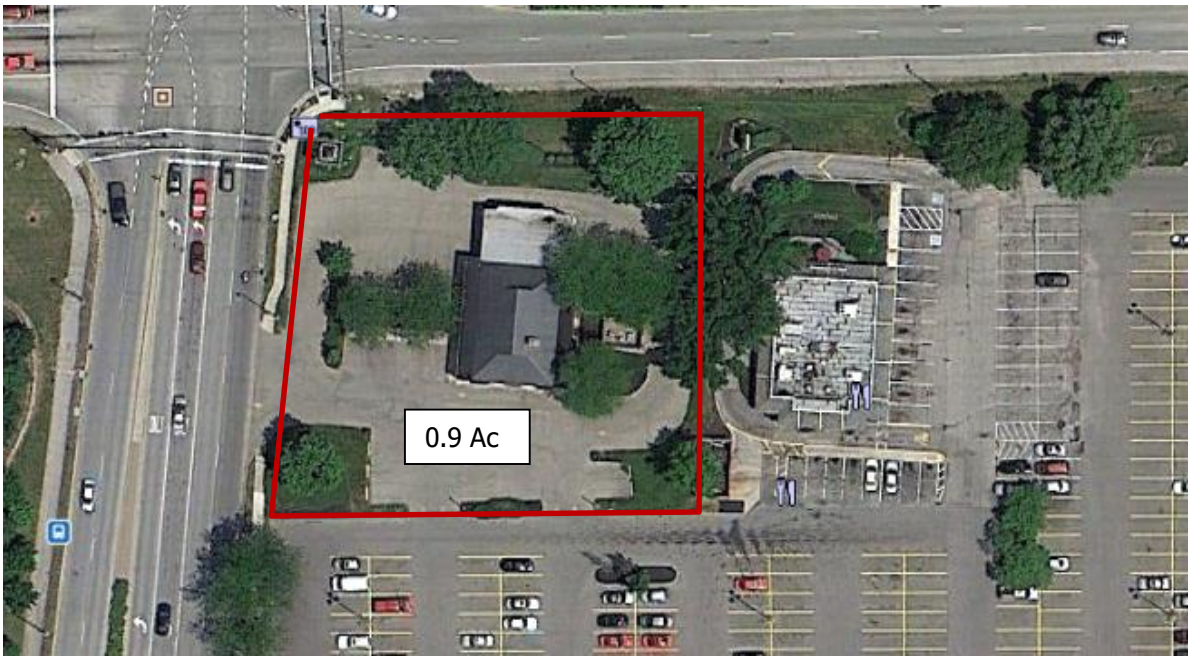
Bioretention surface area required: 9,604 SF
Bioretention total water storage: 20,492 CF
Drainage Area: 0.36 Ac
Surface Storage: 10 inches (3H:1V side slope)
Growing Layer: 24 inches (1H:1V side slope)
Drainage Layer: 30 inches (vertical side slope)
Orifice 1 Offset: 0 inches from bottom of storage layer
Orifice 1 Area: 0.016 SF (1.7-inch diameter)
Orifice 2 Offset: 60 inches from bottom of storage layer
Orifice 2 Area: 2 SF (1.6-foot diameter)
Evapotranspiration: 0.1 inches/day
Infiltration through bottom of SCM: 0.06 inches/hr

TABLE B-6 PLANTER BOX AND BIORETENTION STORMWATER DATA

	1-year	2 year	5 year	10 year	25 year	50 year	100 year
Predeveloped Q (cfs)	0.86	1.26	1.88	2.42	3.21	3.89	4.62
Postdeveloped Q (cfs)	3.74	4.64	5.88	6.92	8.35	9.54	10.8
Allowable Release (cfs)	0.18	0.18	0.18	0.18	0.18	1.44	1.98
Actual Release (cfs)	0.11	0.13	0.15	0.17	0.17	0.82	1.06
Surface Water Dewater Time (hr)	Before end of storm	Before end of storm	Before end of storm	Before end of storm	4.2	5.1	5.8
Total Dewater Time (hr)	20.8	25.3	30.6	34.6	40.7	41.6	42.2

Stormwater calculations must be included per Chapter 7. See Alternative 1 for example calculations.

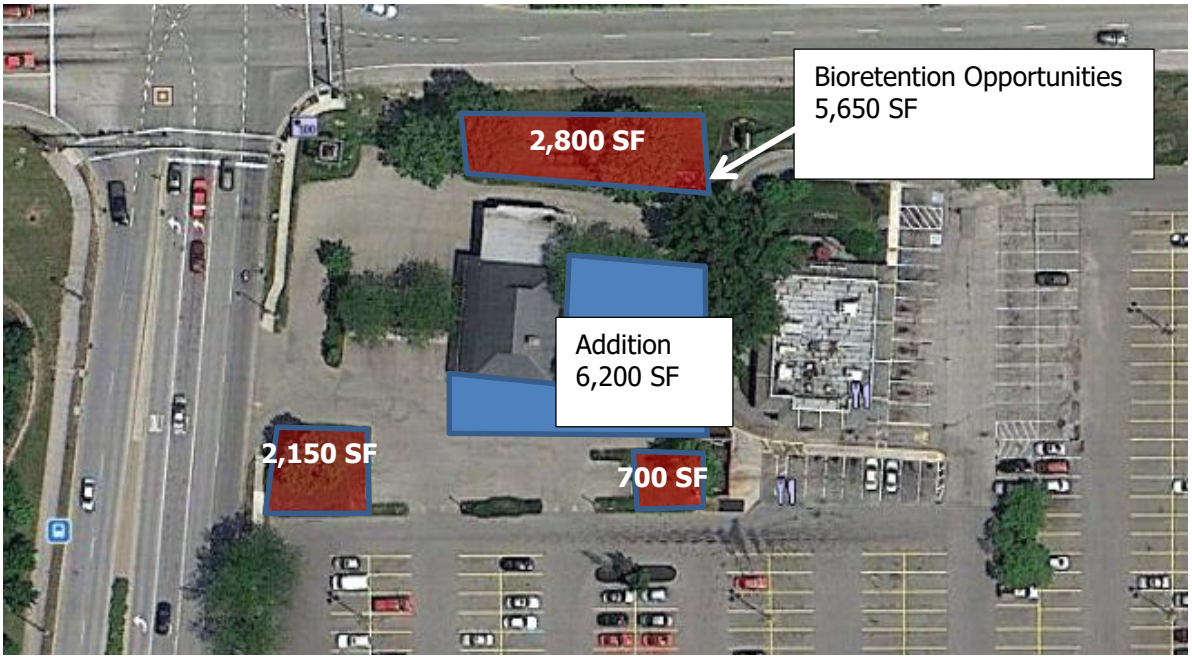
EXAMPLE 2: REDEVELOPMENT



Pre-Development Data
Site Area = Total Drainage Area (A) = 0.9 Ac
Impervious Area = 72% = 0.65 Ac
Soils Type "D" http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious = 0.65 Ac
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >50%) = 0.25 Ac
Curve Number = 93 (NEH Part 630, Chapter 9, Table 9-1 and Table 9-5)

Compute Time of Concentration: (example uses NEH Part 630, Chapter 15, Velocity Method)
Sheet Flow: 175 feet at 0.019 ft/ft smooth surface
Tc = 0.1 hours



The redevelopment on this site constitutes reconstruction of more than fifty percent of an existing building or structure. Therefore, all of the stormwater requirements, including quantity and quality control, must be met for the entire site.

Post-Development Data

Site Area = Total Drainage Area (A) = 0.9 Ac
Impervious Area = 74% = 0.67 Ac
Soils Type "D" http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

Urban | Paved Parking, Roofs, Driveways (excl. ROW) | 100% impervious = 0.67 Ac
Urban | Open Space (lawns, parks, golf, cemeteries) | Good (grass cover >50%) = 0.23 Ac
Curve Number = 93.4 (NEH Part 630, Chapter 9, Table 9-1 and Table 9-5)

Compute Time of Concentration: (example uses NEH Part 630, Chapter 15, Velocity Method)
Sheet Flow: 175 feet at 0.019 ft/ft smooth surface
Tc = 0.1 hours

Critical Storm Calculation

This example uses a unit hydrograph approach as described in the National Engineering Handbook (NEH) Part 630, Chapter 16, Hydrographs. Per City standards, a NRCS Type II 24-hour design storm is used. The curve number method is used to estimate runoff volume per NEH Part 630, Chapter 10, Estimation of Direct Runoff from Storm Rainfall.

Pre-development: 1-year, 24-hour storm runoff volume = 4,927 CF
Post-development: 1-year, 24-hour storm runoff volume = 5,038 CF

(Post – Pre)/Pre x 100 = Percent of Increase in Runoff Volume = Critical Storm
(5,038 – 4,927)/ 4,927 x 100 = 2.2%
Critical Storm = 1-year storm

TABLE B-7 CRITICAL STORM DETERMINATION

CRITICAL STORM DETERMINATION		
If the Percent of Increase in Runoff Volume is		The Critical Storm Runoff Rate Will Be Limited to:
Equal to or Greater than	And less than	
--	10	1 year
10	20	2 year
20	50	5 year
50	100	10 year
100	250	25 year
250	500	50 year
500	--	100 year

On-Site and Off-Site Area Allocation

Supply project location information to Engineering Development Group Civil Engineers, and they will supply the sub-basin information.

Supplied Information:

TABLE B-8 EXCERPT FROM CITY OF DUBLIN STORMWATER MASTER PLAN

	Design Storm (CFS/Ac)						
Sub-basin	1	2	5	10	25	50	100
80	1.8	2.4	3.1	3.7	4.6	5.5	6.4

Allowable release rate for the critical storm is 1.8 CFS x 0.9 Ac = 1.62 CFS

Show the allocation of on-site and off-site area contributory to the facility for each applicable Stormwater Master Plan sub-basin as follows:

TABLE B-9 ON-SITE AND OFF-SITE AREA ALLOCATION

Sub-Basin Identifier #	On-Site Area (acre)	Off-Site Area (acre)	Total (acre)
80	0.9	0	0.9
Total (acre)	0.9	0	0.9

Maximize Treatment Opportunities

Convert turf areas to bioretention.

Available construction area: 0.13 acres = 5,650 SF

***Please note that the following example is utilizing the previous method of calculating water quality volume that would not be applicable today.**

Water Quality Volume (WQv): C*(P/12)*A = (1.4)*(0.75/12)*0.9 = 0.079 (ac-ft) = **3,441 CF**

C=runoff quality coefficient (Refer to OEPA Permit No.: OHC000003 for values) or use
$C=0.858i^3-0.78i^2+0.774i+0.04 = 1.4$
where i=fraction of post-const. impervious surface = 0.74
P=0.75 Precipitation depth, inches
A=area tributary to the basin, acres

In this example, bioretention storage volume is calculated assuming vertical movement of water within the bioretention facility is ignored. Hence the time required for the water to filter through a soil or aggregate layer is ignored. Infiltration rates are only used at the bottom of the facility to release the water back into the native soil. The facility is sized to control the allowable peak rate of runoff from the critical storm and the less frequent storm events. Allowable peak rates are included in Table B-10. Following the determination of the size of the bioretention facility to meet the peak rate of runoff requirements, a cross-check is performed to ensure that the facility volume is at least as great as the water quality volume.

Note that the bioretention total water storage required to control the allowable peak rate of runoff from the critical storm and the less frequent storm events is less than the water quality volume. Therefore, the bioretention facilities will need to be designed with an additional 3,441 CF – 1,903 CF = 1,538 CF of added storage to meet the water quality requirement.

Model Results Summary:
Bioretention surface area required: 1,225 SF
Bioretention total water storage: 1,903 CF
Surface Storage: 8 inches (3H:1V side slope)
Growing Layer: 18 inches (1H:1V side slope)
Drainage Layer: 30 inches (vertical side slopes)
Orifice 1 Offset: 0 inches from bottom of storage layer
Orifice 1 Area: 0.2 SF (6-inch diameter)
Orifice 2 Offset: 55 inches from bottom of storage layer
Orifice 2 Area: 1.6 SF (1.4-foot diameter)
Evapotranspiration: 0.1 inches/day
Infiltration through bottom of SCM: 0.06 inches/hr

TABLE B-10 TRADITIONAL BIORETENTION STORMWATER DATA

	1-year	2 year	5 year	10 year	25 year	50 year	100 year
Predeveloped Q (cfs)	2.05	2.58	3.31	3.92	4.77	5.47	6.21
Postdeveloped Q (cfs)	2.09	2.62	3.35	3.96	4.8	5.5	6.24
Allowable Release (cfs)	1.62	2.16	2.79	3.33	4.14	4.95	5.76
Actual Release (cfs)	1.38	1.65	1.95	2.03	3.84	4.88	5.67
Surface Water Dewater Time (hr)	Before end of storm	Before end of storm	Before end of storm	Before end of storm	Before end of storm	Before end of storm	Before end of storm
Total Dewater Time (hr)	0.2	0.2	0.2	0.2	.02	.02	.02

Stormwater calculations must be included per Chapter 7. See Example 1: New Development, Alternative 1 for example calculations.

APPENDIX C
SUPPLEMENTAL RAINFALL INFORMATION

TABLE C-1 RAINFALL INTENSITIES (39.972 N, 83.01 W)

Duration		Intensity, inches/hour						
		1-yr	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
Minutes	5	4.25	5.06	6.06	6.84	7.85	8.62	9.37
	10	3.30	3.95	4.71	5.28	6.00	6.53	7.06
	15	2.70	3.22	3.86	4.33	4.94	5.39	5.84
	30	1.78	2.16	2.64	3.01	3.49	3.85	4.22
Hours	1	1.09	1.32	1.66	1.91	2.26	2.54	2.82
	2	0.636	0.771	0.966	1.12	1.34	1.51	1.70
	3	0.450	0.542	0.678	0.789	0.943	1.07	1.20
	6	0.269	0.322	0.401	0.467	0.560	0.638	0.722
	12	0.156	0.187	0.232	0.270	0.323	0.368	0.416
	24	0.092	0.110	0.135	0.156	0.185	0.209	0.235

Source: Bonnin, Martin, Lin, Parzybok, Yekta, Riley, *NOAA Atlas 14, Volume 2, Version 3.0*, 2004. and NOAA Precipitation Frequency Data Server http://dipper.nws.noaa.gov/hdsc/pfds/ June 10, 2012

OPTIMAL RAINFALL INTENSITY EQUATION COEFFICIENTS AND TIME-TO-PEAK INTENSITY RATIOS

Source: Froehlich, D.C. (March/April 2009, Errata 2010). Mathematical Formulations of NRCS 24-Hour Design Storms. *Journal of Irrigation and Drainage Engineering.* ASCE. Vol. 135, No. 2, pp. 241-247

$i_{p*} = 39.261$	$rainfall\ intensity\ equation\ coefficient\ (dimensionless)$
$i_{o*} = 0.311$	$rainfall\ intensity\ equation\ coefficient\ (dimensionless)$
$\eta = 0.0522$	$rainfall\ intensity\ equation\ coefficient\ (dimensionless)$
$\eta' = 1 - \eta$	$rainfall\ intensity\ equation\ coefficient\ (dimensionless)$
$m_1 = 0.264$	$rainfall\ intensity\ equation\ coefficient\ (rainfall\ depth\ units/hr)$
$m_2 = 4.098$	$rainfall\ intensity\ equation\ coefficient\ (rainfall\ depth\ units/hr)$
$r = 0.493$	$time - to - peak\ rainfall\ intensity\ ratio\ (dimensionless)$
t	$time\ (hours)$
t_d	$design\ storm\ duration\ (hours)$
$\hat{P}_*$	$cumulative\ design\ storm\ precipitation\ depth$

$$\hat{P}_*(t) = \begin{cases} r\left(i_{p*} - i_{o*}\right)\left[\eta \dfrac{e^{\frac{(-m_1)(rt_d - t)}{r}} - e^{-m_1 t_d}}{m_1 t_d} + \eta' \dfrac{e^{\frac{(-m_2)(rt_d - t)}{r}} - e^{-m_2 t_d}}{m_2 t_d}\right] + i_{o*}\left(\dfrac{t}{t_d}\right) & for\ 0 \le t \le rt_d \\ (1-r)\left(i_{p*} - i_{o*}\right)\left[\eta \dfrac{1 - e^{\frac{(-m_1)(t - rt_d)}{1-r}}}{m_1 t_d} + \eta' \dfrac{1 - e^{\frac{(-m_2)(t - rt_d)}{1-r}}}{m_2 t_d}\right] + i_{o*}\left(\dfrac{t}{t_d} - r\right) + r & for\ rt_d < t \le t_d \end{cases}$$

TABULAR DISTRIBUTION

Distribution Source: Chow, V. T., Maidment, D. R., Mays, L. W. (1988). Applied Hydrology.

Rainfall Depth Source: Bonnin, Martin, Lin, Parzybok, Yekta, Riley, *NOAA Atlas 14, Volume 2, Version 3.0*, 2004. and NOAA Precipitation Frequency Data Server http://dipper.nws.noaa.gov/hdsc/pfds/ June 10, 2012

TABLE C-2 NRCS TYPE II DESIGN STORM HYETOGRAPH

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (inches)						
			Frequency (Depth in inches)						
			100yr (5.63)	50yr (5.02)	25yr (4.44)	10yr (3.74)	5yr (3.24)	2yr (2.63)	1yr (2.20)
0:00	0		0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:15	0.002	0.002	0.011	0.010	0.009	0.007	0.006	0.005	0.004
0:30	0.005	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:45	0.008	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:00	0.0108	0.0028	0.016	0.014	0.012	0.010	0.009	0.007	0.006
1:15	0.014	0.0032	0.018	0.016	0.014	0.012	0.010	0.008	0.007
1:30	0.017	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:45	0.02	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:00	0.023	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:15	0.026	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:30	0.029	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:45	0.032	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:00	0.0347	0.0027	0.015	0.014	0.012	0.010	0.009	0.007	0.006
3:15	0.038	0.0033	0.019	0.017	0.015	0.012	0.011	0.009	0.007
3:30	0.041	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:45	0.044	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
4:00	0.0483	0.0043	0.024	0.022	0.019	0.016	0.014	0.011	0.009
4:15	0.052	0.0037	0.021	0.019	0.016	0.014	0.012	0.010	0.008
4:30	0.056	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
4:45	0.06	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:00	0.064	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:15	0.068	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:30	0.072	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:45	0.076	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
6:00	0.0797	0.0037	0.021	0.019	0.016	0.014	0.012	0.010	0.008
6:15	0.085	0.0053	0.030	0.027	0.024	0.020	0.017	0.014	0.012
6:30	0.09	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
6:45	0.095	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:00	0.1	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:15	0.105	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:30	0.11	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:45	0.115	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (inches)						
			Frequency (Depth in inches)						
			100yr (5.63)	50yr (5.02)	25yr (4.44)	10yr (3.74)	5yr (3.24)	2yr (2.63)	1yr (2.20)
8:00	0.1203	0.0053	0.030	0.027	0.024	0.020	0.017	0.014	0.012
8:15	0.126	0.0057	0.032	0.029	0.025	0.021	0.018	0.015	0.013
8:30	0.133	0.007	0.039	0.035	0.031	0.026	0.023	0.018	0.015
8:45	0.14	0.007	0.039	0.035	0.031	0.026	0.023	0.018	0.015
9:00	0.1467	0.0067	0.038	0.034	0.030	0.025	0.022	0.018	0.015
9:15	0.155	0.0083	0.047	0.042	0.037	0.031	0.027	0.022	0.018
9:30	0.163	0.008	0.045	0.040	0.036	0.030	0.026	0.021	0.018
9:45	0.172	0.009	0.051	0.045	0.040	0.034	0.029	0.024	0.020
10:00	0.1808	0.0088	0.050	0.044	0.039	0.033	0.029	0.023	0.019
10:15	0.191	0.0102	0.057	0.051	0.045	0.038	0.033	0.027	0.022
10:30	0.203	0.012	0.068	0.060	0.053	0.045	0.039	0.032	0.026
10:45	0.218	0.015	0.084	0.075	0.067	0.056	0.049	0.039	0.033
11:00	0.236	0.018	0.101	0.090	0.080	0.067	0.058	0.047	0.040
11:15	0.257	0.021	0.118	0.105	0.093	0.079	0.068	0.055	0.046
11:30	0.283	0.026	0.146	0.131	0.115	0.097	0.084	0.068	0.057
11:45	0.387	0.104	0.586	0.522	0.462	0.389	0.337	0.274	0.229
12:00	0.6632	0.2762	1.555	1.387	1.226	1.033	0.895	0.726	0.608
12:15	0.707	0.0438	0.247	0.220	0.194	0.164	0.142	0.115	0.096
12:30	0.735	0.028	0.158	0.141	0.124	0.105	0.091	0.074	0.062
12:45	0.758	0.023	0.129	0.115	0.102	0.086	0.075	0.060	0.051
13:00	0.776	0.018	0.101	0.090	0.080	0.067	0.058	0.047	0.040
13:15	0.791	0.015	0.084	0.075	0.067	0.056	0.049	0.039	0.033
13:30	0.804	0.013	0.073	0.065	0.058	0.049	0.042	0.034	0.029
13:45	0.815	0.011	0.062	0.055	0.049	0.041	0.036	0.029	0.024
14:00	0.825	0.01	0.056	0.050	0.044	0.037	0.032	0.026	0.022
14:15	0.834	0.009	0.051	0.045	0.040	0.034	0.029	0.024	0.020
14:30	0.842	0.008	0.045	0.040	0.036	0.030	0.026	0.021	0.018
14:45	0.849	0.007	0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:00	0.856	0.007	0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:15	0.863	0.007	0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:30	0.869	0.006	0.034	0.030	0.027	0.022	0.019	0.016	0.013
15:45	0.875	0.006	0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:00	0.881	0.006	0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:15	0.887	0.006	0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:30	0.893	0.006	0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:45	0.898	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:00	0.903	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:15	0.908	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:30	0.913	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:45	0.918	0.005	0.028	0.025	0.022	0.019	0.016	0.013	0.011

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (inches)						
			Frequency (Depth in inches)						
			100yr (5.63)	50yr (5.02)	25yr (4.44)	10yr (3.74)	5yr (3.24)	2yr (2.63)	1yr (2.20)
18:00	0.922	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:15	0.926	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:30	0.93	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:45	0.934	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:00	0.938	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:15	0.942	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:30	0.946	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:45	0.95	0.004	0.023	0.020	0.018	0.015	0.013	0.011	0.009
20:00	0.953	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:15	0.956	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:30	0.959	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:45	0.962	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:00	0.9653	0.0033	0.019	0.017	0.015	0.012	0.011	0.009	0.007
21:15	0.968	0.0027	0.015	0.014	0.012	0.010	0.009	0.007	0.006
21:30	0.971	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:45	0.974	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:00	0.977	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:15	0.98	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:30	0.983	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:45	0.986	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:00	0.9892	0.0032	0.018	0.016	0.014	0.012	0.010	0.008	0.007
23:15	0.992	0.0028	0.016	0.014	0.012	0.010	0.009	0.007	0.006
23:30	0.995	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:45	0.998	0.003	0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:00	1	0.002	0.011	0.010	0.009	0.007	0.006	0.005	0.004

APPENDIX D

STORMWATER TREATMENT AND CONTROL FEASIBILITY ASSESSMENT FOR REDEVELOPMENT

The objective of the feasibility assessment is to achieve the maximum practicable degree of treatment and control for Water Quality Volume and Peak Rate of Runoff, while accommodating the space, development, and natural resource constraints on previously-developed sites, and supporting the City of Dublin's community development objectives.

In preparing a Stormwater Management Plan, applicants for redevelopment will evaluate the degree to which stormwater treatment and control can be incorporated to treat runoff from existing and proposed impervious surfaces using the stormwater control measures outlined in this Manual. The final feasibility assessment shall reflect the assessment of the degree to which the treatment and control goals in Table D-1 (as further defined in Chapter 2) can be achieved using the design approaches in Table D-2. In no case shall any applicant be required to undertake any of the measures listed in Table D-3 in developing a Stormwater Management Plan.

TABLE D-1 TREATMENT AND CONTROL OBJECTIVES

Water Quality Volume (WQv)	Provide treatment of the water quality volume.
Peak Rate of Runoff Control	Provide peak rate of runoff control of the critical storm and the less frequent storms.

TABLE D-2 ANALYSIS REQUIREMENTS

The objective of the analysis is to identify opportunities to treat and control impervious surface runoff through the use of stormwater control measures, including consideration of the following design techniques: Refer to Example 2: Redevelopment in Appendix B.	
1.	Disconnection or redirection of rooftop drainage or gutters into infiltration areas or vegetated stormwater control measures.
2.	Substitution of vegetated stormwater control measures for curb-and-drain systems, or installation of vegetated stormwater control measures where runoff currently drains overland into surface waters, particularly at edges of impervious surfaces such as parking lots, sidewalks, patios, or buildings.
3.	Substitution of permeable surfacing for impervious surfacing for parking areas, patios, driveways, or public safety access areas.
4.	Substitution of engineered and designed vegetated stormwater control measures for existing turfgrass or other landscaped areas that do not function as stormwater treatment areas.
5.	Maximize treatment by routing flows through bioretention swales whenever possible.
6.	Maximize control of runoff from the critical storm and the less frequent storms through the above techniques and through re-design, retrofit and/or expansion of existing detention structures. If there are no existing detention structures or modification is infeasible, this standard is met.

TABLE D-3 DESIGN, TREATMENT AND CONTROL MEASURES NOT REQUIRED

	The following measures are NOT required to be utilized for redevelopment sites:
1.	Installation of sub-surface storage or treatment structures.
2.	Purchase or acquisition of additional land.
3.	Demolition of buildings or removal/substitution of existing impervious surfaces to point of interference with either the existing land use or material conditions of any existing land use permits.
4.	Substitution of existing impervious surfaces that are not otherwise planned to be renovated or replaced as part of the redevelopment plan.
5.	Off-site treatment of stormwater.
6.	Site re-grading or site re-contouring to the point of permanent interference with either the existing use of the site or the material conditions of any existing land use permits.
7.	Pumping or otherwise mechanical re-routing of stormwater runoff.
8.	Mechanical or chemical treatment of stormwater.
9.	Infiltration where basement flooding or subsurface pollutant plume transport will occur.
10.	Construction of any infrastructure within the Fluvial Erosion Hazard area of any receiving water or within any wetland or its 50-foot buffer zone.
11.	Removal of mature trees.