

Stormwater Drainage Manual



Mayor Michael B. Coleman

City of Columbus

Division of Sewerage and Drainage Department of Public Utilities

Director Cheryl Roberto

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Contents

Introduction	1
Purpose	1
Applicability	2
Organization	2
Construction Requirements	3
Variances	3
Definitions	4
Acronyms	10
Part I Stormwater Policy and Facility Design Criteria	
Section 1 Preservation and Protection	1-1
1.1 Stream Protection Policy Statement	1-1
1.2 Stream Identification	1-1
1.3 Stream Corridor Protection Zone	1-2
1.3.1 Definitions	1-2
1.3.2 Permanent Protection of the Stream Corridor	1-3
1.3.3 Prohibited Uses in the Stream Corridor Protection Zone	1-4
1.3.4 Permitted Uses in the Stream Corridor Protection Zone	1-4
1.3.5 Applicability of Stream Corridor Protection Zones	1-5
1.4 Floodplain Preservation and Developments within Special Flood Hazard Areas	1-6
1.5 Wetland Policy	1-7
Section 2 Stormwater Conveyance	2-1
2.1 General Criteria	2-1
2.1.1 Offsite Tributary Area	2-1
2.1.2 Onsite Stormwater Conveyance	2-1
2.1.3 Downstream Analysis	2-1
2.1.4 Agricultural Field Tile Systems	2-3
2.1.5 Stormwater System Diversions	2-3
2.2 Hydrology Requirements	2-4
2.2.1 Acceptable Hydrologic Method/Models	2-4
2.2.2 Hydrologic Components	2-6
2.2.2.1 Rainfall	2-6
2.2.2.2 Time of Concentration	2-9
2.2.2.3 Soil Variables	2-11
2.2.3 Peak Flow Calculation Methods/Models	2-11
2.2.3.1 Rational Method	2-11
2.2.3.2 Regression Equations	2-13

2.2.3.3	The NRCS (SCS) Curve Number Method	2-14
2.2.4	Acceptable Runoff Hydrograph Development Methods	2-18
2.2.4.1	Rainfall Hyetographs	2-18
2.2.4.2	Abstractions from Rainfall	2-18
2.2.4.3	Unit Hydrographs	2-19
2.3	Design of Minor Stormwater Conveyance Systems	2-20
2.3.1	Storm Sewers	2-22
2.3.1.1	Storm Sewer Hydrology Requirements.....	2-22
2.3.1.2	Storm Sewer Hydraulic Requirements	2-23
2.3.1.3	Pipe Material, Bedding, Cover, and Encasement Requirements.....	2-26
2.3.1.4	Storm Sewer Easement Requirements	2-26
2.3.2	Curb Inlets and Catch Basins	2-27
2.3.2.1	General Criteria.....	2-27
2.3.2.2	Underpass or Sag Requirements	2-28
2.3.2.3	Inlets on Continuous Grade Requirements.....	2-28
2.3.3	Culverts	2-28
2.3.3.1	General Requirements.....	2-28
2.3.3.2	Culvert Hydrology Requirements.....	2-29
2.3.3.3	Culvert Hydraulic Requirements	2-29
2.3.3.4	Culvert Layout Requirements.....	2-32
2.3.3.5	Culvert Easement Requirements	2-33
2.3.4	End Treatments	2-33
2.3.5	Outlet Channel Protection	2-34
2.3.5.1	Outlet Channel Protection Required.....	2-34
2.3.5.2	Rock Channel Protection and Riprap Aprons	2-35
2.3.5.3	Energy Dissipation Devices.....	2-39
2.3.6	Level Spreaders	2-42
2.3.6.1	Layout Requirements	2-45
2.3.6.2	Level Spreader Sizing.....	2-45
2.3.6.3	Level Spreader Materials	2-45
2.3.6.4	Maintenance	2-46
2.3.7	Open Watercourses.....	2-46
2.3.7.1	Channel Hydrology Requirements	2-47
2.3.7.2	Channel Hydraulic Requirements.....	2-47
2.3.7.3	Constructed Open Watercourse Easement Requirements.....	2-50
2.4	Design of Major Stormwater Routing Systems	2-51
 Section 3 Stormwater Controls.....		3-1
3.1	General Criteria.....	3-1
3.2	Stormwater Quantity Controls	3-1
3.2.1	Stormwater Quantity Control Exemptions	3-2
3.2.2	Hydrologic Requirements.....	3-2

3.2.3	Acceptable Methods and Criteria	3-4
3.2.4	Dry and Wet Detention Basins.....	3-4
3.2.4.1	General Requirements for All Detention Basins	3-4
3.2.4.2	Additional Layout Requirements for Dry Detention Basins.....	3-8
3.2.4.3	Additional Layout Requirements for Wet Detention Basins.....	3-9
3.2.5	Parking Lot Storage	3-10
3.2.6	Tank Storage	3-10
3.2.7	Green Roof Technologies	3-11
3.2.7.1	Design Guidelines and Performance Standards	3-12
3.2.7.2	Maintenance Requirements.....	3-12
3.2.7.3	Monitoring Requirements	3-12
3.3	Post-Construction Stormwater Quality Controls.....	3-15
3.3.1	General Requirements.....	3-15
3.3.1.1	Stormwater Runoff Quality Control	3-15
3.3.1.2	Illicit Discharge and Illegal Dumping Control	3-16
3.3.2	Water Quality Volume (WQ _v) Determination	3-16
3.3.2.1	Runoff Coefficients for Water Quality	3-16
3.3.2.2	Minimum Drawdown Requirements	3-17
3.3.3	Stormwater Quality Control - Acceptable Methods and Criteria	3-17
3.3.4	Group 1 - Stormwater Basins.....	3-20
3.3.4.1	Extended Dry Detention Basins.....	3-21
3.3.4.2	Extended Wet Detention Basins	3-27
3.3.4.3	Stormwater Wetlands.....	3-30
3.3.5	Group 2 - Media Filters.....	3-35
3.3.5.1	Bioretention Facilities.....	3-35
3.3.5.2	Sand Filters	3-40
3.3.6	Group 3 - Swales and Filter Strips	3-44
3.3.6.1	Vegetated Swales	3-45
3.3.6.2	Vegetated Filter Strips.....	3-47
3.3.6.3	Dry Extended Detention Swales.....	3-49
3.3.7	Group 4 - Water Quality Controls for Commercial Activity Areas	3-52
3.3.7.1	Businesses Subject to Controls for High-Risk Pollutant Sources	3-53
3.3.7.2	Commercial Activity Areas Requiring Control.....	3-54
3.3.7.3	Requirements for Commercial Activity Areas	3-54
3.3.8	Applicant-Proposed Stormwater Controls.....	3-57
3.4	As-built Surveys	3-59
3.5	Construction Stormwater Quality Controls.....	3-60
3.5.1	Additional Requirements.....	3-60

Section 4	Operation and Maintenance of Stormwater Controls.....	4-1
4.1	Stormwater Control Facility Maintenance Responsibilities	4-1
4.1.1	Stormwater Control Facility Easement and Access Requirements.....	4-1
4.1.2	Stormwater Control Facility Maintenance Plan	4-2
4.1.3	Maintenance Inspection and Reporting Requirements	4-3

Part II – Submittal Requirements

Section 5	Private and Public Development Review Processes	5-1
------------------	--	------------

Section 6	Stormwater Management Report.....	6-1
------------------	--	------------

6.1	Master Drainage Plan Requirements	6-1
6.2	Calculation Requirements	6-3
6.2.1	Stream Corridor Protection Calculations.....	6-3
6.2.2	Compensatory Floodplain Fill Calculations	6-3
6.2.3	Impervious Area Calculations	6-3
6.2.4	Storm Sewer Calculations	6-3
6.2.5	Culvert Calculations	6-4
6.2.6	Constructed Open Watercourse Calculations.....	6-4
6.2.7	Flood Routing Calculations	6-5
6.2.8	Stormwater Detention Calculations	6-5
6.2.9	Water Quality Volume (WQ _v) Calculations for Extended Detention Ponds, Wetlands, and Bioretention Facilities	6-6
6.2.10	Swale and Filter Strip Calculations	6-6
6.3	Stormwater Quality BMP Maintenance Plan Requirements	6-6
6.4	Compensatory Floodplain Restoration Plan Requirements	6-7
6.5	Easement Preparation Requirements.....	6-7
6.6	Subsurface Investigation Reports.....	6-8
6.7	Non-City Submittals/Permits.....	6-8

Section 7	Stormwater Management Report Submittal Requirements	7-1
------------------	--	------------

7.1	Minimum Plan Format Requirements.....	7-1
7.1.1	Title Sheet	7-1
7.1.2	Plan View	7-2
7.1.3	Profile View	7-4
7.1.4	Details and Cross Sections	7-5
7.1.5	Erosion and Sediment Control Plan	7-5

References

Appendices

<i>Appendix A</i>	City of Columbus Erosion and Sediment Pollution Control Regulation
<i>Appendix B</i>	Native Plant Species for Stormwater Quality Best Management Practices

<i>Appendix C</i>	Calculation Worksheets
<i>Appendix D</i>	Example Calculations for Stream Corridor Protection Zone and Stormwater Quality Controls
<i>Appendix E</i>	Operation and Maintenance Inspection Report Checklists
<i>Appendix F</i>	CC Drawing Submittal Forms
<i>Appendix G</i>	As-Built Location Forms

Figures

1-1	Downtown Zoning District as Defined in City Code 3359.03	1-9
2-1	Intensity Duration Frequency (IDF) Curves Central Ohio (Section 05).....	2-6
2-2	Unit Peak Discharge Determination	2-17
2-3	Riprap Apron Detail.....	2-36
2-4	Design of Outlet Protection – Minimum Tailwater Condition	2-37
2-5	Design of Outlet Protection – Maximum Tailwater Condition.....	2-38
2-6	Riprap Outlet Basin Detail	2-40
2-7	Baffled Outlet Detail.....	2-41
2-8	Typical Level Spreader Applications.....	2-43
2-9	Level Spreader Details	2-44
2-10	Parabolic and Trapezoidal Channel Shapes for Open Watercourses.....	2-48
3-1	Schematic of Typical Extensive Green Roof	3-11
3-2	Schematics of Extended Dry Detention Basins.....	3-22
3-3	Perforated Riser Design for Extended Dry Detention Basins without Micropools	3-26
3-4	Schematic of a Typical Extended Wet Detention Basin.....	3-28
3-5	Accepted Outlet Designs for Extended Wet Detention Basins and Micropools within Extended Dry Detention Basins	3-31
3-6	Schematic of a Typical Stormwater Wetland.....	3-32
3-7	Schematic of a Typical Bioretention Facility	3-36
3-8	Schematic Representation of an Austin Sand Filter.....	3-40
3-9	Schematic Representation of a Delaware Sand Filter	3-41
3-10	Sand Bed Profile with Gravel Filter	3-43
3-11	Schematic Representation of a Perforated Riser for Discharging the Sedimentation Basin into the Sand Filter	3-44
3-12	Typical Vegetated Swale and Vegetated Filter Strip	3-45
3-13	Schematic of Typical Dry Extended Detention Swale	3-50
5-1	Development Review and Approval Process for CC Drawings.....	5-2
5-2	Public Roadway Plan Review Process.....	5-3

Tables

1-1	Required Stream Corridor Protection Zone Width By Contributing Drainage Area	1-3
1-2	Facilities and Activities Prohibited in the Stream Corridor Protection Zone	1-5
2-1	Applications of the Recommended Hydrologic Methods	2-5
2-2	Constraints to Using Recommended Hydrologic Methods	2-5
2-3	Type II SCS Design Storm Hyetograph	2-7
2-4	Roughness Coefficients (Manning's "n") for Sheet Flow	2-10
2-5	Runoff Coefficients "C" for Typical Land Uses in Columbus	2-12
2-6	Example Determination of the Basin Development Factor	2-14
2-7	Runoff Curve Numbers (CN) for Typical Land Uses in Columbus	2-16
2-8	Adjustment Factor (F_p) for Ponds and Swamps	2-17
2-9	Pavement Design Criteria	2-21
2-10	Storm Sewers, Culverts, Level Spreaders, and Open Watercourses Design Criteria	2-22
2-11	Minor Loss Coefficients for Storm Sewers	2-26
2-12	City Catch Basin Grate and Curb Inlet Dimensions	2-27
2-13	Culvert Design Storm Frequency	2-29
2-14	Minor (Entrance) Loss Coefficients for Culverts under Outlet Control, Full or Partly Full Entrance Head Loss	2-31
2-15	Allowable Conduit Invert Depression	2-32
2-16	Minimum Allowable Pipe Size for Various Fill Depths	2-33
2-17	Maximum Velocities for Channel Lining Materials	2-34
2-18	Level Spreader Dimensions	2-45
2-19	Manning's Roughness Coefficients (n) for Vegetative and Artificial Channels	2-49
2-20	Allowable Shear Stress for Rock Channel Protection	2-50
3-1	Critical Storm Determination	3-3
3-2	Peak Basin Water Surface Elevation Requirements	3-5
3-3	Extensive Green Roof System Components	3-13
3-4	Green Roof Maintenance Requirements	3-14
3-5	Runoff Coefficients for Determining WQ_v	3-17
3-6	Major Selection Criteria for Stormwater Quality Controls	3-18
3-7	Major Design Criteria for Stormwater Basins	3-21
3-8	Control Requirements for Materials Handling Areas	3-55

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Stormwater Drainage Manual



Introduction

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Introduction

The City of Columbus (City) was founded in 1812 and has served as the state capital since 1816. The City has the largest population in the state of Ohio and a land area of nearly 213 square miles, making it the sixteenth largest city by area in the United States. The City's administrative structure and development regulations related to stormwater have evolved to address the City's growth. The Division of Sewerage and Drainage (DOSD) was created by ordinance in 1950 as a part of the Department of Public Service (renamed Department of Public Utilities in 1991). As of year end 2004, the DOSD has managed two wastewater treatment plants and has been responsible for maintaining over 160 miles of combined sewers, 2500 miles of storm sewers, and 2700 miles of separate sanitary sewers. In 1993, the City created a Stormwater Management Program and established a stormwater utility fee to finance infrastructure improvement projects and implement programs designed to improve stormwater quality.

Purpose

Experience has shown that most of the more serious flooding, erosion, and water quality problems are "created." Usually this occurs from conveying more stormwater to a given area than can be carried away effectively. Ever increasing drainage problems emerge unless well-conceived, cooperative stormwater drainage and flood control programs are undertaken throughout the entire watershed. The stormwater management goals of the City of Columbus, Ohio, are to prevent flooding, streambank erosion, and water quality degradation that may result from stormwater runoff from development and redevelopment projects. The City's Stormwater Drainage Manual (the Manual) provides guidance and direction for meeting these goals.

The purpose of the Manual is to protect existing natural stormwater resources, convey and control stormwater in a safe and responsible manner, and meet water quality goals. The Manual is intended to provide information to the general public on the City's stormwater policies and design practices, as well as assist developers, engineers, and City staff in the preparation, review and approval of the Stormwater Management Report and Construction Drawings that must accompany private and public development proposals. This document is organized to facilitate specific design and submittal activities related to stormwater management infrastructure.

Stormwater management, particularly in the area of stormwater quality management, is an evolving science. The goal of the City is to be responsive to changes in stormwater policy and design brought forth by the natural progression of the industry. As such, the Manual will be updated as necessary to reflect accepted standard practice in stormwater management.

The City also recognizes that there may be instances where alternative stormwater standards may apply to protect sensitive ecological areas (i.e., Hellbranch Run and the Darby Creek watersheds) or to meet the goals of Total Maximum Daily Loads established by Ohio EPA. Where alternative standards conflict with the requirements of the Manual, the more stringent criteria shall apply.

Applicability

The Manual is being adopted as a rule of the Director of Public Utilities pursuant to the authority provided in Columbus City Code 1145.11, 1145.71 and 1149.04. Unless otherwise exempted, the Manual shall be used for all public and private projects that change land use, existing stormwater flow patterns, and/or stormwater pollutant discharges as applicable to all premises within the City of Columbus.

Any new development or redevelopment involving the following shall be subject to the Manual:

- 1) Construction of commercial, industrial or institutional facilities,
- 2) Expansion of commercial, industrial or institutional facilities,
- 3) Redevelopment of commercial, industrial or institutional facilities if the renovation will substantially affect stormwater drainage,
- 4) Construction of multi-family residential facilities,
- 5) Expansion of multi-family residential facilities,
- 6) Redevelopment of multi-family residential facilities if the renovation will substantially affect stormwater drainage,
- 7) Construction of residential subdivisions as defined in Columbus City Code 3123.01,
- 8) Expansion of residential subdivisions as defined in Columbus City Code 3123.01,
- 9) Redevelopment of residential subdivisions, as defined in Columbus City Code 3123.01, if the renovation will substantially affect stormwater drainage, and
- 10) Construction, reconstruction, improvement, and/or modification of all private and public transportation and transit facilities which alter existing drainage patterns under this item. Routine maintenance of these facilities or construction of elements that do not impact the existing drainage patterns are excluded.

The Manual is not applicable to the expansion, construction, or reconstruction of one single-family dwelling or one two-family dwelling on a single parcel.

This manual will be affective thirty (30) days after public notification in the City Bulletin. Any development that occurs after this date must comply with the Manual, unless they have obtained a variance as described below.

Organization

To simplify the use of the Manual, it is organized into two parts. Part I of the Manual supports the layout, design, and maintenance of stormwater management facilities. Four sections make up this part of the Manual:

- 1) Preservation and Protection (Section 1) defines how to site the project in relation to any streams, floodplains, steep slopes, and wetlands within the project site.
- 2) Stormwater Conveyance (Section 2) provides design requirements for storm sewers, open watercourses, stream crossings, and other facilities intended to convey stormwater from the site.
- 3) Stormwater Controls (Section 3) provides design requirements for detention basins and stormwater quality control devices intended to control the rate, volume, and/or pollutant load in stormwater runoff.
- 4) Operation and Maintenance of Stormwater Controls (Section 4) defines maintenance responsibilities for stormwater controls and provides easement, access, inspection and reporting requirements.

Part II describes the City's submittal requirements related to stormwater management:

- 1) Private and Public Development Review Processes (Section 5) provides guidance on the review process for public and private development which propose to construct stormwater infrastructure within the City limits.
- 2) Stormwater Management Report submittal requirements (Section 6) are summarized in this section. The design for proposed stormwater management systems shall be submitted to the City for review and approval in accordance with this section.
- 3) Stormwater Management Report Submittal Requirements (Section 7) provides guidance on the information required for plan approval and presents plan details (including title, plan, profile, and cross section sheets) which shall be included in the construction plans.

Construction Requirements

The City's Construction and Materials Specifications (CMSC), current edition, and the Standard Construction Drawings maintained by the City shall govern the construction of stormwater facilities described in the Manual. All construction activity within the City must also comply with the requirements stipulated by the OEPA and the City's Erosion and Sediment Control Regulations, whichever is more restrictive. Copies of the current CMSC and Standard Construction Drawings are available at the Division of Sewerage and Drainage, Sewer Permits Desk, Room 3051, 910 Dublin Road, Columbus, Ohio, or online at:

http://utilities.ci.columbus.oh.us/sewers_drains/for_contractors.htm.

The City's Erosion and Sediment Control Regulation, outlined in Section 3.5, is included in **Appendix A**.

Variations

Accepted procedures and requirements for stormwater management within the City are provided by the Manual and supplemented by reference materials identified herein. The City's

stormwater policies and design criteria, as expressed in the Manual, may not provide solutions to all drainage problems. The City recognizes that there may be individual projects involving special or unusual design challenges that must be resolved prior to development approval. The Administrator, therefore, may grant variances in the following circumstances.

- 1) Any person who submitted a master drainage plan on or before January 1, 2006 may apply for a variance to the requirements of the Manual. The variance application must demonstrate that the site plan met the stormwater drainage requirements applicable at the time the plan was submitted, and that compliance with the requirements of the Manual will cause a hardship to the applicant.
- 2) Any person may apply for a variance by demonstrating that the application of the Manual is impracticable because of specific site conditions. The variance application must demonstrate either:
 - a. that the proposed alternative will provide the same level of flood and water quality protection as those provided for in the Manual, or
 - b. that the project provides for stormwater quality and quantity protection to the extent practicable, and that the project provides a substantial public benefit, such as brownfield redevelopment, urban infill development, or substantial environmental benefit.

Any variance granted shall require, at a minimum, compliance with all applicable state laws and regulations.

Definitions

For the purpose of the Manual, the following terms, phrases, and definitions shall apply and are provided here for quick reference and convenience. Words used in the singular shall include the plural, and the plural - the singular. Words used in the present tense shall include the future tense. The word SHALL is mandatory and not discretionary.

Administrator – The Administrator of the Division of Sewerage and Drainage, or his/her designee.

Agricultural Lands – Those lands in any agricultural use, including forestry.

Applicant – Any person or duly designated representative applying for a permit or other type of city, federal, or state regulatory approval to proceed with a project.

Best Management Practice (BMP) – Schedules of activities, programs, technology, processes, siting criteria, operating methods, measures, devices, prohibitions of practices, maintenance procedures, and other management practices used to prevent, control, remove or reduce the pollution of waters of the United States. BMPs also include, but are not limited to, treatment requirements, operating procedures, practices to control site runoff, spillage or leaks, waste disposal, or drainage from raw material. BMPs may include structural or nonstructural practices.

CC Drawings – Plans for stormwater infrastructure that are privately owned, capital projects or public sanitary sewer projects.

Check Storm – A lesser frequency event used to assess the hydraulic grade line, pavement spread, flood routing and hazard analysis, and critical locations where water can pond to appreciable depths.

City – The City of Columbus, Ohio.

Commercial Activity Areas – Outdoor areas within non-residential properties where pollutants are or may become more concentrated than typical urban runoff as characterized by the USEPA National Urban Runoff Program (NURP). Commercial/industrial activity areas are as listed below or otherwise defined by the City:

- 1) Material and waste handling and storage areas, including but not limited to loading docks, fuel and other liquid storage/dispensing facilities, material bins, containers, stockpiles, and other storage containers, waste dumpsters, bins, cans, tanks, stockpiles, and other waste containers,
- 2) Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas, and
- 3) Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed.

Compensatory Floodplain Storage – Equivalent floodplain storage provided to counterbalance floodplain filling within designated FEMA floodplain boundaries.

Constructed Open Watercourses – Constructed drainage courses that confine and conduct a periodic flow of water in such a way that concentrates flow. For the purposes of the Manual, constructed open watercourses include swales or ditches that are constructed to convey stormwater runoff within development sites and along public and private roadway systems.

Construction – The building, assembling, expansion, modification or alteration of the existing contours of the site, the erection of buildings or other structures, or any part thereof, or land clearing.

Culvert or Stream Crossing – A closed conveyance structure with open ends, designed to carry water through a roadway embankment.

Detention or to Detain – To retard or slow the discharge, directly or indirectly, of a given volume of stormwater runoff into surface waters or downstream system.

Development or Development Activity – The alteration, construction, installation, demolition or removal of a structure, impervious surface or drainage facility; or 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.

Discharge – The outflow of stormwater runoff from a project, site, aquifer, drainage basin or facility.

Division – Division of Sewerage and Drainage.

Drainage Facility – Any component of the drainage system.

Drainage System – All facilities used for the movement of stormwater through and from a drainage area, including, but not limited to, any and all of the following conduits and appurtenant features: channels, ditches, flumes, culverts, storm sewers, curb inlets, catch basins, headwalls, detention basins, etc., as well as all watercourses, waterbodies and wetlands.

Drawer D – Plans for new or improved infrastructure associated with a private development project that is to be publicly owned and operated within a public right-of-way or in publicly owned easements, formatted to fit onto a “D” size drawing sheet.

Drawer E – Plans for new or improved infrastructure associated with a private development project that is to be publicly owned and operated within a public right-of-way or in publicly owned easements, formatted to fit onto an “E” size drawing sheet.

Easement – A grant by a Property Owner for the use of a specified portion of land for a specified purpose.

Erosion – The wearing or washing away of soil by the action of water due to either natural or manmade causes.

FEMA 100-year Floodplain – Any land area recognized by FEMA as susceptible to being inundated by flood waters with a one percent chance of annual recurrence, as defined on the FIS and FIRM for Franklin County and incorporated areas.

FEMA 100-year Floodway – The place in which water is likely to be the deepest and fastest; the area of the floodplain which should be reserved to allow floodwaters to move downstream without causing the 100-year peak flood water surface elevation to raise more than one foot, as defined on the FIS and FIRM for Franklin County and incorporated areas. (The maximum allowable surcharge for the City of Columbus is 0.5 feet.)

Forebays – Areas at detention basin inlets that are designed to trap coarse sediment particles and trash by separating a specified volume from the remainder of the basin with a lateral sill, rock-filled gabions, a retaining wall, or horizontal rock filters.

Groundwater – Water below the surface of the ground, whether or not flowing through known or defined channels.

Hydrograph – A graph of discharge rate versus time for a selected point in the drainage system.

Illicit Discharges – Any natural or man-made conveyance or drainage system, pipeline, conduit, inlet, or outlet (including natural surface flow patterns, depressions or channels

traversing one or more properties) through which the discharge of any pollutant to the stormwater drainage system occurs or may occur unless the connection is authorized under a discharge permit issued by the Ohio EPA. This definition shall be consistent with the City's existing NPDES permit for stormwater discharges from its municipal separate storm sewer system.

Impervious Surface – A surface which has been covered with a layer of material so that it is resistant to infiltration by water. Impervious surfaces include conventionally surfaced streets, roofs, sidewalks, paved parking lots, and other similar surfaces.

Maintenance – The action taken to restore or preserve the design functionality of any facility or system.

Major Outfall – A municipal separate storm sewer system (MS4) outfall that discharges from a single pipe with an inside diameter of 36 inches or more or its equivalent (discharge from a single conveyance other than circular pipe which is associated with a drainage area of more than 50 acres); or for MS4s that receive stormwater from lands zoned for industrial activity (based on comprehensive zoning plans or the equivalent), an outfall that discharges from a single pipe with an inside diameter of 12 inches or more or from its equivalent (discharge from other than a circular pipe associated with a drainage area of 2 acres or more).

Major Stormwater Routing Systems – An above ground conveyance system which routes stormwater from larger runoff events. This is often the portion of the total drainage system which collects, stores, and conveys runoff that exceeds the capacity of the minor system. It is usually less controlled than the minor system and will function regardless of whether or not it has been deliberately designed and/or protected against encroachment, including when the minor system is blocked or otherwise inoperable.

Minor Drainage Systems – Portions of a stormwater conveyance system within the urban environment including things such as catch basins, detention basins, and storm sewer pipes. The portion of the drainage system that collects, stores and conveys frequently occurring runoff, and provides relief from nuisance and inconvenience. This system has been traditionally planned and constructed, and normally represents the major portion of the urban drainage infrastructure investment. Minor systems include curbs, gutters, ditches, inlets, access holes, pipes and other conduits, open channels, pumps, detention basins, water quality control facilities, etc.

Offsite – Taking place or located away from the site.

Onsite – Taking place or located within the site.

Ordinary High-Water Mark – The point on one or both banks of a stream to which the presence and action of surface water is so continuous as to leave a distinctive mark by erosion, destruction, or prevention of terrestrial vegetation, predominance of aquatic vegetation, or other easily recognized characteristics. Where the bank or shore of any particular place is of such character that it is difficult or impossible to ascertain where the point of ordinary high-

water mark is, it shall be established at the elevation of the ordinary high-water mark on the opposite bank.

Outfall – A point source where an MS4 discharges to Waters of the State and does not include open conveyances connecting two municipal separate storm sewers, or pipes, tunnels, or other conveyances which connect segments of the same stream or other Waters of the United States and are used to convey Waters of the State.

Parcel or Parcel of Land – A contiguous quantity of land in possession or owned by, or recorded as property of the same claimant person.

Person – Any individual, firm, corporation, governmental agency, business trust, estate, trust, partnership, association, two or more persons having a joint or common business interest, or any other legal entity.

Post-development or Post-construction – Site conditions at the completion of construction that pertains to the management of stormwater from a site.

Pre-development – The hydrologic and hydraulic condition of the project site immediately before development or construction begins.

Private Facility – Property or facility which is not owned by the City of Columbus.

Professional Engineer – A professional engineer licensed by the State of Ohio skilled in the practice of civil engineering and the engineer of record for the project under consideration.

Professional Landscape Architect – A person licensed by the State of Ohio to practice landscape architecture.

Public Facility – Property or facility which is owned by the City of Columbus.

Redevelopment – A change to previously existing, improved real estate, including but not limited to the demolition or building of structures, filling, grading, paving, or excavating.

Riparian – Situated or dwelling on the bank of a stream or other body of water.

Roadside Ditch – An artificial watercourse designed to convey stormwater runoff generated from the roadway surface.

Runoff – Precipitation, snow melt, or irrigation water not absorbed by soil.

Sediment – Solid material, whether mineral or organic, that is in suspension, is being transported, or has been moved from its site of origin by water.

Site – Any tract, lot, or parcel of land or combination of tracts, lots, or parcels of land which is in one ownership, or contiguous and in diverse ownership where development is to be performed as part of a unit, subdivision, or project.

Storm Event – The storm of a specific duration, intensity, and frequency.

Stormwater – Discharges to surface waters that originate from precipitation events.

Stormwater Management Report – Refers to the approved detailed analysis and supporting documentation for the design of the stormwater management system required for all construction.

Stormwater Management System – All natural and constructed facilities used for the conveyance and storage of stormwater through and from a drainage area, including, but not limited to, any and all of the following: channels, ditches, swales, flumes, culverts, streets, streams, watercourses, waterbodies, wetlands, detention/retention facilities, and treatment devices.

Stormwater Pollutants – Any liquid, solid, or semi-solid substance, or combination thereof, that enters stormwater runoff in concentrations or quantities large enough to contribute to the degradation of the beneficial uses of the body of water receiving the discharge or are prohibited by state law.

Stream – A surface watercourse with a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water.

Stream Corridor Protection Zone – A zone that allows for the natural, lateral movement of open watercourses and prevents structures from being impacted by natural streambank erosion. A corridor with natural vegetation is left in its natural state, typically vegetated to provide stream stabilization and water quality benefits through infiltration.

Streambank Erosion – The removal of streambanks by flowing water below the ordinary high water mark.

Streambed – The portion of a stream below the ordinary high-water mark where the erosion and deposition of sediments occur.

Swale – An artificial watercourse that may contain contiguous areas of standing or flowing water only following a rainfall event, or is planted with or has stabilized vegetation suitable for soil stabilization, stormwater treatment, and nutrient uptake, or is designed to take into account the soil erodibility, soil percolation, slope, slope length, and contributing area so as to prevent erosion and reduce the pollutant concentration of a given volume.

Terrestrial Vegetation – Upland vegetation and facultative upland vegetation, as defined in the City's Approved Native Plant Species for Stormwater Quality Best Management Practices, found in **Appendix B**.

Tier I Streams – Streams shown on USGS 7.5 minute Quad maps as solid or dashed blue lines.

Tier II Streams – Streams not classified as Tier I streams.

Watershed – A region draining into a river, river system, or body of water.

Wetland Vegetation – Obligate hydrophyte, facultative wetland and facultative vegetation as defined in the Native Plant Species list. (Reference Appendix B for the City’s list of approved native plant species.)

Wetlands – Those areas that are inundated or saturated by surface or groundwater with a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

Acronyms

BDF	Basin Development Factor
BMP	Best Management Practice
CC	City of Columbus
CMSC	City of Columbus Construction and Materials Specifications
CN	Curve Number
Corps	Army Corps of Engineers
DOSD	Division of Sewerage and Drainage
ESC	Erosion and Sediment Control
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
HGL	Hydraulic Grade Line
HSG	Hydrologic Soil Group
IDF	Intensity-Duration-Frequency
L & D Manual	ODOT Location and Design Manual, Volume 2, Drainage Design
MS4	Municipal Separate Storm Sewer System
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly the SCS)
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Department of Transportation
OEPA	Ohio Environmental Protection Agency
ORC	Ohio Revised Code
TND	Traditional Neighborhood Development
WQv	Water Quality Volume
SCS	The United States Department of Agriculture Soil Conservation Service (which is now the NRCS)
SWPPP/SWP3	Stormwater Pollution Prevention Plan
USGS	United States Geologic Survey

Stormwater Drainage Manual



Part I Introduction

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Part I – Stormwater Policy and Facility Design Criteria

Part I of the Manual supports the layout and design of stormwater management facilities. The City’s Division of Sewerage and Drainage (part of the Department of Public Utilities) was granted the authority to generate design standards and to enforce rules governing stormwater management under Title 2 Administrative Codes, Section 221.05 of the Columbus City Code. Columbus City Code Title 11, Section 1145.11 grants the Director authority to adopt rules and regulations as necessary for administration of this chapter, Regulation of Sewer Use. In addition, section 1145.71 authorizes the Director to adopt regulations governing the quantity and quality of stormwater discharges from premises within the City, and from premises outside of the City which are tributary to the City’s sewer system. Furthermore, section 1149.04 authorizes the Director to promulgate rules as are necessary for the safe, economical, and efficient management and protection of the stormwater system. The City has determined that the stormwater management requirements set forth in the Manual are necessary to govern stormwater quantity and quality, and for the safe and efficient management of the stormwater system. This section provides the City’s requirements for successfully designing the stormwater management facilities and the layout requirements that must accompany acceptable projects altering land use. These requirements are organized in three sections containing subsections for each pertinent element of the stormwater management system.

- Section 1 Preservation and Protection
 - Stream Protection Policy Statement
 - Stream Identification
 - Stream Corridor Protection Zone
 - Floodplain Preservation and Developments within Special Flood Hazard Areas
 - Wetland Policy

- Section 2 Stormwater Conveyance
 - General Criteria
 - Offsite Tributary Area
 - Onsite Stormwater Conveyance
 - Downstream Analysis
 - Agricultural Field Tiles
 - Stormwater System Diversions
 - Hydrology Requirements
 - Design of Minor Stormwater Conveyance Systems
 - Storm sewers
 - Curbs Inlets and Catch Basins
 - Culverts
 - End Treatments
 - Outlet Channel Protection
 - Level Spreaders
 - Open Watercourses
 - Design of Major Stormwater Routing Systems

- Section 3 Stormwater Controls
 - General Criteria
 - Stormwater Quantity Controls
 - Stormwater Quantity Control Exemptions
 - Hydrologic Requirements
 - Acceptable Methods and Criteria
 - Dry and Wet Detention Basins (general criteria)
 - Parking Lot Storage
 - Tank Storage
 - Green Roof Technologies
 - Stormwater Quality Controls
 - General Requirements
 - Water Quality Volume (WQv) Determination
 - Stormwater Quality Control - Acceptable Methods and Criteria
 - Group 1 - Stormwater Basins
 - Group 2 - Media Filters
 - Group 3 - Swales and Filter Strips
 - Group 4 - Water Quality Controls for Commercial Activity Areas
 - Applicant-Proposed Stormwater Controls
 - As-built Surveys
 - Construction Stormwater Quality Controls
 - Additional Requirements

- Section 4 Operation and Maintenance of Stormwater Controls
 - Stormwater Control Facility Maintenance Responsibilities
 - Stormwater Control Facility Easement and Access Requirements
 - Stormwater Control Facility Maintenance Plan
 - Maintenance Inspection and Reporting Requirements

Stormwater Drainage Manual



Part I
Section 1

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Section 1

Preservation and Protection

The City has determined that establishing a Stream Corridor Protection Zone along streams is necessary to protect structures from damage caused by natural erosion. Unless otherwise exempt, all development and redevelopment projects that include a portion of the Stream Corridor Protection Zone must minimize alterations of the stream, keep new structures out of the Stream Corridor Protection Zone, and maintain a riparian corridor along the stream to minimize streambank erosion and to protect stream habitat. Section 1 of the Manual provides stream protection standards for all development and redevelopment projects in the City.

1.1 Stream Protection Policy Statement

With the exception of roadside ditches and approved roadway crossings, all Tier I (those identified on the United States Geologic Survey (USGS) quad maps with solid or blue dashed lines) and Tier II (those not classified as Tier I but having a well-defined bed and bank) streams shall remain open and shall not be enclosed within a storm sewer or other engineered structure. A Stream Corridor Protection Zone shall be established that allows for the natural, lateral movement of streams and to prevent structures from being impacted by natural streambank erosion. Stream relocation and/or realignment projects are permitted through proper permitting requirements (including, but not limited to, requirements under Section 401 and 404 of the Clean Water Act) and the use of appropriate stream restoration techniques.

1.2 Stream Identification

A stream is a surface watercourse with a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water. The Applicant shall identify and label all streams within the project site and/or receiving stormwater discharges from the project site on the master drainage plan (Section 6) submitted as part of the Stormwater Management Report. The Applicant shall provide information that supports the classification of Tier I and Tier II streams. Such information may include, but not be limited to, copies from USGS Quad sheets showing a Tier I stream, or photographs, FEMA maps, or soils maps showing the location of a Tier II stream.

If the City determines that the submitted evidence is inconclusive, then they may require a site inspection and input from other sources of information including the U.S. Army Corps of Engineers, Ohio EPA, ODNR, or the appropriate County Soil and Water Conservation District. Final determination regarding whether the watercourse or channel meets the classification of a Tier II stream for the purposes of the Manual shall be at the discretion of the Director or designee. Photographs of a stream and a constructed open channel, which is not considered to be a stream, are on the following page. Stream Corridor Protection Zones are not required along constructed open channels that are not classified as streams.

Example of a Stream



Example of a Swale/Open Channel that is not classified as a stream



1.3 Stream Corridor Protection Zone

A Stream Corridor Protection Zone consists of the stream and the riparian area along the stream. Its purpose is to allow the natural, lateral movement of open water courses and prevent structures from being impacted by natural streambank erosion.

1.3.1 Definitions

The total width of the Stream Corridor Protection Zone for Tier I and Tier II streams shall be established using the following criteria, whichever is greater:

- 1) The Federal Emergency Management Agency (FEMA) designated 100-year floodway, or
- 2) **Table 1-1**, based upon the upstream drainage area of the stream, or

Table 1-1

Required Stream Corridor Protection Zone Width By Contributing Drainage Area

Contributing Drainage Area (ac)	Stream Corridor Protection Zone Width (ft) ¹
<100	75
101-250	100
251-500	125
501-750	150
751-1200	175
1201-1750	200
1751 - 2500	225
>2500	250

- 3) 50 feet from the top of each bank for fourth order streams or larger.

In most instances the Stream Corridor Protection Zone is located by placing its centerline over the centerline of the watercourse. However, individual site conditions including, but not limited to, topography and slope must be considered when determining the precise location of the Stream Corridor Protection Zone.

The width of the Stream Corridor Protection Zone will be extended to include slopes that are greater than 15 percent and begin at a point within the Stream Corridor Protection Zone. The maximum width of the Stream Corridor Protection Zone extension shall be to the top of the slope or to a point up-slope, as measured horizontally, where the width of the Stream Corridor Protection Zone is doubled, whichever is less. Slope protection widths may be extended beyond these limits at the City's discretion on a case-by-case basis.

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 (see Section 1.5).

1.3.2 Permanent Protection of the Stream Corridor

The Stream Corridor Protection Zone shall be kept in as natural state as possible so that it can perform its inherent function of erosion protection, flood storage, and water quality protection. In order to ensure the permanent protection of the zone, the developer shall provide for the permanent protection of the zone.

The developer shall identify on the plat or plan and visibly delineate on the site the Stream Corridor Protection Zone prior to any construction on the site to prevent excursions onto the

¹ Based on the following equation:

Stream Corridor Protection Zone, in feet of width = 129 (DA)^{0.43} where DA is the drainage area of the stream in square miles. This equation was developed and recommended by the Ohio Department of Natural Resources (ODNR) based on regional curve analysis for various watercourses measured in the eastern United States region. Based on studies conducted by Ward (2001), Williams (1986), and Leopold (1978), the equation yields a protection zone wide enough to include a meander belt width plus two channel widths.

zone during construction. Such delineation must be submitted to the Director of Public Utilities or the Director's designee for review and approval prior to construction.

No later than the conclusion of construction, the developer shall permanently delineate the Stream Corridor Protection Zone in an aesthetically harmonious manner, approved by the director, such that the location of the zone is apparent to casual observers and permits access to the zone.

Language preventing Property Owners from constructing facilities and performing activities that are prohibited within the Stream Corridor Protection Zone, as described in Section 1.3.3, shall be shown on the plat and reflected on all deeds. Land designated as a Stream Corridor Protection Zone may, at the option of the land owner, be deeded in fee simple to the City of Columbus.

That portion of a lot or parcel reserved as the Stream Corridor Protection Zone may be included in the total area for computing the density permitted by the particular underlying zoning district for that parcel, even if ownership of the Stream Corridor Protection Zone is subsequently transferred. The resulting increase in net density permitted on that portion of the lot or parcel located outside of the Stream Corridor Protection Zone is acceptable to the extent that the gross density for the total area does not exceed the density prescribed by the underlying zoning district.

1.3.3 Prohibited Uses in the Stream Corridor Protection Zone

Table 1-2 lists facilities/activities that are prohibited within the Stream Corridor Protection Zone. No stormwater pipe outfalls shall be located within the Stream Corridor Protection Zone unless it is determined after review that no other alternative is feasible. Stormwater pipe outfalls shall be located outside the Stream Corridor Protection Zone and discharged into either a structural level spreader or a constructed open channel with appropriate protection from erosion.

1.3.4 Permitted Uses in the Stream Corridor Protection Zone

Uses permitted within the Stream Corridor Protection Zone include, but are not limited to, the following:

- 1) Passive uses including hiking, fishing, picnicking, and similar uses. Construction of paved trails to further such passive recreation uses is permitted; however, trails that become damaged due to natural erosion should not be repaired but should be moved upland or removed altogether,
- 2) Vegetation removal on existing levees and dikes,
- 3) Activities by City personnel that are necessary to maintain the function of any open watercourse and the West Columbus Local Protection Project (floodwall),
- 4) Removal of damaged or diseased trees.

Table 1-2

Facilities and Activities Prohibited in the Stream Corridor Protection Zone

Prohibited Facilities	Prohibited Activities*
<ul style="list-style-type: none"> ▪ Buildings/structures (except bridges) ▪ Swimming pools ▪ Signs ▪ Billboards ▪ Fences ▪ Parking lots ▪ Electric lines that run parallel to the stream (with the exception of transmission lines) ▪ Utility lines or pipes that run parallel to the stream (except for necessary public sanitary, water, stormwater [see above] and public utility transmission lines as approved by the City) ▪ Telecommunications lines that run parallel to the stream (with the exception of transmission lines) ▪ Cable TV lines that run parallel to the stream ▪ Other improvements deemed unacceptable to the City 	<ul style="list-style-type: none"> ▪ Agriculture ▪ Industry/ commercial business ▪ Filling ▪ Excavation ▪ Ditching/diking ▪ Removal of topsoil, sand, gravel, rock, oil, gas ▪ Any other change in topography other than what is caused by natural forces ▪ Herbicides/pesticides ▪ Removal of native trees /vegetation except as approved by the City

* Unless designated a permitted use by the City

- 5) Revegetation and/or reforestation with plantings of native species,
- 6) Public utility crossings (Those utilities owned by the City, suburb or any entity contracting with the City as defined by Title 11 of the City Code.),
- 7) Street crossings,
- 8) Excavation for providing compensatory floodplain volume immediately adjacent to the channel,
- 9) Construction activities associated with properly permitted stream restoration projects,
- 10) Disturbances resulting from permitted stream and/or wetland mitigation projects provided the mitigation is to offset impacts to local protected wetlands (See Section 1.5), and
- 11) Activities related to enhancement of existing wetlands.

Disturbances within the Stream Corridor Protection Zone as a result of a permitted use must be mitigated through revegetation/reforestation, with the exception of vegetation removal for floodwall and dike/berm maintenance and inspection.

1.3.5 Applicability of Stream Corridor Protection Zones

A Stream Corridor Protection Zone is required for all projects subject to the Manual, except as follows:

Exemption 1 – Stream Corridor Protection Zones will not be required along existing streams located within the Downtown Zoning District as defined in City Code 3359.03 (See **Figure 1-1** at the end of this section).

Exemption 2 – Where the Stream Corridor Protection Zone for the Scioto River falls beyond the limits of the existing West Columbus Local Protection Project (floodwall), the limits of the Stream Corridor Protection Zone for the Scioto River shall end at the river side face of the floodwall or floodwall easement. Streams tributary to the Scioto River, however, that are not located within the downtown zoning district, will have a Stream Corridor Protection Zone based on their respective tributary area or floodway width as specified in Section 1.3.

Exemption 3 – First consideration must be given to providing the full Stream Corridor Protection Zone width as presented in Section 1.3. Based on plan review, the City may allow the Stream Corridor Protection Zone to be reduced if the project is a redevelopment, and the existing buildings already exist within the protection zone. The redevelopment shall not encroach further into the protection zone.

1.4 Floodplain Preservation and Developments within Special Flood Hazard Areas

All development within FEMA designated Special Flood Hazard Areas is subject to conditions of the City of Columbus' Title 33 Zoning Code, Chapter 3385 Flood Plain Development. The process for approving and administering floodplain fill permits is administered by the Columbus Development Department.

The Division of Sewerage and Drainage prohibits the filling of FEMA designated floodplains without compensation due to potential for problems associated with flooding, erosion, and environmental impact. With the exception of fills associated with widening an existing public roadway within a FEMA designated Flood Hazard Area, fill within the FEMA delineated 100-year floodplain outside of the Stream Corridor Protection Zone must be compensated by removing an equivalent volume of material or greater. (Information on FEMA's 100-year floodplains can be obtained through ODNR's Geographic Information Management Systems metadata or directly through FEMA.) The amount of compensatory storage shall be determined by the volume of material removed above the ordinary high-water mark of the stream and below the 100-year flood elevation established for the area. The compensation area must have an unrestricted hydraulic connection to the affected stream and provide the same rate of flood storage capture and discharge over the course of the flood event as in pre-project conditions. First consideration shall be given to expanding the stream's existing floodplain next to the existing channel and within the limits of the development site. In instances where compensatory storage within the limits of the development site is proven to be impractical, the City will consider offsite compensatory storage as long as:

- 1) First consideration is given to performing compensatory storage by expanding the stream's existing floodplain next to the channel.
- 2) The mitigation is performed as close to the proposed fill area as possible.

- 3) The mitigation occurs within the same hydraulic reach of the same stream in which filling is proposed to occur.
- 4) Where the Applicant proposes to provide compensatory storage on property owned by others, the Applicant must submit a written agreement between such landowner and the Applicant wherein the landowner agrees to convey an easement or other property interest or right to the Applicant allowing compensatory storage, and to permanently maintain such area for flood storage purposes in the event that the City approves the Applicant's proposed project.

The same hydraulic reach is defined as the reach of a stream between the nearest features controlling the flood water elevations upstream and downstream from the proposed fill area.

Disturbances created within the Stream Corridor Protection Zone for the purpose of providing compensatory floodplain storage adjacent to the stream are permitted; however, all disturbances must be mitigated through reforestation and revegetation. A streambank restoration plan that incorporates bioengineering techniques shall be prepared for compensatory floodplain fill work that occurs immediately adjacent to the streambank. The streambank restoration plan shall be submitted as part of the Stormwater Management Report and Construction Plan submission (Part II) for the project. The means and methods for stream restoration work, including non-vegetative and vegetative materials, shall be shown in the plan. Streambank restoration plans shall be designed and constructed based on the bankfull discharge and able to withstand the inundation, stream velocities, and channel stresses associated with the 100-year flood event without structural failure once vegetative cover is established. Streambank restoration plans shall be submitted with the construction plans. Guidance and further references for streambank stabilization techniques are provided under USDA's *Stream Corridor Restoration: Principles, Practices and Processes* and *Engineering Handbook*.

Embankment slopes proposed in compensatory storage areas must reasonably conform to the natural slopes adjacent to the disturbed area. The use of vertical retaining structures constructed of concrete, brick, block or other like-material is specifically prohibited. The use of crib walls with bioengineered fascines may be approved on a case-by-case basis.

1.5 Wetland Policy

The City of Columbus supports the preservation of existing wetlands and values the stormwater benefits that they 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 U.S. Army Corps of Engineers (Corps) and the Ohio Environmental Protection Agency (OEPA). Wetland boundaries shall be mapped in an acceptable electronic format and submitted to the Division of Sewerage and Drainage. Copies

of all permit applications and any associated wetland mitigation plans shall also be submitted to the Division of Sewerage and Drainage with the Stormwater Management Report. The City may not approve stormwater management reports or plans prior to receipt of copies of approved Federal (404) and State (401) permits if the permits are required.

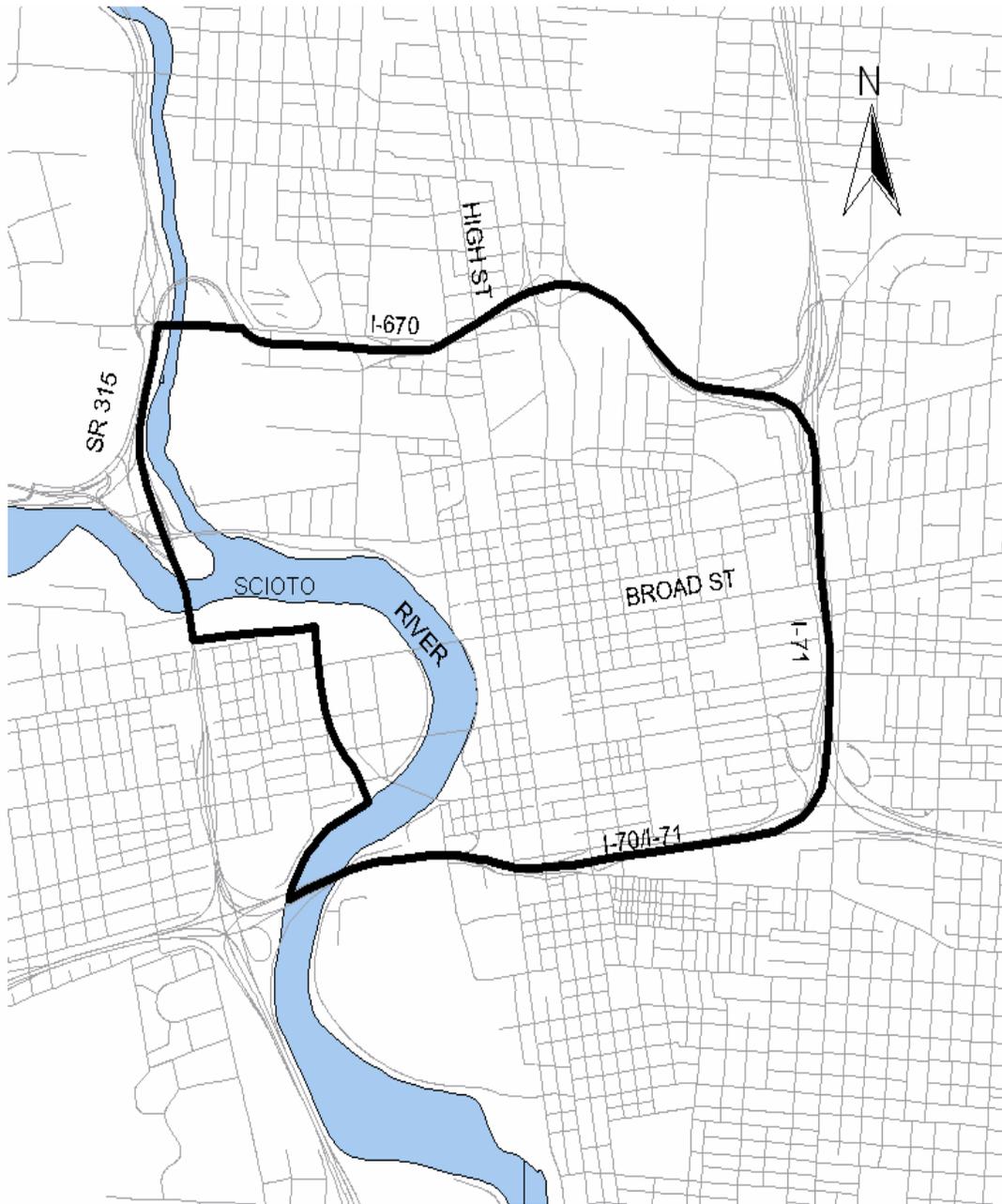
Where wetlands protected under federal or state law are located partially within the Stream Corridor Protection Zone, the Stream Corridor Protection Zone shall be extended to include the full extent of the wetland area plus any setback from the wetland required by a Section 404 permit.

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 subwatershed. To encourage onsite/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/permited by the Corps and/or OEPA, and
- 2) Wetlands constructed for mitigation purposes are not used to serve as a stormwater Best Management Practice (BMP) to treat onsite stormwater runoff.

The stormwater system design for the project shall ensure 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.

Figure 1-1
Downtown Zoning District as Defined in City Code 3359.03



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Stormwater Drainage Manual



Part I
Section 2

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Section 2

Stormwater Conveyance

This section describes the criteria and methodologies that shall be used to plan and design stormwater conveyance systems within the City of Columbus. Subsections include:

- 2.1 General Criteria
- 2.2 Hydrology Requirements
- 2.3 Design of Minor Stormwater Conveyance Systems
- 2.4 Design of Major Stormwater Routing Systems

2.1 General Criteria

The City's stormwater management goals are to prevent hazardous or detrimental flooding, streambank erosion, and water quality degradation that may result from stormwater runoff from development and redevelopment projects. This section presents general criteria for meeting this goal.

2.1.1 Offsite Tributary Area

Stormwater runoff from offsite upstream tributary areas that discharge to or across a development site shall be accommodated within the stormwater facilities planned for the development site. No stormwater management plans will be approved until it is demonstrated that offsite runoff will be adequately conveyed through the development site in a manner that will not cause or contribute to hazardous or detrimental upstream and downstream flooding and erosion. The estimation of the offsite flows must be done separately from the estimation of onsite flows (i.e., separate hydrographs for offsite areas must be determined).

2.1.2 Onsite Stormwater Conveyance

Stormwater runoff generated from the proposed development site shall be accommodated, in addition to offsite flows, within the stormwater facilities planned for the development. Onsite stormwater runoff shall be conveyed through the development site to adequate stormwater control facilities designed in accordance with the requirements specified in Section 3 of the Manual. No stormwater management plans will be approved until it is demonstrated that onsite runoff will not cause flooding within the development site for the designated design storm.

2.1.3 Downstream Analysis

Onsite stormwater systems must discharge to one of the following offsite stormwater systems:

- 1) A tier I stream,
- 2) A tier II stream,
- 3) An open channel system (generally excluding roadside ditches),
- 4) A storm sewer system adequately sized for the intended flows, or

- 5) A combined sewer system, if discharging stormwater into either a stream, open channel system, or storm sewer system, is not feasible.

If none of the four options above is feasible, then the Applicant must demonstrate that only sheet flow is being discharged with adequate quantity and quality controls in place, since concentrated flow may cause offsite erosion unless it is discharged into a conveyance system. In general, sheet flow occurs at the upstream extent of an overland flow path, rarely exceeding a length of 300 feet in mildly sloped, undeveloped areas. In developed areas, sheet flow lengths are typically no longer than 100 to 150 feet in pervious areas, and 50 to 75 feet in impervious areas. Flow that has become concentrated must be converted to sheet flow using a level spreader (see Section 2.3.6) or other similar device. Flow from drainage areas with overland flow paths greater than 300 feet must discharge into one of the five defined conveyance systems listed above.

The Applicant shall use one of the accepted hydrologic methods defined in Section 2.2.1 to demonstrate that the offsite stormwater system can convey existing offsite flows and projected onsite flows in a manner that does not increase downstream peak water surface elevations during the 1-year through the 100-year design storms and satisfies the various design criteria in the Manual. Downstream analysis shall be performed between the outlet of the onsite system and one of the following points:

- 1) The next increase in pipe diameter in an existing downstream storm sewer system,
- 2) The downstream face of the next bridge or culvert crossing in an open conveyance system (generally excluding roadside ditches), or
- 3) A point designated by the Administrator based upon known drainage issues in the downstream system.

In instances where it is determined that the existing downstream system(s) does not meet the criteria of the Manual, the Administrator will require that more stringent release rates from onsite detention facilities built for the development site be required, and/or require the Applicant to provide the necessary downstream improvements to satisfy the conditions of this section.

The following sources of information may be utilized to establish downstream tailwater conditions:

- 1) Previous studies that may be on file at the City,
- 2) Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and data, and/or
- 3) Calculations prepared by a Professional Engineer using standard engineering practice.

The Applicant must prepare a preliminary Stormwater Management Report (Section 6) that shall clearly show, through use of drawings, calculations, and narrative, how the proposed

development project will comply with these requirements. One of the hydrologic calculation methods described in Section 2.2 must be used, and design criteria specified in the Manual shall be used to evaluate the offsite drainage systems of the same type.

2.1.4 Agricultural Field Tile Systems

Agricultural field tiles are for agricultural drainage purposes only and, in general, may not be used as an outlet of any development or stormwater facility except in instances where the field tile is the only available outlet of the site. Field tiles that are discovered or intercepted during construction and do not exhibit evidence of conveying septic effluent shall be reconnected or connected into the proposed stormwater system. Field tiles that exhibit evidence of conveying septic effluent shall not be used for stormwater conveyance and shall be reported to the City Health Department for resolution upon discovery.

Designers preparing plans for development on existing agricultural lands shall, at a minimum, contact the respective County Engineer's office and local Soil and Water Conservation District to confirm the existence and location of existing tile systems. All visible field tile outlets and locations shall be field located and shown on the stormwater management plans. Any plan information for field tile systems received from county agencies shall also be shown.

In the event that a development proposes to discharge into an existing downstream field tile system on an adjacent property, the following requirements shall apply:

- 1) Runoff from the proposed development plus offsite flows currently entering the field tile system must be restricted to no more than the development's "fair-share" of full-flow hydraulic capacity of the field tile system for all storms up to and including the critical storm as defined in Section 3.2.2. The development's "fair-share" of the full-flow tile capacity is defined as the ratio of the development's tributary area to the total area tributary to the field tile system at the point of discharge. In no instance shall the release rate for any storm, up to and including the critical storm, exceed the 1-year predevelopment rate. Full-flow capacity, based upon the entire tributary area, shall be determined through a field survey and hydraulic evaluation of the receiving tile system to the nearest open watercourse.
- 2) An easement or other written owner agreement(s), as necessary, (such as making improvements to the downstream system) with the downstream owner is required for discharges to "private" (i.e., non-petitioned) field tile systems.

2.1.5 Stormwater System Diversions

The diversion of stormwater runoff from one watershed or receiving stormwater system to another is generally prohibited because such diversions have the potential to cause or exacerbate flooding, erosion, or water quality problems in receiving watercourses. For the purposes of the Manual, stormwater diversions are defined as the relocation of stormwater discharges from original receiving streams or stormwater systems to other systems that did not receive such discharges prior to construction. While it is recognized that stormwater runoff from small, onsite, tributary areas must be conveyed between catch basin subcatchments, the City will not allow the diversion of stormwater runoff from one major storm sewer system or

open watercourse to another without proper documentation that includes proof of benefit and public comment. Stormwater system diversions between Tier I and Tier II watercourses shall be considered on a case-by-case basis under circumstances where it can be shown that flooding and erosion will not increase and benefits to each watercourse can be achieved as a result of diverted flows. The diversion of any stormwater runoff from one stormwater system or watercourse to another shall be at the sole discretion of the Administrator or his/her designee.

2.2 Hydrology Requirements

The hydrology requirements provided in the Manual shall be used to determine the volume and discharge rate of stormwater from land areas. All Applicants shall satisfy the requirements of this section.

2.2.1 Acceptable Hydrologic Methods/Models

Tables 2-1 and 2-2 indicate which method must be used to design various components of the stormwater system. In general, the peak flow calculation methods (the maximum runoff flow rates at a given point as a result of a storm event) presented in Sections 2.2.3 shall be used for designing conveyances serving areas less than 200 acres (e.g., stream crossings, storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets). The City allows three methods for calculating stormwater runoff peak flows:

- 1) The Rational Method described in Section 2.2.3.1,
- 2) USGS Regression Equations (limited to analysis of Tier I and II stream crossings draining more than 17 acres) described in Section 2.2.3.2, and
- 3) The Natural Resources Conservation Service (NRCS, formerly the Soil Conservation Service or SCS) Curve Number method described in Section 2.2.3.3.

The fundamental hydrologic components defined in Section 2.2.2 shall be used in each of these methods.

Hydrograph methods better account for the timing of runoff in larger watersheds and storage provided by detention facilities and/or floodplains. Therefore the hydrograph methods presented in Section 2.2.4 may be used to size any drainage component, but must be used for downstream analysis and to design detention facilities. Section 2.2.4 defines acceptable hydrograph methods. Information regarding the water quality volume used to design stormwater quality management facilities is provided in Section 3.3.3.

Table 2-1
Applications of the Recommended Hydrologic Methods

Method	Manual Section	Rational Method (Section 2.2.3.1)	Regression Equations (Section 2.2.3.2)	NRCS (SCS) Curve Number Method (Section 2.2.3.3)	Approved Hydrograph Method (Section 2.2.4)	Water Quality Volume (Section 3.3)
Storm Sewers	2.3.1	√		√	√	
Curb Inlets & Catch Basins	2.3.2	√			√	
Culverts for Constructed Open Watercourses	2.3.3	√	√	√	√	
Culverts for Tier I or II Streams	2.3.3		√ ¹		√	
Constructed Open Watercourses	2.3.7	√		√	√	
Downstream Analysis	2.1.3				√	
Detention Basins for Quantity Control	3.2.2				√	
Water Quality Controls	3.3.2					√

Table 2-2
Constraints to Using Recommended Hydrologic Methods

Method	Size Limitation	Applicability
Peak Flow Methods <ul style="list-style-type: none"> ▪ Rational Method ▪ Regression Equations ▪ NRCS (SCS) Curve Number Method 	Up to 200 acres Between 17 and 2600 acres with defined channels Peak flow for areas 200 to 640 acres ²	Method can be used for estimating peak flows and the design of small conveyance systems. Method can be used for estimating peak flows along Tier I and Tier II streams. More specific size limitations are outlined in each of the USGS reports. Method can be used for estimating peak flows and the design of larger conveyance systems
Approved Hydrograph Methods	All drainage area sizes	Method can be used for estimating peak flows and hydrographs for all design applications
Water Quality	Limits set for each Structural Control	Method used for calculating the Water Quality Volume (WQ _v)

¹ For new culvert or culvert replacements developed under City CIP projects only

² Mid-Ohio Regional Planning Commission, Stormwater Design Manual, 1977, pg.30

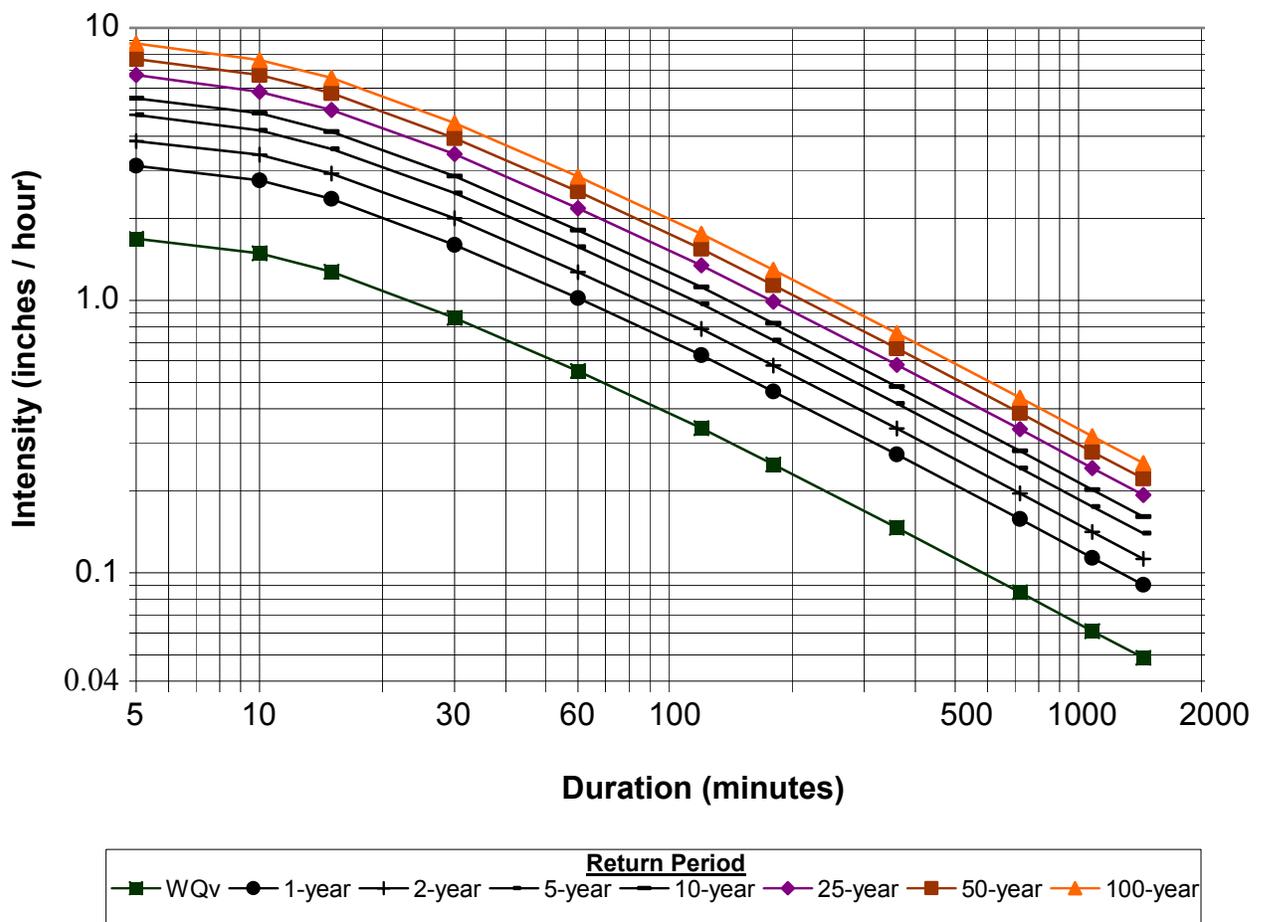
2.2.2 Hydrologic Components

2.2.2.1 Rainfall

Rainfall intensity-duration-frequency (IDF) curves for Central Ohio³ (**Figure 2-1**) shall be used in conjunction with the appropriate hydrologic method and/or model defined in Sections 2.2.3 and 2.2.4 to determine design runoff volumes and intensities. In general, these curves shall be used directly where the rational formula is appropriate to calculate runoff, or shall be used to develop a design rainfall hyetograph for runoff calculations using hydrograph methods.

Design rainfall hyetographs shall be developed using the 24-hour rainfall volume from Figure 2-1, distributed over a 24-hour period with the SCS Type II distribution (**Table 2-3**). 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.

Figure 2-1
Intensity Duration Frequency (IDF) Curves
Central Ohio (Section 05)



³ Huff and Angel, *Rainfall Frequency Atlas of the Midwest*, 1992.

Table 2-3
Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (in)							
			Frequency:	100yr	50yr	25yr	10yr	5yr	2yr	1yr
			Duration:	24 hour						
			Depth (in):	6.06	5.33	4.64	3.86	3.35	2.7	2.17
0:00	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:15	0.002	0.002		0.012	0.011	0.009	0.008	0.007	0.005	0.004
0:30	0.005	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
0:45	0.008	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
1:00	0.0108	0.0028		0.017	0.015	0.013	0.011	0.009	0.008	0.006
1:15	0.014	0.0032		0.019	0.017	0.015	0.012	0.011	0.009	0.007
1:30	0.017	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
1:45	0.02	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
2:00	0.023	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
2:15	0.026	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
2:30	0.029	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
2:45	0.032	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
3:00	0.0347	0.0027		0.016	0.014	0.013	0.010	0.009	0.007	0.006
3:15	0.038	0.0033		0.020	0.018	0.015	0.013	0.011	0.009	0.007
3:30	0.041	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
3:45	0.044	0.003		0.018	0.016	0.014	0.012	0.010	0.008	0.007
4:00	0.0483	0.0043		0.026	0.023	0.020	0.017	0.014	0.012	0.009
4:15	0.052	0.0037		0.022	0.020	0.017	0.014	0.012	0.010	0.008
4:30	0.056	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
4:45	0.06	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
5:00	0.064	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
5:15	0.068	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
5:30	0.072	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
5:45	0.076	0.004		0.024	0.021	0.019	0.015	0.013	0.011	0.009
6:00	0.0797	0.0037		0.022	0.020	0.017	0.014	0.012	0.010	0.008
6:15	0.085	0.0053		0.032	0.028	0.025	0.020	0.018	0.014	0.012
6:30	0.09	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
6:45	0.095	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
7:00	0.1	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
7:15	0.105	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
7:30	0.11	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
7:45	0.115	0.005		0.030	0.027	0.023	0.019	0.017	0.014	0.011
8:00	0.1203	0.0053		0.032	0.028	0.025	0.020	0.018	0.014	0.012
8:15	0.126	0.0057		0.035	0.030	0.026	0.022	0.019	0.015	0.012
8:30	0.133	0.007		0.042	0.037	0.032	0.027	0.023	0.019	0.015
8:45	0.14	0.007		0.042	0.037	0.032	0.027	0.023	0.019	0.015
9:00	0.1467	0.0067		0.041	0.036	0.031	0.026	0.022	0.018	0.015
9:15	0.155	0.0083		0.050	0.044	0.039	0.032	0.028	0.022	0.018
9:30	0.163	0.008		0.048	0.043	0.037	0.031	0.027	0.022	0.017
9:45	0.172	0.009		0.055	0.048	0.042	0.035	0.030	0.024	0.020
10:00	0.1808	0.0088		0.053	0.047	0.041	0.034	0.029	0.024	0.019
10:15	0.191	0.0102		0.062	0.054	0.047	0.039	0.034	0.028	0.022
10:30	0.203	0.012		0.073	0.064	0.056	0.046	0.040	0.032	0.026
10:45	0.218	0.015		0.091	0.080	0.070	0.058	0.050	0.041	0.033
11:00	0.236	0.018		0.109	0.096	0.084	0.069	0.060	0.049	0.039
11:15	0.257	0.021		0.127	0.112	0.097	0.081	0.070	0.057	0.046
11:30	0.283	0.026		0.158	0.139	0.121	0.100	0.087	0.070	0.056
11:45	0.387	0.104		0.630	0.554	0.483	0.401	0.348	0.281	0.226

Table 2-3 (Continued)
Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Delta Rain	Type II 24-Hour Distribution Rainfall (in)							
			Frequency:	100yr	50yr	25yr	10yr	5yr	2yr	1yr
			Duration: Depth (in):	24 hour 6.06	24 hour 5.33	24 hour 4.64	24 hour 3.86	24 hour 3.35	24 hour 2.7	24 hour 2.17
12:00	0.6632	0.2762	1.674	1.472	1.282	1.066	0.925	0.746	0.599	
12:15	0.707	0.0438	0.265	0.233	0.203	0.169	0.147	0.118	0.095	
12:30	0.735	0.028	0.170	0.149	0.130	0.108	0.094	0.076	0.061	
12:45	0.758	0.023	0.139	0.123	0.107	0.089	0.077	0.062	0.050	
13:00	0.776	0.018	0.109	0.096	0.084	0.069	0.060	0.049	0.039	
13:15	0.791	0.015	0.091	0.080	0.070	0.058	0.050	0.041	0.033	
13:30	0.804	0.013	0.079	0.069	0.060	0.050	0.044	0.035	0.028	
13:45	0.815	0.011	0.067	0.059	0.051	0.042	0.037	0.030	0.024	
14:00	0.825	0.01	0.061	0.053	0.046	0.039	0.034	0.027	0.022	
14:15	0.834	0.009	0.055	0.048	0.042	0.035	0.030	0.024	0.020	
14:30	0.842	0.008	0.048	0.043	0.037	0.031	0.027	0.022	0.017	
14:45	0.849	0.007	0.042	0.037	0.032	0.027	0.023	0.019	0.015	
15:00	0.856	0.007	0.042	0.037	0.032	0.027	0.023	0.019	0.015	
15:15	0.863	0.007	0.042	0.037	0.032	0.027	0.023	0.019	0.015	
15:30	0.869	0.006	0.036	0.032	0.028	0.023	0.020	0.016	0.013	
15:45	0.875	0.006	0.036	0.032	0.028	0.023	0.020	0.016	0.013	
16:00	0.881	0.006	0.036	0.032	0.028	0.023	0.020	0.016	0.013	
16:15	0.887	0.006	0.036	0.032	0.028	0.023	0.020	0.016	0.013	
16:30	0.893	0.006	0.036	0.032	0.028	0.023	0.020	0.016	0.013	
16:45	0.898	0.005	0.030	0.027	0.023	0.019	0.017	0.014	0.011	
17:00	0.903	0.005	0.030	0.027	0.023	0.019	0.017	0.014	0.011	
17:15	0.908	0.005	0.030	0.027	0.023	0.019	0.017	0.014	0.011	
17:30	0.913	0.005	0.030	0.027	0.023	0.019	0.017	0.014	0.011	
17:45	0.918	0.005	0.030	0.027	0.023	0.019	0.017	0.014	0.011	
18:00	0.922	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
18:15	0.926	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
18:30	0.93	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
18:45	0.934	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
19:00	0.938	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
19:15	0.942	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
19:30	0.946	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
19:45	0.95	0.004	0.024	0.021	0.019	0.015	0.013	0.011	0.009	
20:00	0.953	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
20:15	0.956	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
20:30	0.959	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
20:45	0.962	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
21:00	0.9653	0.0033	0.020	0.018	0.015	0.013	0.011	0.009	0.007	
21:15	0.968	0.0027	0.016	0.014	0.013	0.010	0.009	0.007	0.006	
21:30	0.971	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
21:45	0.974	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
22:00	0.977	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
22:15	0.98	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
22:30	0.983	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
22:45	0.986	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
23:00	0.9892	0.0032	0.019	0.017	0.015	0.012	0.011	0.009	0.007	
23:15	0.992	0.0028	0.017	0.015	0.013	0.011	0.009	0.008	0.006	
23:30	0.995	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
23:45	0.998	0.003	0.018	0.016	0.014	0.012	0.010	0.008	0.007	
0:00	1	0.002	0.012	0.011	0.009	0.008	0.007	0.005	0.004	

2.2.2.2 Time of Concentration

A time of concentration shall be calculated for each drainage structure that is designed. This time of concentration relates the maximum amount of flow coming from any watershed to the amount of time it takes for the entire watershed to be contributing flow to the point of interest. Although some places in a watershed are “hydraulically” closer to the point of discharge than others, peak flow generation calculations with the Rational Method (Section 2.2.3.1) shall consider only the most hydraulically remote location in the largest drainage area contributing to the point of discharge. Time of concentration is defined by the amount of time it takes for the first drop of water from this location to reach the discharge point.⁴

The time of concentration (t_c) shall be calculated as the summation of overland flow time (t_o), the time of shallow concentrated flow (t_s), and the time of pipe or open channel flow (t_d). The minimum time of concentration shall be five (5) minutes. Time of concentration calculations shall be based on the ultimate buildout land use for the tributary area. The time of concentration calculations shall assume that upstream, offsite, undeveloped areas will be served by storm sewers with a design flow velocity of 3.5 feet/sec.

Overland Flow or Sheet Flow

Overland flow, or sheet flow, is defined as flow that maintains a uniform depth across a sloping surface with no discernible channel. In general, sheet flow occurs at the upstream extent of an overland flow path, rarely exceeding a length of 300 feet in mildly sloped, undeveloped areas. In developed areas, sheet flow lengths are typically no longer than 100 to 150 feet in pervious areas, and 50 to 75 feet in impervious areas. The overland flow time shall be calculated using Manning’s kinematic equation⁵:

$$t_o = \frac{0.007(nL)^{0.8}}{P_2^{0.5}s^{0.4}}$$

where:

- t_o = Time of overland flow (hr),
- n = Manning’s roughness coefficient for sheet flow
- L = Flow length (ft)
- P_2 = 2-year, 24-hour rainfall (in)
- s = Slope of hydraulic grade line (land slope, ft/ft)

Table 2-4 gives Manning’s n values for sheet flow for various surface conditions. These n values are for very shallow flow depths less than or equal to 0.1 foot.

⁴ Haestad Methods Engineering Staff, *Computer Applications in Hydraulic Engineering*, 2002, pg. 56.

⁵ United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.

Table 2-4
Roughness Coefficients (Manning's "n") for Sheet Flow

Surface Description	n ¹
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses ²	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods: ³	
Light underbrush	0.40
Dense underbrush	0.80

¹ The n values are a composite of information compiled by Engman (1986).

² Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

³ When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Shallow Concentrated Flow

Beyond the maximum overland flow length defined in the previous section, sheet flow becomes concentrated flow and must be conveyed by a storm sewer, drainage ditch, or natural channel. The average velocity for shallow concentrated flow shall be determined from Figure 3-1 of SCS TR-55⁶, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in Appendix F of SCS TR-55.

Pipe or Open Channel Flow

The velocity of flow in an open channel or pipe shall be estimated using the Manning's Equation. The travel time for both shallow concentrated flow and open channel or pipe flow is calculated as follows⁷:

$$t_s \text{ or } t_d = L / (60V)$$

where:

t_s = Travel time for shallow concentrated flow in minutes

t_d = Travel time for open channel or pipe flow in minutes

L = Flow length in feet

V = Velocity in fps

⁶ United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.

⁷ Ohio Department of Transportation, *Location and Design Manual, Volume 2 – Drainage Design*, Section 1101.2.2.

2.2.2.3 Soil Variables

The hydrologic soil group (HSG) associated with soils on the project site prior to development shall be defined by Table 16 – Soil and Water Features⁸ of the latest edition of the “Soil Survey of Franklin County”. A table of the HSGs for the United States soil classifications is also provided in Appendix A of SCS TR-55⁹. Pertinent figures, tables, and infiltration parameters characterizing the soils native to the project site and the soils that will be re-graded, compacted or otherwise altered to a degree that changes their hydrologic characteristics shall be included in the Stormwater Management Report prepared for the project. Designers should be aware that hydrologic characteristics of soils on a given site can change significantly as a result of grading and compaction during construction. The use of different hydrologic soil groups that reflect the changes in post construction soil hydrology shall be considered when determining runoff estimates for post construction conditions.

2.2.3 Peak Flow Calculation Methods/Models

In general, peak flow calculation methods shall be used to design the stormwater conveyance systems within a development. The following sections describe peak flow calculation methods acceptable for use within Columbus.

2.2.3.1 Rational Method

The rational method shall be used to estimate runoff from drainage areas smaller than 200 acres. Its use shall be limited to the evaluation and design of storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets. Design discharge, “Q” is obtained from the equation:

$$Q = fCIA$$

where:

Q = Discharge in cubic feet per second

C = Coefficient of runoff, see **Table 2-5**. An average C is to be computed based on the percentage of each land use within the drainage area

f = C value correction factor for the design storm, listed in footnote 7 of Table 2-5

I = Average rainfall intensity in inches per hour from Figure 2-1 for a given storm frequency and a duration equal to the time of concentration

A = Drainage area in acres

⁸ United States Department of Agriculture, Soil Conservation Service, *Soil Survey of Franklin County*, February 1980.

⁹ United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.

Table 2-5
Runoff Coefficients “C” for Typical Land Uses in Columbus

Cover Type and Hydrologic Condition	Average percent impervious area (5)	Runoff Coefficient for Hydrologic Soil Group (7)			
		A	B	C	D
<i>Fully developed urban areas (vegetation established) (1)</i>					
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		0.94	0.94	0.94	0.94
Open space (lawns, parks, golf courses, cemeteries, etc)					
Poor condition (grass cover, 50%)		0.29	0.48	0.63	0.70
Fair condition (grass cover 50% to 75%)		0.07	0.30	0.48	0.58
Good condition (grass cover >75%)		NA	0.19	0.39	0.50
Commercial and business (TND – TC) (6)	85	0.70	0.77	0.83	0.85
Industrial	72	0.52	0.67	0.75	0.80
Residential Districts by Average Lot Size (6):					
Multi-family (TND – NC)	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots (TND – NG)	75	0.56	0.70	0.77	0.83
1/8 acre (TND – NE)	65	0.44	0.60	0.72	0.77
1/4 acre	38	0.19	0.40	0.56	0.65
1/2 acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
<i>Undeveloped or agricultural lands(1)</i>					
Cultivated Land:					
Without conservation treatment		0.35	0.52	0.67	0.75
With conservation treatment		0.21	0.34	0.46	0.52
Pasture, grassland, or range – continuous forage for grazing. (2)	Hydrologic condition:				
	Poor	0.29	0.48	0.63	0.70
	Fair	0.07	0.30	0.48	0.58
	Good	NA	0.19	0.39	0.50
Meadow – continuous grass, protected from grazing and generally mowed for hay.	--	NA	0.16	0.34	0.46
Brush – brush-weed-grass mixture with brush the major element. (3)	Poor	0.06	0.27	0.44	0.56
	Fair	NA	0.13	0.32	0.44
	Good	NA	0.06	0.25	0.37
Woods. (4)	Poor	0.04	0.26	0.44	0.56
	Fair	NA	0.18	0.37	0.48
	Good	NA	0.12	0.32	0.44
Farmsteads – buildings, lanes, driveways, and surrounding lots.	--	0.17	0.39	0.54	0.63

Notes:

NA – Method to derive value is not applicable for curve number values less than 40.

(1) Average runoff condition, and $la=0.2s$.

(2) Poor: <50% ground cover or heavily grazed with no mulch.

Fair: 50 to 75% ground cover and not heavily grazed.

Good: >75% ground cover and lightly or only occasionally grazed.

(3) Poor: <50% ground cover.

Fair: 50 to 75% ground cover.

Good: >75% ground cover.

(4) Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

Fair: Woods are grazed but not burned, and some forest litter covers the soil.

Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

(5) The average percent impervious area shown was used to develop the composite CN's which were then used to derive runoff coefficient values. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a runoff coefficient of 0.94 (or CN of 98), and pervious areas are considered equivalent to open space in good hydrologic condition.

(6) Acronyms for zoning of residential districts are as follows:

TND – TC: Traditional Neighborhood Development – Town Center

TND – NC: Traditional Neighborhood Development – Neighborhood Center

TND – NG: Traditional Neighborhood Development – Neighborhood General

TND – NE: Traditional Neighborhood Development – Neighborhood Edge

(7) These runoff coefficients were calculated from CN's drawn from the NRCS (SCS) Peak Discharge Method from TR-55 assuming a 10-year, 24-hour storm. For larger design storms, the runoff coefficients should be increased using the following C value correction factors:

1.0 for the 10-year design storm and less

1.1 for the 25-year design storm

1.2 for the 50-year design storm

1.3 for the 100-year design storm

The coefficient of runoff is expressed as a dimensionless decimal value that estimates the percentage of rainfall that becomes runoff. The residential runoff coefficients in Table 2-5 shall be used for runoff projections using the rational formula. Runoff coefficients used to project onsite flows for multi-family, commercial, and industrial type developments must be calculated based on the actual impervious surface amounts planned for the development site. The estimation of offsite flows may be determined using the appropriate runoff coefficient for the undeveloped land uses and/or the categorical development types (residential, commercial, and industrial) listed in Table 2-5.

2.2.3.2 Regression Equations

The regression equations presented in USGS Report 93-135¹⁰ is an accepted method for estimating design peak-discharge values for streams with drainage areas between 17 and 2600 acres. The application of this method is limited to the estimation of peak discharges for City funded culvert installation and replacement projects. The following equations shall be used for the various design storms:

$$Q_2 = 155 (A)^{0.68} (P-30)^{0.5} (13-BDF)^{-0.5}$$

$$Q_5 = 200 (A)^{0.71} (P-30)^{0.63} (13-BDF)^{-0.44}$$

$$Q_{10} = 228 (A)^{0.74} (P-30)^{0.68} (13-BDF)^{-0.41}$$

$$Q_{25} = 265 (A)^{0.76} (P-30)^{0.72} (13-BDF)^{-0.37}$$

$$Q_{50} = 293 (A)^{0.78} (P-30)^{0.74} (13-BDF)^{-0.35}$$

$$Q_{100} = 321 (A)^{0.79} (P-30)^{0.76} (13-BDF)^{-0.33}$$

where:

Q_N = peak discharge rate in cfs,

A = the drainage area in square miles,

P = average annual precipitation in inches = 37 inches for Columbus, and

BDF = the basin development factor.

The basin development factor (BDF) is determined by subdividing the drainage basin into thirds (lower, middle, and upper) with two lines drawn across the basin that are perpendicular to the main channel and principal tributaries. Four aspects of the drainage system are then evaluated within each third of the basin and assigned a value of 1 or 0:

- 1) **Channel improvements** include any straightening, enlarging, deepening, and clearing made in the main drainage channel and principal tributaries. If at least 50 percent of the upstream channels in the basin are improved, then a value of 1 is assigned.

¹⁰ United States Geological Survey, USGS Report 93-135 *Estimation of Peak-Frequency Relations, Flood Hydrographs, and Volume-Duration-Frequency Relations of Ungaged Small Streams in Ohio*.

- 2) **Channel linings** include any length of the main drainage channels and principal tributaries that have been lined with an impervious material such as concrete. A value of 1 is assigned if at least 50 percent of the upstream channels have been lined.
- 3) **Storm drains or storm sewers** are defined as enclosed drainage structures (usually pipes) frequently used on secondary tributaries where drainage is received directly from streets or parking lots. A value of 1 is then assigned when more than 50 percent of the upstream secondary tributaries consist of storm drains.
- 4) **Curb and gutter streets** frequently empty into storm drains. If more than 50 percent of the upstream basin is developed with streets and highways constructed with curbs and gutters, then a value of 1 will be assigned.

Table 2-6 provides an example for calculating the overall BDF for the entire basin that has channel improvements throughout, no channel linings, and storm drains with curb and gutter streets in the lower 2/3rds of the basin:

Table 2-6
Example Determination of the Basin Development Factor

Portion of Basin	Channel Improvements	Channel Linings	Storm Drains	Curb & Gutter Streets	Basin Development Factor
Lower 1/3	1	0	1	1	3
Middle 1/3	1	0	1	1	3
Upper 1/3	1	0	0	0	1
				Total:	7

2.2.3.3 The NRCS (SCS) Curve Number Method

The NRCS (SCS) Curve Number method, developed in 1969, partitions the total depth of rainfall into initial abstractions, retention, and effective rainfall. This method shall be used for areas larger than 200 acres. Worksheets 2 through 6 are available in the TR-55 publication and are acceptable methods for showing calculations described in this and other applicable sections. The following equation ¹¹ is used to estimate runoff:

$$Q = (P - I_a)^2 / [(P - I_a) + S]$$

where:

Q = runoff depth (in)

P = rainfall (in)

S = potential maximum retention after runoff begins (in)
= 1000/CN-10,

CN = runoff curve number, and

I_a = initial abstraction (in)
= 0.2 * S

¹¹ United States Department of Agriculture, Soil Conservation Services, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986, pgs.2-1 to 2-10.

CN values range between 0 and 100, while practical CN values range from 30 to 98 where larger values are associated with more impervious land surface. Soil groups are classified by NRCS into four hydrologic groups: Groups A, B, C, and D. Group A soils have high infiltration rates while Group D soils have low infiltration rates. **Table 2-7** (adapted from SCS) shall be used to define curve numbers for normal antecedent moisture conditions (Type II) for various land uses and soil classifications. The residential curve numbers in Table 2-7 shall be used for runoff projections using the SCS method. Curve numbers used to project onsite flows for multi-family, commercial, and industrial type developments must be calculated based on the actual impervious surface amounts planned for the development site. For example, an area with a directly connected impervious area (DCIA) of 70 percent with good grass cover on hydrologic soil group D soils would have the following curve number:

$$\begin{aligned} \text{CN} &= \text{CN}_{\text{Impervious}} * \% \text{ Imperviousness} + \text{CN}_{\text{pervious}} * (1 - \% \text{ imperviousness}) \\ &= 98 * 0.7 + 80 * (1-0.7) \\ &= 93 \end{aligned}$$

The estimation of offsite flows may be determined using the appropriate curve numbers for the undeveloped land uses and/or the categorical development types (residential, commercial, and industrial) listed in Table 2-7. Additional information regarding the use of SCS's runoff curve number method is available in Technical Release 55 – *Urban Hydrology for Small Watersheds*.

The peak rate of runoff is then calculated as:

$$q_p = q_u A_m Q F_p$$

where:

- q_p = peak discharge (cfs)
- q_u = unit peak discharge (csm/in) (see **Figure 2-2**)
- A_m = drainage area (mi²)
- Q = runoff depth (in)
- F_p = pond and swamp adjustment factor (see **Table 2-8**)

Table 2-7

Runoff Curve Numbers (CN) for Typical Land Uses in Columbus (SCS, 1986 except as noted)

Cover Type and Hydrologic Condition	Average percent impervious area (6)	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
<i>Fully developed urban areas (vegetation established) (1)</i>					
Impervious areas: Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Open space (lawns, parks, golf courses, cemeteries, etc)					
Poor condition (grass cover, 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover >75%)		39	61	74	80
Commercial and business (TND – TC) (7)	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size (7):					
Multi-family (TND – NC) (9)	80	86	91	93	94
1/12 to 1/6 acre lots (TND – NG) (9)	75	83	89	92	94
1/8 acre (TND – NE)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
<i>Undeveloped or agricultural lands (1)</i>					
Cultivated Land: (8)					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture, grassland, or range – continuous forage for grazing. (2)	Hydrologic condition:				
	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow – continuous grass, protected from grazing and generally mowed for hay.	--	30	58	71	78
Brush – brush-weed-grass mixture with brush the major element. (3)	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 ⁽⁴⁾	48	65	73
Woods. (5)	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 ⁽⁴⁾	55	70	77
Farmsteads – buildings, lanes, driveways, and surrounding lots.	--	59	74	82	86

Notes:

- (1) Average runoff conditions, and $I_a=0.2s$.
- (2) Poor: <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.
- (3) Poor: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
- (4) Actual curve number is less than 30; use CN=30 for runoff computations.
- (5) Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.
- (6) The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.
- (7) Acronyms for zoning of residential districts are as follows:
TND – TC: Traditional Neighborhood Development – Town Center
TND – NC: Traditional Neighborhood Development – Neighborhood Center
TND – NG: Traditional Neighborhood Development – Neighborhood General
TND – NE: Traditional Neighborhood Development – Neighborhood Edge
- (8) Source: SCS National Engineering Handbook, Section 4, Hydrology, Chapter 9, August 1972.
- (9) Source: Curve numbers were calculated based upon percent of impervious area.

Figure 2-2
Unit Peak Discharge Determination

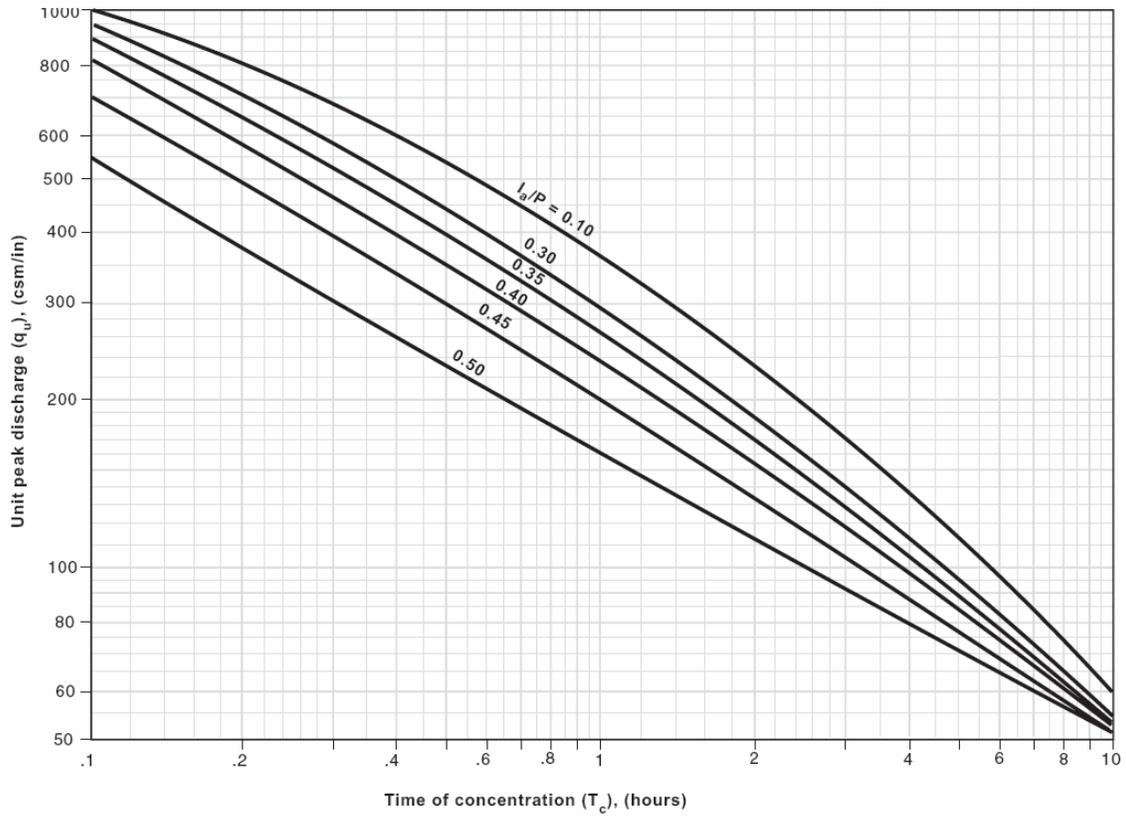


Table 2-8
Adjustment Factor (F_p) for Ponds and Swamps

Percentage of pond and swamp areas	F _p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

(Note: Per TR-55 pgs.4-1:4-2, Include Adjustment Factor F_p if pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation.)

2.2.4 Acceptable Runoff Hydrograph Development Methods

Peak flow methods are not appropriate for designing stormwater detention basins, evaluating downstream impacts on streams, and designing major conveyances with drainage areas larger than 200 acres. In these cases, the City requires that a hydrograph be developed and routed through the system to support design and/or evaluation. In addition, hydrograph methods may be used to design other elements of the drainage system as part of a comprehensive hydrologic/hydraulic evaluation supported by computer models or other appropriate means. Designs using hydrograph methods shall be accepted if the results are presented in the format defined in the Manual for peak flow calculations.

Several methodologies are available for defining runoff hydrographs and routing them through the drainage system. The City will accept the unit hydrograph methodology presented in this section, and may accept other equivalent methods if supported by proper documentation and a demonstrated record of successful application for drainage system design. Furthermore, hydrograph methods are generally provided by common engineering computer software, such as the NRCS TR-20, the US Army COE HEC-1 models and U.S. EPA SWMM, which may be allowed if the model results are presented in the format defined in the Manual.

2.2.4.1 Rainfall Hyetographs

All runoff hydrographs shall be based upon a design storm hyetograph defined using the 24-hour design storm rainfall volumes for the City of Columbus extracted from Figure 2-1, and the 24-hour SCS Type II rainfall distribution. These design rainfall hyetographs for the various design storms referenced in the Manual are provided in Table 2-3.

2.2.4.2 Abstractions from Rainfall

For each catchment, abstractions from rainfall must be determined for each 15-minute rainfall volume within this hyetograph. Abstractions are comprised of depression storage and infiltration into the soil, and shall be based upon the soil and land cover characteristics of the catchment. The initial abstraction at the beginning of the design storm shall be based upon average soil moisture conditions. Changes in abstractions shall be tracked during the storm event as available depression storage and soil infiltration capacity is filled. The NRCS curve number methodology presented in Section 2.2.3.3 is accepted by the City for defining rainfall abstractions. Other methods, including the Green-Ampt and Horton's methods¹², for determining the change in soil infiltration during a precipitation event may be used with appropriate documentation at the discretion of the City.

¹² Mays, Larry, *Stormwater Collection Systems Design Handbook*, McGraw-Hill, 2001.

2.2.4.3 Unit Hydrographs

A unit hydrograph is the hydrograph of direct runoff that results from one inch of excess rainfall generated uniformly over a watershed at a constant rate during a specified time. The City will accept the SCS dimensionless unit hydrograph as the basis for developing runoff hydrographs. This method uses the table at the right, in conjunction with the following equations, to develop a unit runoff hydrograph from each catchment for each 15 minute rainfall increment within the SCS Type II distribution:

$$t_p = 0.666 * t_c \quad \text{and}$$

$$Q_p = P_e * 484 * A / t_p$$

where:

- t_p = time to peak, hours
- t_c = time of concentration, hours, from Section 2.2.2.2
- Q_p = peak flow rate from one inch of excess rainfall, cfs
- P_e = excess rainfall during the 15 minute rainfall increment, in.
= total rainfall minus the abstraction to rainfall
- A = watershed area, mi^2

The total hydrograph responding to the SCS Type II rainfall hyetograph from the catchment is determined by adding the individual unit hydrographs determined using the previous equation. The City will accept calculations based on computer models that use the SCS unit hydrograph method to develop runoff hydrographs. In addition, the City will consider use of alternative methods for developing runoff hydrographs, including the Snyder and Clark unit hydrograph methods included in the US Army COE HEC-1 model, and the kinematic wave method included in the US Army COE HEC-1 model and U.S. EPA SWMM.

SCS Dimensionless Unit Hydrograph	
t/t_p	Q/Q_p
0.0	0.000
0.2	0.100
0.4	0.310
0.6	0.660
0.8	0.930
1.0	1.000
1.2	0.930
1.4	0.780
1.6	0.560
1.8	0.390
2.0	0.280
2.2	0.207
2.4	0.147
2.6	0.107
2.8	0.077
3.0	0.055
3.2	0.040
3.4	0.029
3.6	0.021
3.8	0.015
4.0	0.011
4.2	0.008
4.4	0.006
4.6	0.004
4.8	0.002
5.0	0.000

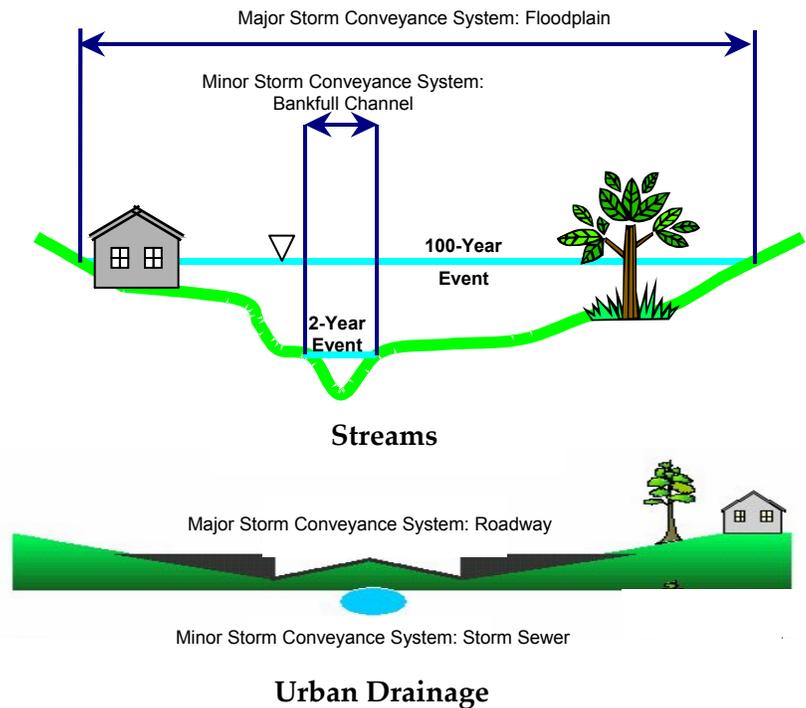
2.3 Design of Minor Stormwater Conveyance Systems

Flooding is a natural phenomenon accommodated within natural drainage systems. During rainfall events of small to moderate size, stormwater runoff is contained within the banks, or the bankfull channel, of streams. During larger, less frequent storms, runoff overflows the channel banks into the surrounding floodplain. As areas develop, portions of the natural drainage system are often replaced with underground storm sewers sized to collect and convey runoff from small to moderate storms. Properly designed developments will use streets or swales as a major storm conveyance system to convey runoff from larger, less frequent storms to the open channel drainage system.

Effective drainage system design depends upon how frequently the capacity of the minor storm conveyance system should be exceeded, and how severe the impact of flooding would be within the major storm conveyance system. Frequency is expressed as a probability of occurrence in any given year. For example, the 100-year design storm event is defined as a storm that has a 1% chance of occurring in any given year. While a 100-year storm event could occur more frequently than once in every 100 years, over a very long period of time the frequency of a storm of this magnitude occurring averages to once in a hundred years.

Table 2-9 and **Table 2-10** provide a summary of the hydraulic design requirements for conveyance infrastructure discussed in this section.

On roadways with multiple through lanes in each direction, or one direction on a one-way roadway, one driving lane in each direction must be free of water. If there is only one through lane in each direction, or one direction on a one-way roadway, then the Check Storm Spread must be the same as the Maximum Design Spread. Stormwater spread on shoulders, full-time parking lanes, and other paved roadside areas and non-traffic lanes is permitted to be full width.



Both natural streams and urban drainage systems need a minor and major storm conveyance system to accommodate flooding.

Table 2-9
Pavement Design Criteria (Manual Section 2.3.2)

Functional Classification	Design Speed	Design Storm Frequency	Maximum Design Spread**	Check Storm Frequency	Check Storm Spread Criteria
Interstate Highways	All	10-year	0 feet	100-year	All traffic lanes free of water
	All	100-year	0 feet	Applies at underpasses and sag points	
Other freeways and expressways	≥ 45 mph	10-year	0 feet	25-year	*
	< 45 mph	10-year	3 feet	25-year	*
	All	50-year	3 feet	Applies at underpasses and sag points	
Major arterial (ADT > 10000)	≥ 45 mph	10-year	0 feet	25-year	*
	< 45 mph	10-year	3 feet	25-year	*
	All	50-year	3 feet	Applies at underpasses and sag points	
Minor arterial and collectors (ADT 3501 – 10000)	≥ 45 mph	5-year	0 feet	25-year	*
	< 45 mph	5-year	½ of driving lane	25-year	*
	All	10-year	½ of driving lane	Applies at underpasses and sag points	
Locals (ADT ≤ 3500), Other parking and development areas	< 45 mph	5-year	½ of driving lane	10-year	One lane open to traffic
	< 45 mph	5-year	½ of driving lane	Applies at underpasses and sag points	

* On roadways with multiple through lanes in each direction, or one direction on a one-way roadway, one driving lane in each direction must be free of water. If there is only one through lane in each direction, or one direction on a one-way roadway, then the Check Storm Spread must be the same as the Maximum Design Spread. Stormwater spread on shoulders, full-time parking lanes, and other paved roadside areas and non-traffic lanes is permitted to be full width.

** The allowable depth of water on a roadway within the design spread shall be 1" below the top of curb or 5" maximum. 6" is permissible when a barrier shape is provided adjacent to the pavement.

Table 2-10
Storm Sewers, Culverts, Level Spreaders, and Open Watercourses
Design Criteria (Manual Sections 2.3.1, 2.3.3, 2.3.6 and 2.3.7)

Functional Classification	Storm Sewers		Culverts ¹³	Level Spreaders	Open Watercourses
	Design Storm	Check Storm			
Interstate highways, other freeways, and expressways	10-year	25-year	50-year	Used to prevent offsite erosion where onsite discharges cannot be directed to an offsite conveyance system. This shall be limited to sites where flows are less than 30 cfs during a 10-year frequency storm.	Designed to carry the peak rate of runoff from a 10-year, 24-hour frequency storm. Those used for major storm routing shall be designed to convey the 100-year, 24-hour storm.
Major arterial (ADT > 10000)	10-year	25-year	25-year		
Minor arterial and collectors (ADT 3501 – 10000)	5-year	25-year	25-year		
Locals (ADT ≤ 3500), other parking and development areas	5-year	10-year	10-year		

2.3.1 Storm Sewers

Storm sewer systems are designed to collect and carry stormwater runoff from the first pavement, ditch inlet, or catch basin to the predetermined outlet. Storm sewers shall generally follow the alignment of the roadway, increasing in size as necessary to accept the flow from a series of inlets. Existing drainage patterns should be perpetuated insofar as practicable, and storm sewer outlets shall be located to minimize the possibility of actionable damage for the diversion of substantial volumes of flow.

Storm sewer calculations shall be summarized onto a Storm Sewer Computation Sheet and a Storm Sewer Check Sheet, presented in **Appendix C**, for each proposed sewer run. These sheets shall be submitted to the City as part of the Stormwater Management Report (see Section 6).

2.3.1.1 Storm Sewer Hydrology Requirements

The Rational Method shall be used to size storm sewers, as described in Section 2.2.3.1. The City will also accept storm sewer designs based on hydrograph methods in Section 2.2.4 as long as the results are tabulated in the referenced storm sewer computation and check sheets (Appendix C).

¹³ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

2.3.1.2 Storm Sewer Hydraulic Requirements

Pipe Sizing Criteria

All storm sewer systems shall be designed using Manning's Equation:

$$Q_f = (1.49/n) AR^{2/3} S^{1/2}$$

where:

Q_f = Full flow capacity of the storm sewer (cfs)

n = Manning's roughness coefficient

R = Hydraulic radius (feet)

= A/P

A = Cross-sectional area (feet²)

P = wetted perimeter (feet)

S = Slope of the conduit

= vertical rise of the pipe (feet) / length of the pipe (feet)

A Manning's "n" or roughness coefficient of 0.012 per ODOT 1104.4.5 shall be used to design storm sewer systems for all City-approved pipe materials.

Table 2-9 specifies the design storm frequency that shall be used to size storm sewers for various types of roadways. Storm sewer sizes may need to be increased as necessary to meet the allowable spread requirements specified in Section 2.3.2.1.

Storm Sewer Layout Requirements

All storm sewer systems shall be deep enough to receive the flow from all possible nearby sources within the watershed. Crown elevations for storm sewers shall be matched at junctions where possible. If the outlet elevation permits, the crown of the outlet pipe may be lowered.

Unless located within City Right-of-Way, storm sewers that are to be privately maintained shall have a minimum pipe inside diameter of eight inches. Storm sewers located within the City Right-of-Way that connect a private storm sewer system to a storm sewer owned by the City shall have a minimum inside diameter of 12 inches. Storm sewers that are to be publicly owned and maintained shall have a minimum inside diameter of 12 inches.

Storm sewers shall be designed to operate under subcritical flow conditions at all times because flow transients and/or small blockages may cause storm sewers built on supercritical slopes to surcharge unexpectedly. Drop manholes or other drop structures shall be used to maintain a mild pipe slope where ground slopes are steeper than critical slope. The maximum length between access structures shall be as follows:

- 1) Pipes under 60 inches in diameter - 300 feet
- 2) Pipes 60 inches in diameter and larger - 500 feet

All storm sewers shall be centered in the middle of easements established according to criteria in Section 2.3.1.4.

Endwalls shall be provided at all storm sewer outlets and shall conform to the most current edition of the City's Division of Sewerage and Drainage Standard Construction Drawings.

All storm sewers and their structures shall be kept away from building foundations or sanitary sewers as much as practicable to minimize stormwater inflow into these facilities. In instances where a proposed storm sewer will cross a sanitary sewer trench, watertight joints and trench dams shall be provided along the entire length of the proposed storm sewer from each manhole on either side of the crossing. If the storm and sanitary sewers are parallel and are within 5 feet of each other, water-tight joints and trench dams shall be installed along the entire run of the storm sewer until the distance between the storm sewer and sanitary sewer trenches exceed 5 feet.

Watertight joints and trench dams shall be specified for storm sewers that are to be located along side lot lines in a single family development site or where the trench limits of the storm sewer are to be within 10 feet of a building foundation. Trench limits for storm and sanitary sewers, as referenced herein, shall be defined as the minimum trench limits listed in the City's Division of Sewerage and Drainage Standard Construction Drawings AA-S149, AA-S151, and AA-S153.

Hydraulic Grade Line and Energy Loss Considerations

The hydraulic grade line shall be calculated based on an observed or calculated tailwater depth in the receiving channel determined through downstream analysis or the following equation, whichever is greater:

$$Tw = (d_c + D)/2$$

where:

- Tw = Tailwater depth (feet)
- d_c = Critical depth in the pipe (feet)
- D = Inside pipe diameter (feet)

The hydraulic grade line shall not exceed the window, grate, or casting elevation of any structure for the design storm frequency noted in Table 2-10.

Major energy losses within storm sewer systems are primarily caused by friction resistance between the fluid being conveyed and the pipe section conveying the flow. The following equation shall be used to calculate energy losses due to pipe friction:

$$H_{major} = S_f * L = [(Q_{HGL} * n) / (1.486 * A * R^{2/3})^2] * L$$

where:

- H_{major} = Major energy loss due to friction (feet)
- S_f = frictional slope (feet)
- Q_{HGL} = Design flow (cfs)

n = Manning's roughness coefficient
 A = cross-sectional area of the pipe (square feet)
 R = hydraulic radius (feet) = cross-sectional area of the pipe (A) / wetted perimeter (P)
 L = length of pipe (feet)

In addition to friction losses, localized disruptions to flow increase turbulence and cause energy losses within storm sewer systems. These disruptions, often caused by manholes or fittings, are generally called minor energy losses. Minor losses shall be calculated using the following equation:

$$H_m = K (V^2) / 2g$$

where:

H_m = minor loss (feet)
 K = minor loss coefficient for the specific fitting
 V = velocity (feet/s)
 g = gravitational acceleration = 32.2 feet/s²

Accepted values for common minor loss coefficients are provided in **Table 2-11**. Applicants must use the appropriate minor loss coefficients, the appropriate design flow (Q_{HGL}) as determined from Table 2-10, and the following equation to check that the slope of the hydraulic grade line will not exceed the ground elevation:

$$S_f = (Q_{HGL} * n / (1.486 * A * R^{2/3}))^2 + H_m / L$$

where:

S_f = frictional slope (feet)
 Q_{HGL} = Design flow (cfs)
 n = Manning's roughness coefficient
 A = cross-sectional area of the pipe (square feet)
 R = hydraulic radius (feet) = cross-sectional area of the pipe (A) / wetted perimeter (P)
 H_m = minor loss (feet)
 L = length of pipe (feet)

Flow Velocity Criteria

All storm sewers shall be designed and constructed to produce a minimum velocity of 3.0 feet per second (fps) when flowing full, unless it can be shown that this requirement cannot be met due to site conditions. In addition, storm sewers shall be designed for subcritical flow conditions with a maximum velocity of 15 ft/sec. The outlet ends of all storm sewers shall be provided with sufficient energy dissipators and erosion protection to withstand the projected full-flow velocity from the pipe.

Table 2-11
Minor Loss Coefficients for Storm Sewers¹⁴

Type/Description of Structure	Coefficient K
Inlet to manhole	0.25
Manhole in straight section of closed conduit	0.10
Manhole at a 45 degree bend	0.25
Manhole at a 90 degree bend	0.50
Exit closed conduit into lake (submerged)	0.90
Exit closed conduit to open channel (submerged)	0.50
Exit closed conduit to open channel (free discharge)	0.10

2.3.1.3 Pipe Material, Bedding, Cover, and Encasement Requirements

The pipe material type and surrounding conditions shall be determined by the Applicant and specified in the Report, including the depth of cover, groundwater levels (if known), location of pipe with respect to roadways or highways, and type of proposed pavement. For pipes having equivalent materials and dimensions, the cover and structural requirements for storm sewer pipes provided in Section 1008 of ODOT's L&D Manual and the requirements of CMSC shall be met. In instances where accepted pipe materials and dimensions are provided in the CMSC but structural criteria are not included in Section 1008 of ODOT's L&D Manual, the cover and structural design of the pipe shall be in accordance with the pipe manufacturer's recommendations.

The trench bedding and backfill design for all pipes shall conform to the requirements of the City's CMSC Section 901 and the City's Standard Construction Drawings. The bedding type (I or II) is specified in CMSC 901.11 for both rigid and flexible pipe. Class A concrete encasement, per CMSC 901.12, shall be required for all pipe materials with inside diameters less than or equal to 27 inches that are located within public rights-of-way during construction, or at proposed final grade where the minimum cover over the outside top of the pipe to the ground surface or pavement subgrade is 30 inches or less.

2.3.1.4 Storm Sewer Easement Requirements

All storm sewers that are to be publicly owned and operated shall have a minimum easement of 20 feet centered on the sewer, or 5 feet beyond the minimum trench limits on either side of the trench (as specified in Standard Construction Drawings AA-S149, AA-S151, and AA-S153), whichever is greater. Additional easements shall also be provided along storm sewers within the public right-of-way but less than 10 feet from the right-of-way line. The added easement width shall be wide enough to provide a total access width (easement plus right-of-way) of 10 feet from the center of the storm sewer. Storm sewer easements shall be expanded to include ancillary structures such as end treatments, outfall protection, and level spreaders that are publicly owned and maintained. The width of easements shall include the area of the ancillary structure plus 10 feet around the structure's perimeter.

¹⁴ Water Environment Federation and American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992.

2.3.2 Curb Inlets and Catch Basins

Stormwater inlets and catch basins direct surface runoff into a storm sewer system or culvert. The three types of stormwater inlet structures include curb inlets, catch basins, and combination inlets. Curb inlets consist of an opening in the side of a curb, catch basins are slotted inlets usually flush with the surrounding ground, and combination inlets have a curb opening and a catch basin with a slotted grate.

2.3.2.1 General Criteria

Inlets and catch basins shall be sized and spaced to restrict the spread of runoff along roadway surfaces and limit ponding in low areas. Table 2-9 summarizes the allowable spread of runoff on various classifications of roadways.

The rational method (see Section 2.2.3.1) and a minimum time of concentration of 5 minutes shall be used to determine the amount of runoff that will be collected by the proposed inlet structures. Hydraulic analyses used to size and space inlets and catch basins shall be based on the methods presented in (FHWA) Hydraulic Engineering Circular No. 12 "Drainage of Highway Pavements" and Hydraulic Engineering Circular No. 22 "Urban Drainage Design Manual." **Table 2-12** summarizes the dimensions of the inlets and catch basins that are provided in the City's standard drawings. These dimensions may be used with the design aids (i.e., charts, graphs, nomographs, etc.) provided in the references cited above to assist in determining the capacity and spacing of the inlets and catch basins under different pavement and flow conditions.

Table 2-12
City Catch Basin Grate and Curb Inlet Dimensions

Standard Drawing	Shape	Clear Opening Area, A (ft ²)	Grate Length, L (ft)	Grate Width, W (ft)	Inlet Length (ft)	Inlet Height (ft) ²
AA-S115	Round Catch Basin	2.9	3.0	3.0	-	-
AA-S116	Round Catch Basin	2.7	3.0	3.0	-	-
AA-S123	42" Curb Inlet	-	-	-	3.5	>4
AA-S123	60" Curb Inlet	-	-	-	5.0	>4
AA-S126	Standard Curb Inlet	-	-	-	2.33	6.25
AA-S128 ¹	Combination Curb and Gutter - Standard	2.7	2.8	1.4	-	-
AA-S133	Square Catch Basin	2.5	3.9	2.1	-	-
AA-S138	Round Catch Basin	0.9	1.9	1.9	-	-
AA-S139	Square Catch Basin	1.9	1.6	2.0	-	-
AA-S140	Rectangular Catch Basin	1.1	1.8	1.2	-	-
AA-S141	Square Catch Basin	1.9	1.9	2.0		

1. The capacity of combination curb and gutters shall be calculated as a grate inlet. The additional capacity from the curb inlet is to serve as overflow when grate becomes blocked with debris.
2. Depth of inlet opening can vary depending on height of curb and capacity needs. A depression should be provided to achieve an inlet height of at least 4 inches.

2.3.2.2 Underpass or Sag Requirements

An underpass or sag condition is a point where water can be removed only through a storm sewer system. Inlets shall be placed in low areas such as sag curves along a highway, underpasses, and other depressions where runoff may concentrate and the only outlet is the storm sewer system. The number and type of inlets to be used to drain underpass or sag locations shall be designed to achieve the roadway classifications and storm frequencies provided in Table 2-9.

2.3.2.3 Inlets on Continuous Grade Requirements

At a minimum, the catch basin and/or curb inlet shall be placed at the point where the flow spread is projected to reach the maximum allowable spread listed in Table 2-9. In addition, a basin/inlet shall be placed at intersections where necessary to prevent the gutter flow from crossing the pavement. The City may require additional inlets at intermediary points if the flow in the gutter at design conditions might create a hazard to vehicular traffic, public safety, or property flooding. The projected gutter flow approaching each basin/inlet, the flow projected to enter each basin/inlet, and the flow projected to bypass each basin/inlet shall be provided in the Stormwater Management Report.

2.3.3 Culverts

The purpose of a culvert is to safely convey water from one side of a roadway or embankment to the other. The size and shape of the culvert should be such that it will carry a predetermined design peak discharge without the depth of water at the entrance or the velocity at the outlet exceeding allowable limits.

Section 1105 of the latest edition of the ODOT L&D Manual shall be used to design culverts unless alternative criteria are explicitly stated in this document. Other acceptable design procedures are contained in the FHWA's Hydraulic Engineering Circular No. 5¹⁵ and in FHWA's HY8 model¹⁶. All materials used in construction of roadway culverts shall conform to the City's CMSC.

2.3.3.1 General Requirements

Stream crossings shall be located at a relatively straight and stable section of the stream. The horizontal and vertical alignment of the culvert shall generally follow the alignment of the stream at the crossing. Stream crossings at right angles to the stream are preferred to maximize hydraulic efficiency and minimize environmental impacts. If the skew angle of the culvert exceeds 45°, then either the roadway alignment or the culvert alignment (or both) shall be revised to achieve a skew angle less than 45°.

A single barrel round pipe shall be used where flow, headwater, tailwater, and pipe cover conditions allow. Where round pipes are not feasible, single barrel elliptical, pipe arch, box culvert, and three-sided structures shall be used, in order of preference. Where single barrel

¹⁵ FHWA, Hydraulic Engineering Circular No. 5 *Hydraulic Charts for the Selection of Highway Culverts*, available from the Superintendent of Documents, U.S. Government Printing Office.

¹⁶ FHWA, *Culvert Analysis Microcomputer Program*. FHWA-EPD-87-101.

conduits are not feasible, multi-barreled culverts shall be used to minimize the disturbance to the stream channel and provide capacity for flows within the floodplain to minimize backwater.

2.3.3.2 Culvert Hydrology Requirements

The hydrologic computation methods specified in Section 2.2.1 shall be used to design culverts in the City. Culverts spanning open channels conveying onsite flows shall be designed according to the same method used to design other onsite drainage facilities. Culverts spanning Tier I and Tier II watercourses shall be designed using the regression equations presented in Section 2.2.3.2.

2.3.3.3 Culvert Hydraulic Requirements:

Design Storm Frequency

Table 2-13 provides the design storm frequencies that shall be used to design roadway and other stream crossings:

Table 2-13
Culvert Design Storm Frequency¹⁷

Roadway Type	Design Storm Event
Interstate highways, other freeways, and expressways	50-year
Major arterial (ADT>10000)	25-year
Minor arterial and collectors (ADT 3501 – 10000)	25-year
Locals (ADT ≤ 3500), other parking and development areas	10-year

Types of Culvert Flow

Two types of flow may occur in a culvert: flow with inlet control and flow with outlet control. Designers shall determine the design flow regime for each culvert within the project, and use appropriate design nomographs for the appropriate flow condition, found in the drainage design aids contained in the ODOT L&D Manual.¹⁸

Tailwater Conditions

The designer shall perform hydraulic calculations necessary to determine the depth of flow in the outlet channel when the culvert is discharging the design flow. This determination shall take into account downstream constraints, obstructions, grades, confluences with other streams, or other hydraulic features that may create a backwater at the culvert outlet. The following sources contain information that might aid in establishing downstream tailwater conditions:

- 1) Previous studies that may be on file within the Division of Sewerage and Drainage, or
- 2) Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and data.

The tailwater depth for the design frequency of the culvert shall be used to size the culvert.

¹⁷ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

¹⁸ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

Maximum Allowable Headwater

The headwater depth at the inlet of each roadway culvert shall not exceed any of the following conditions during the design storm listed in Table 2-13:

- 1) 2 feet below the near, low edge of the pavement for drainage areas 1000 acres or greater, and 1 foot below for culverts draining less than 1000 acres,
- 2) 2 feet above the inlet crown of the culvert or above a tailwater elevation that submerges the inlet crown in flat to rolling terrain,
- 3) 4 feet above the inlet crown of a culvert in a deep ravine,
- 4) 1 foot below the near edge of pavement for bicycle pathways, and
- 5) At or below the near edge of pavement for driveway culverts conveying runoff along roadside ditches.

In addition, the peak headwater depth during the 100-year frequency event shall be 1 foot below the finished grade adjacent to any existing or proposed building. Section 2.4 provides additional overtopping requirements related to culverts within major flood routing paths.

Manning's "n" Value

Acceptable materials for culverts, defined in CMSC Section 603, include concrete (non and reinforced), corrugated steel, bituminous corrugated steel, and precast box and concrete sections. With the exception of corrugated metal pipes, a Manning's "n" value of 0.012 shall be used for the hydraulic design of culverts. ODOT L&D Manual Section 1105.5.5 and Figure 1105-2 shall be used to determine acceptable "n" values for corrugated metal pipes.

Entrance Loss Coefficients

Table 2-14 shall be used to define (minor) entrance loss coefficients for culverts under outlet control conditions.

Maximum Allowable Outlet Velocity

The Applicant shall determine the cross-sectional area of flow from the culvert outlet, and use this area, the design flow, and other characteristics of the culvert to determine the outlet velocity at design conditions. If the outlet velocity is larger than the maximum velocity for the channel lining material that is listed in Table 2-17 of Section 2.3.5.1, then erosion protection and/or energy dissipaters shall be required to properly armor the receiving channel and control outlet velocities. Section 2.3.5 provides design requirements for rock protection and recommendations for energy dissipation devices at culvert outlets.

Table 2-14
Minor (Entrance) Loss Coefficients for Culverts under Outlet Control,
Full or Partly Full Entrance Head Loss ^{19, 20}

Type of Structure and Design of Entrance	Coefficient K
Pipe, Concrete	
▪ Projecting from fill, socket end (groove-end)	0.2
▪ Projecting from fill, sq. cut end	0.5
▪ Headwall or headwall and wingwalls	
- Socket end of pipe (groove-end)	0.2
- Square-edge	0.5
- Rounded (radius = 1/2D)	0.2
▪ Mitered to conform to fill slope	0.7
▪ End-section conforming to fill slope	0.5
▪ Beveled edges, 33.7° or 45° levels	0.2
▪ Side – or slope – tapered inlets	0.2
Pipe or Pipe-Arch, Corrugated Metal	
▪ Projecting from fill (no headwall)	0.9
▪ Headwall or headwall and wingwalls square-edge	0.5
▪ Mitered to conform to fill slope, paved or unpaved slope	0.7
▪ End-section conforming to fill slope	0.5
▪ Beveled edges, 33.7° or 45° bevels	0.2
▪ Side- or slope-tapered inlet	0.2
Box, Reinforced Concrete	
▪ Headwall parallel to embankment (no wingwalls)	
- Square – edged on 3 edges	0.5
- Rounded on 3 edges to radius of 1/12 barrel dimension, or beveled edges on 3 sides	0.2
▪ Wingwalls at 30° to 75° to barrel	
- Square-edged at crown	0.4
- Crown edge rounded to radius of ½ barrel dimension, or beveled top edge	0.2
▪ Wingwall at 10° to 25° to barrel, square-edged at crown	0.5
▪ Wingwalls parallel (extension of sides), square-edged at crown	0.7
▪ Side- or slope-tapered inlet	0.2

¹⁹ Water Environment Federation and American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992, pg 156.

²⁰ Federal Highway Administration, *Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5*, Report No. FHWA-IP-85-15, Washington DC, 1985.

Bankfull Design Considerations

The designer shall check that any culvert sized to meet the hydraulic design conditions in this section will also convey the bankfull discharge with minimal change to the bankfull depth of flow in the adjoining channel sections, as compared to existing conditions. The bankfull discharge shall be determined using a field-obtained stream cross-section from a portion of the stream that does not exhibit bank or bed erosion.²¹ If such a cross-section is not available, then the 2-year discharge shall be used to approximate the bankfull discharge. A hydraulic profile through the channel shall be prepared to demonstrate that the culvert does not alter existing water surface elevations at bankfull conditions. If significant changes in water surface elevation are determined, larger pipe sizes and/or alternative pipe shapes shall be used to reduce the impact.

The City also requires that the inverts of culverts at Tier I and Tier II stream crossings be depressed to minimize stream impacts. Depressed inverts shall be filled with substrate necessary for aquatic life to migrate through the culvert. The culvert design shall be based on the remaining pipe diameter and increased Manning’s “n” after the invert has filled with substrate. **Table 2-15** shows the amount of invert depression that should be provided for different sized pipes.

Table 2-15
Allowable Conduit Invert Depression²²

Pipe Diameter or Rise	Depression
< 36 inch	None
36 to 60 inch	6 inches
66 to 120 inch	12 inches
120 to 180 inch	18 inches
186 to 252 inch	24 inches
> 252 inch	30 inches

2.3.3.4 Culvert Layout Requirements

Culverts shall be aligned according to the general criteria in Section 2.3.3.1. It is preferable that the culverts be located at or near the low point of the roadway sag vertical curve to allow for major storm routing across the roadway and along the natural routing path of the existing open channel.

Minimum Pipe Size

Minimum pipe size for roadway culverts shall be based on the fill depth over the crown of the culvert, as specified in **Table 2-16**.

²¹ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

²² Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*, Table 1105-2.

Table 2-16
Minimum Allowable Pipe Size for Various Fill Depths²³

Fill Depth	Roadway Type	
	Freeway*	Other
<8 feet	24 inch	15 inch
8 feet to < 16 feet	30 inch	24 inch
16 feet to < 32 feet	36 inch	30 inch
> 32 feet	42 inch	36 inch

* or other multi-lane facilities with limited or controlled access

Structural and Cover Requirements

The cover and structural requirements for culverts shall be the same as specified for storm sewers in Section 2.3.1.3.

2.3.3.5 Culvert Easement Requirements

Culverts or portions of culverts and ancillary components (e.g., headwalls, endwalls, and erosion protection areas) shall be located entirely within the public right-of-way to provide future access and maintenance.

2.3.4 End Treatments

End treatments are used to dissipate energy and minimize erosion at the inlet and outlet of culverts and storm sewer outfalls. End treatments shall be provided at the inlet and outlet of all culverts (Section 2.3.3), excluding driveway culverts, and at the outlet of all storm sewer systems (Section 2.3.1). The selection of end treatment type is based on safety and economics. Construction of roadway culvert headwalls shall conform to the City's CMSC Sections 602, including Class C concrete for cast in place headwalls according to Sections 499 and 511 and reinforcing steel.

Cast in place pipe culvert endwalls shall be constructed of Class C concrete and designed per City Standard Construction Drawing AA-S165. Cast in place pipe culvert headwalls, 8 to 84 inches in diameter, shall be constructed per City Standard Construction Drawings AA-S166 and 167.

Precast pipe culvert endwalls approved for pipe culverts 8 to 60 inches in diameter, shall be constructed per City Standard Construction Drawing AA-S169. Precast headwalls approved for pipe culverts 8 to 36 inches in diameter shall be constructed per City Standard Construction Drawing AA-S168.

²³ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*, Figure 1002-1.

2.3.5 Outlet Channel Protection

2.3.5.1 Outlet Channel Protection Required

The appropriate channel protection shall be designed to prevent erosion at the outlet of a culvert or storm sewer outfall where concentrated flows generate peak velocities that exceed the maximum allowable velocity for the constructed channel lining materials listed in **Table 2-17**, or the native vegetation that exists within an existing receiving stream during the design storm event. This section provides general design criteria for two categories of outlet channel protection:

- 1) Rock Channel Protection and Riprap Aprons, suitable for outlet velocities up to 20 feet per second.
- 2) Energy Dissipation Devices, suitable for outlet velocities greater than 20 feet per second.

Table 2-17

Maximum Velocities for Channel Lining Materials^{24,25}

Channel Lining Material	Maximum Allowable Velocity (ft/s) [*]
<i>Tier I and II Streams</i>	
▪ Sand	2.0
▪ Silt	3.5
▪ Firm Loam	3.5
▪ Fine Gravel	5.0
▪ Stiff Clay	5.0
▪ Graded Loam or Silt to Cobbles	5.0
▪ Coarse Gravel	6.0
▪ Shales and Hard Pans	6.0
<i>Vegetated Channels (per CMSC 659.09)</i>	
▪ Seed mixtures for urban areas	2.5**
▪ Other seed mixtures	2.5**
▪ Crown vetch	2.5**
▪ Established Seed or Sodded Channels	6.0
<i>Flexible Linings</i>	
▪ Slope Erosion Protection	Follow manufacturer's criteria
▪ Erosion Control Matting	
▪ Rock Channel Protection	Use shear stress analysis
<i>Rigid linings</i> ²⁶	
▪ Concrete	18
▪ Concrete block mat	18

* In addition, the maximum velocity shall not exceed the velocity under critical flow conditions at all depths within the channel up to the design flow depth.

** Velocity assumes newly seeded areas without erosion control matting provided.

²⁴ American Association of State Highway Transportation Officials, *Model Drainage Manual, 3rd Edition*, 2004.

²⁵ Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia*, 5th Edition, 2000.

²⁶ City of Greeley, Colorado, *Stormwater Drainage Design Criteria and Construction Specifications*, 2002.

2.3.5.2 Rock Channel Protection and Riprap Aprons

Riprap aprons (**Figure 2-3**²⁷) may be used as transitions from culverts or storm sewer outfalls to stable channel sections. Riprap aprons are constructed at a zero grade for a distance related to the outlet flow rate and tailwater depth. The use of riprap aprons is restricted to outlet Froude (Fr) numbers less than or equal to 2.5. Riprap aprons are commonly used because of their low cost and ease of installation. Acceptable design procedures for riprap aprons are found in Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia*, 5th Edition, 2000.²⁸

Tailwater depth

The depth of tailwater immediately below the pipe outlet must be determined for the design capacity of the pipe. Manning's Equation may be used to determine tailwater depth. If the tailwater depth is less than half the diameter of the outlet pipe, it shall be classified as a Minimum Tailwater Condition. If the tailwater depth is greater than half the pipe diameter, it shall be classified as a Maximum Tailwater Condition. Pipes which outlet onto flat areas with no defined channel may be assumed to have a Minimum Tailwater Condition.

Apron length

The apron length shall be determined from the curves according to the tailwater condition:

- 1) Minimum Tailwater – Use **Figure 2-4**
- 2) Maximum Tailwater – Use **Figure 2-5**

Apron width

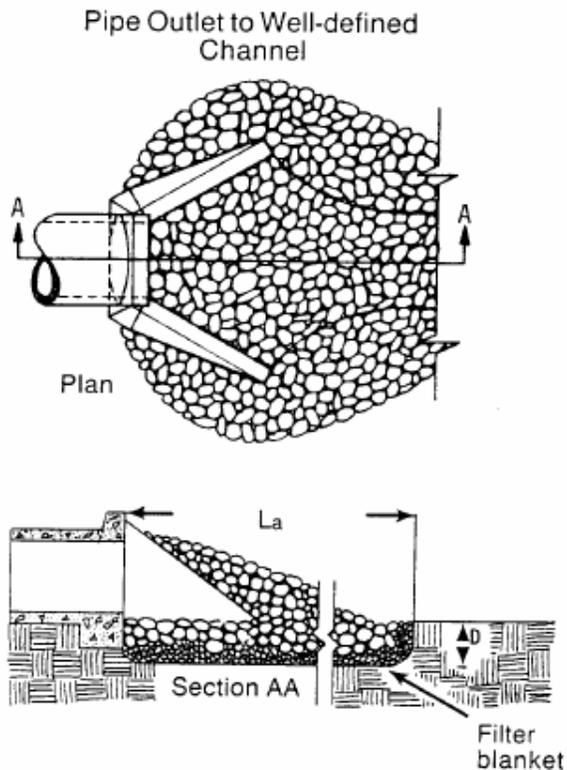
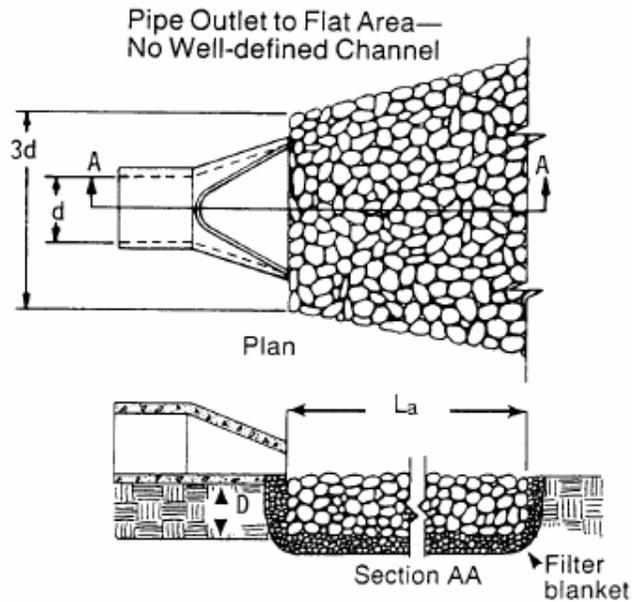
When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less. If the pipe discharges onto a flat area with no defined channel, the width of the apron shall be determined as follows:

- 1) The upstream end of the apron, adjacent to the pipe, shall have a width three times the diameter of the outlet pipe.
- 2) For a Minimum Tailwater Condition, the downstream end of the apron shall have a width equal to the pipe diameter plus the length of the apron.
- 3) For a Maximum Tailwater Condition, the downstream end shall have a width equal to the pipe diameter plus 0.4 times the length of the apron.

²⁷ Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia*, 5th Edition, 2000.

²⁸ Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia*, 5th Edition, 2000.

Figure 2-3
Riprap Apron Detail



Notes

1. L_a is the length of the riprap apron.
2. $D = 1.5$ times the maximum stone diameter but not less than 6".
3. In a well-defined channel extend the apron up the channel banks to an elevation of 6" above the maximum tailwater depth or to the top of the bank, whichever is less.
4. A filter blanket or filter fabric should be installed between the riprap and soil foundation.

Figure 2-4
Design of Outlet Protection – Minimum Tailwater Condition

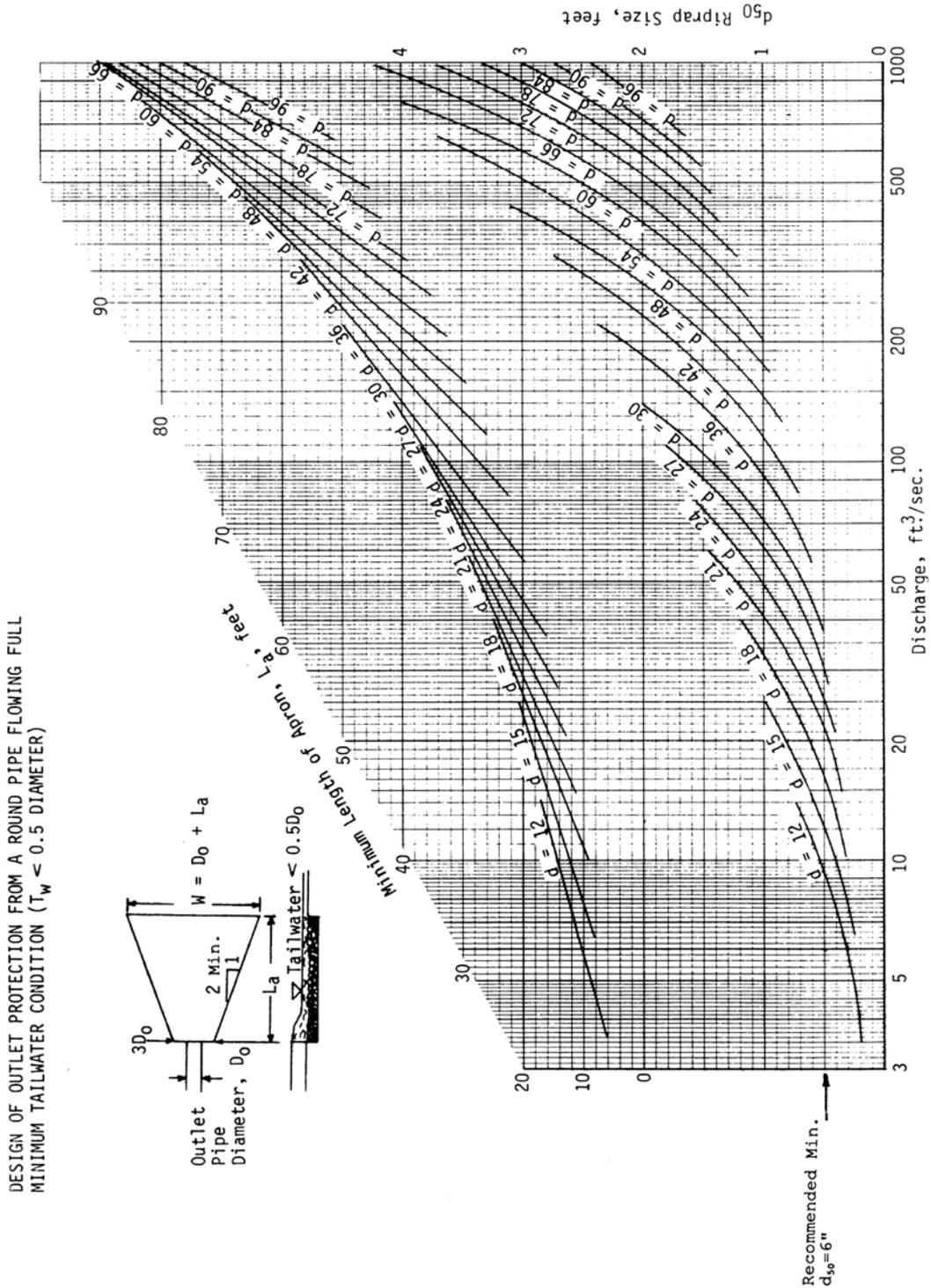
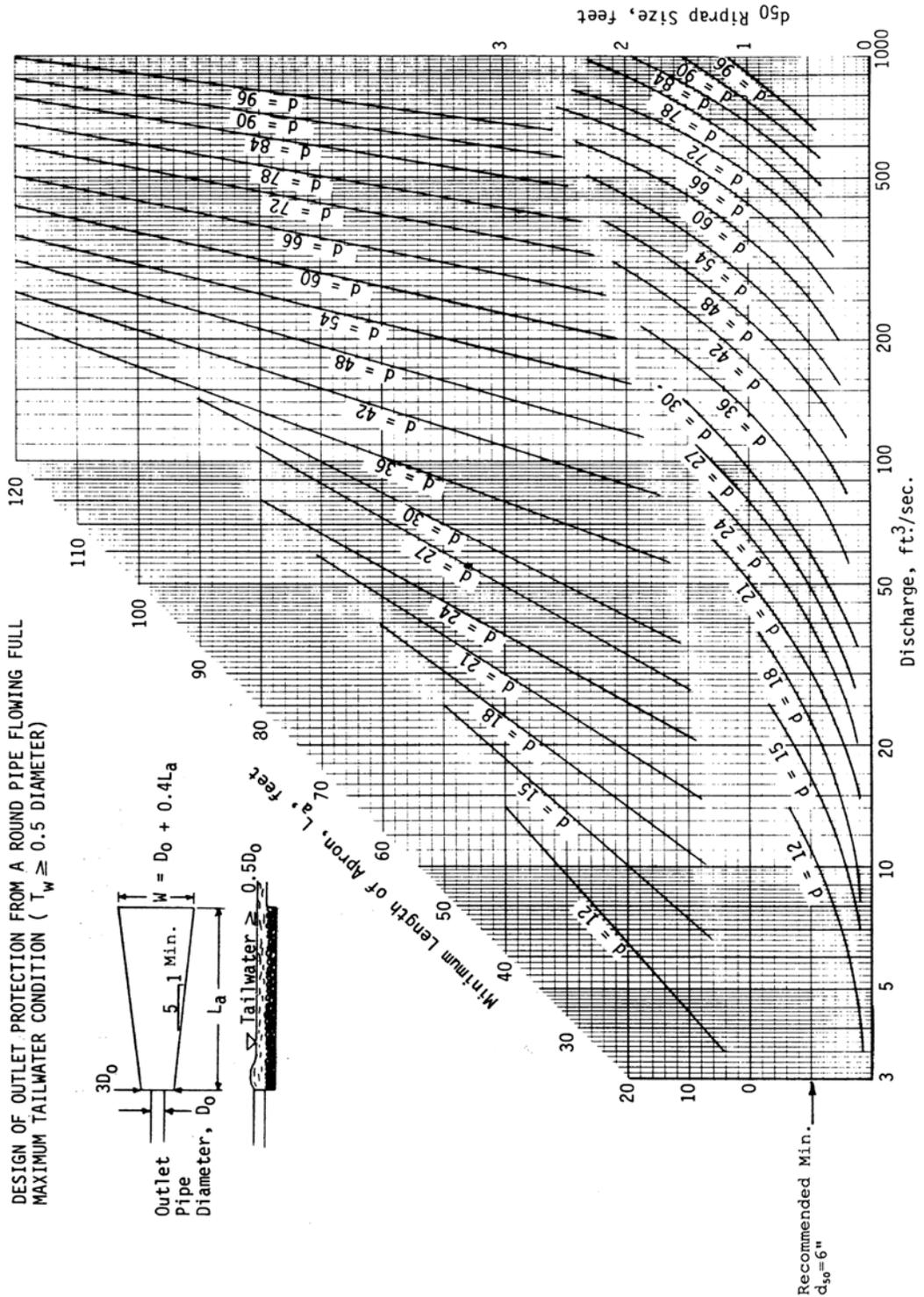


Figure 2-5
Design of Outlet Protection – Maximum Tailwater Condition



Bottom Grade

The apron shall be constructed with no slope along its length (0.0% grade). The invert elevation of the downstream end of the apron shall be equal to the elevation of the invert of the receiving channel.

Side slope

If the pipe discharges into a well-defined channel, the side slopes of the channel shall not be steeper than 2:1 (horizontal: vertical).

Alignment

The apron shall be located so there are no bends in the horizontal alignment.

Materials

The median sized stone for riprap shall be determined from Figures 2-4 and 2-5 according to the tailwater condition. The materials and placement of riprap shall conform to the requirements of the City's CMSC Section 601. At the discretion of the Division of Sewerage and Drainage, the use of flat stones (as referenced in CMSC 601.04) of native material may be used as a streambed liner where it can be demonstrated that the lining will remain stable.

2.3.5.3 Energy Dissipation Devices

Energy dissipation devices²⁹ are required to prevent scour at culvert and storm sewer outlets and minimize potential for downstream erosion whenever the outlet velocity exceeds 20 ft/sec or the outlet discharges under supercritical flow conditions. Since energy dissipaters function by creating a hydraulic jump, performance is dependent on tailwater conditions. If there is potential for high tailwater conditions in the downstream channel and an energy dissipation device is necessary, then the device shall be designed for low tailwater conditions while the downstream channel is sized to account for higher tailwater conditions. Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence. The maximum velocity exiting an energy dissipation device shall not exceed the maximum velocity of the downstream channel lining in Table 2-17.

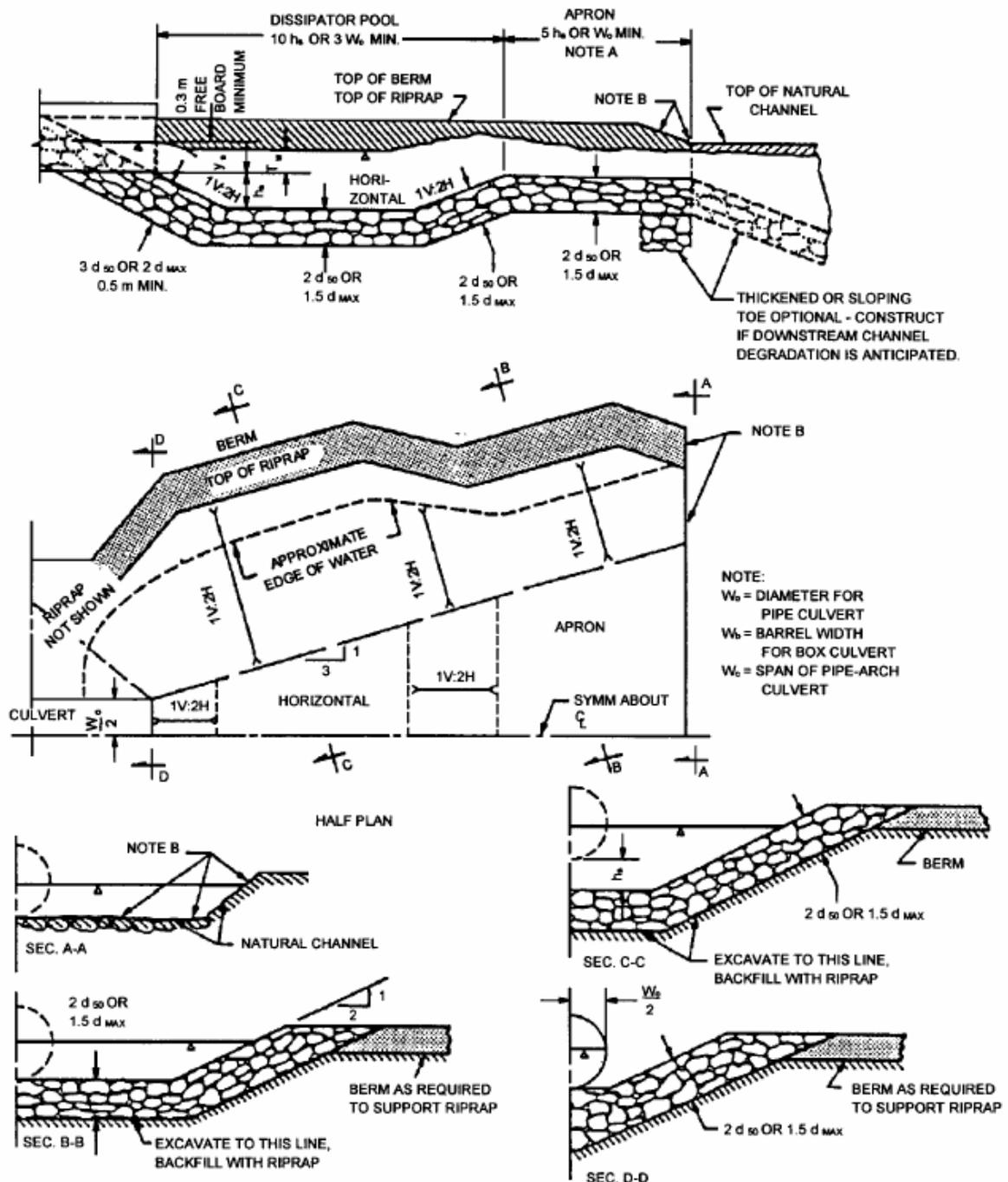
The following sections summarize key design criteria and provide corresponding references for the design of acceptable energy dissipation devices in the City.

Riprap Outlet Basins

One approved method of energy dissipation at storm sewer and culvert outlets is a riprap outlet basin (**Figure 2-6**), which is composed of a dissipation pool and an apron lined with riprap of a median size (d_{50}). The dissipation pool is sized to the approximate depth of scour that would occur in a pad of riprap of size d_{50} if subjected to design discharge, and with a length sufficient to completely contain the hydraulic jump. These structures are generally used for transitions from culverts to stable channels where the Froude Number is less than 2.5. Riprap outlet basins shall be designed according to procedures contained in FWHA's HEC No. 14.

²⁹ Atlanta Regional Commission, *Georgia Stormwater Management Manual*, Volume 2 (Technical Handbook), 1st Edition, August 2001, Section 4.5.

Figure 2-6
Riprap Outlet Basin Detail



NOTE A - IF EXIT VELOCITY OF BASIN IS SPECIFIED, EXTEND BASIN AS REQUIRED TO OBTAIN SUFFICIENT CROSS-SECTIONAL AREA AT SECTION A-A SUCH THAT $Q/(CROSS SECTION AREA AT SEC. A-A) = SPECIFIED EXIT VELOCITY$.

NOTE B - WARP BASIN TO CONFORM TO NATURAL STREAM CHANNEL. TOP OF RIPRAP IN FLOOR OF BASIN SHOULD BE AT THE SAME ELEVATION OR LOWER THAN NATURAL CHANNEL BOTTOM AT SEC. A-A.

2.3.6 Level Spreaders

A level spreader (**Figures 2-8 and 2-9**) is a structure that is designed to convert concentrated flow from stormwater runoff to sheet flow. The purpose of a level spreader is to 1) reduce energy from concentrated flow at stormwater outfalls that might otherwise induce erosion across an area where sheet flow currently exists, and 2) to reduce the depth and velocity of flow such that runoff can be “treated” by a water quality BMP. While level spreaders do offer energy dissipation benefits, they should not be confused with the outlet channel protection and energy dissipation devices in Section 2.3.5 that are typically constructed at the end of outlet pipes within open watercourses.

Level spreaders are appropriate for storm sewers, detention basin outlets, or discharges from impervious areas where the peak flow during the design storm event is less than 30 cfs.³⁰ In instances where concentrated flows from a storm sewer or detention basin outlet exceeds 30 cfs, a constructed open channel conveyance system and/or outlet channel protection shall be provided to a Tier I or II stream. Level spreaders shall be used:

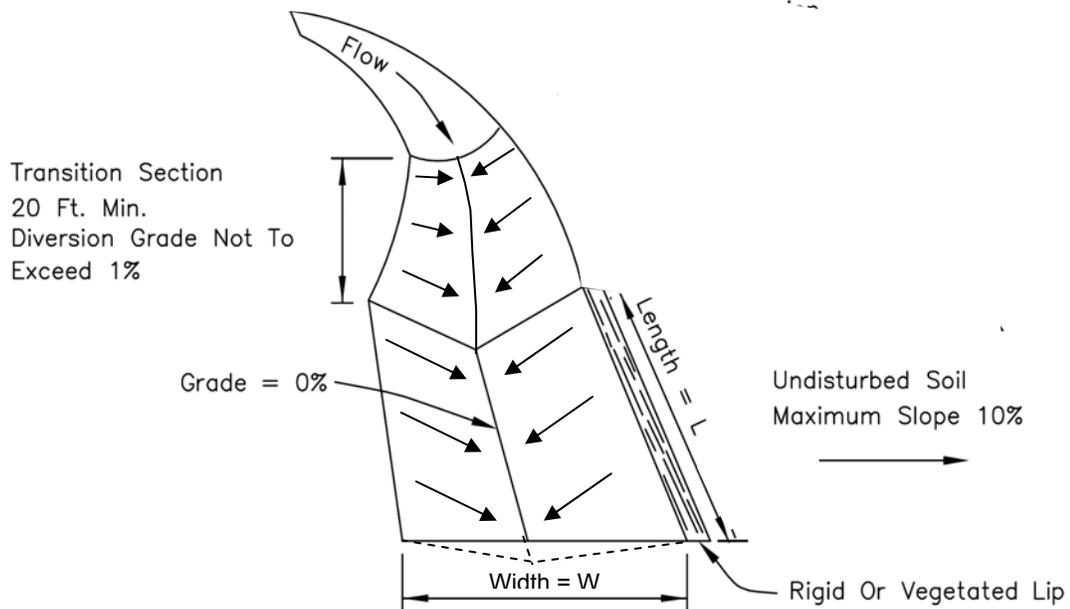
- 1) At the outfall of storm sewers or detention basins where the downstream, offsite, flow regime exists as sheet flow at the time of development. The area immediately downstream of the level spreader must be part of the development or owned by the Applicant.
- 2) At outfalls where concentrated flows less than 30 cfs are directed toward a Tier I or Tier II stream. In such instances, the conversion of concentrated flow to sheet flow shall take place outside of the Stream Corridor Protection Zone. Exceptions may be granted where it can be shown that a concentrated flow regime existed at the outfall point prior to development.
- 3) At outfalls where concentrated flows less than 30 cfs are directed toward an existing wetland system. In instances where the wetland is protected within a Stream Corridor Protection Zone, the conversion of concentrated flow to sheet flow shall take place outside of the Stream Corridor Protection Zone. Exceptions may be granted where it can be shown that a concentrated flow regime existed at the outfall point prior to development.
- 4) Upstream of water quality BMPs (e.g., filter strips; see Section 3.3.6.3) where “treatment” of stormwater runoff is dependent on the velocity and depth of flow.

In addition to the requirements of this section, the following references provide further guidance on the evaluation, planning, and design of level spreaders:

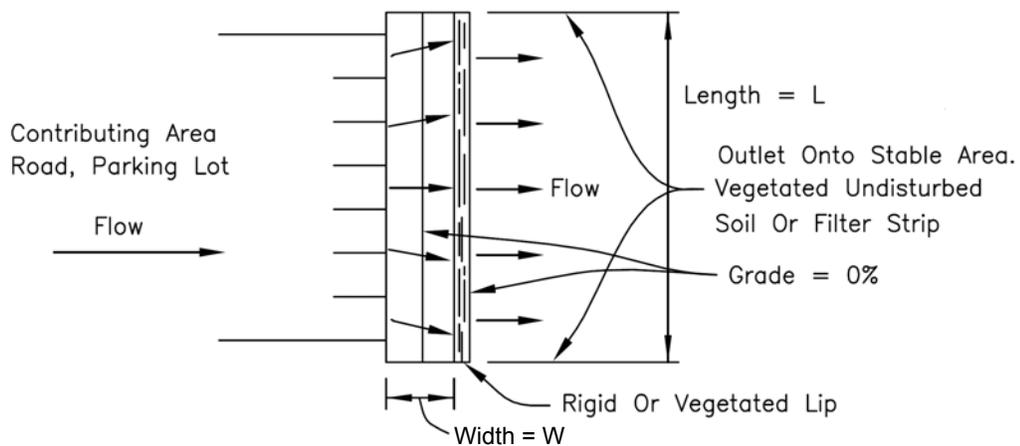
- 1) Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement, prepared for the Illinois EPA by Illinois NRCS;
- 2) Ohio Rainwater and Land Development Manual, Second Edition 1996; NRCS Design Note 24, Guide for Use of Geotextiles.

³⁰ Ohio Department of Natural Resources, *Ohio's Rainwater and Land Development Manual*, 2nd Edition, 1996, Section 2.

Figure 2-8
Typical Level Spreader Applications³¹



LEVEL SPREADER FOR CONCENTRATED FLOW



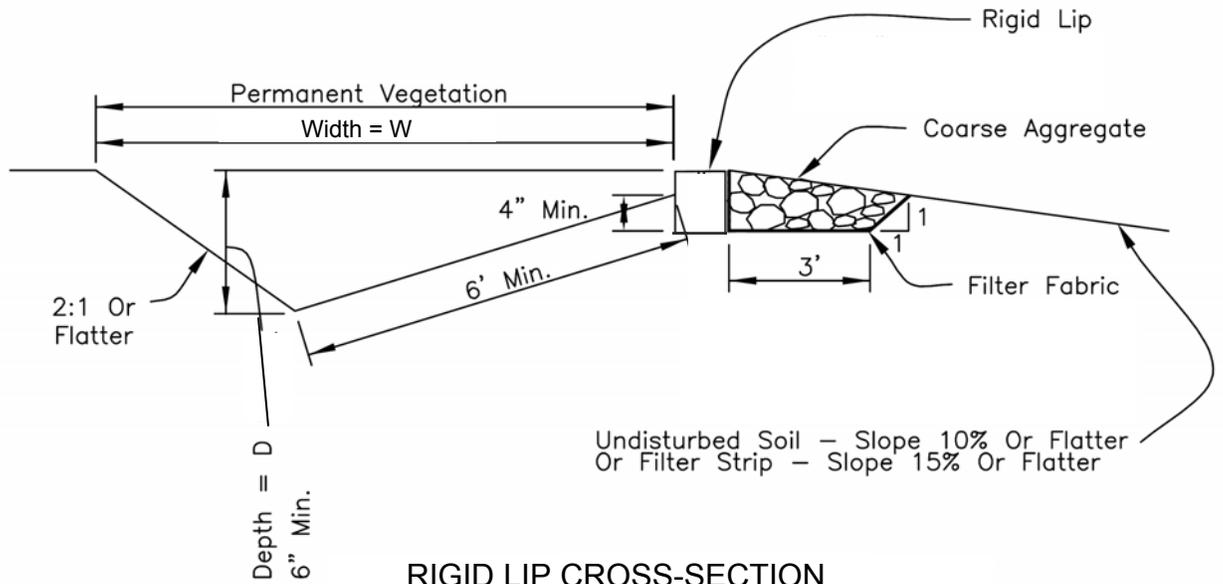
LEVEL SPREADER FOR IMPERVIOUS AREAS

NOTES:

1. Ends of spreader shall be tied into higher ground to prevent flow around the level spreader.
2. See plans for L and W dimensions.

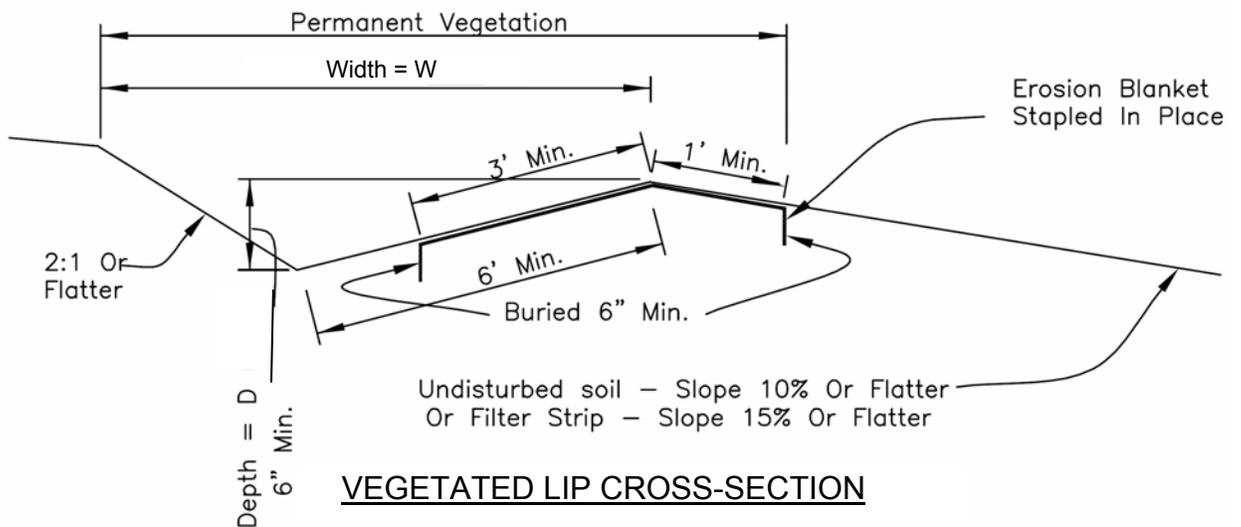
³¹ United States Department of Agriculture, Natural Resources Conservation Service, *Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement*, prepared for the Illinois EPA by Illinois NRCS.

Figure 2-9
Level Spreader Details³²



RIGID LIP CROSS-SECTION

(DESIGN FLOWS 4 C.F.S. TO 30 C.F.S.)



VEGETATED LIP CROSS-SECTION

(DESIGN FLOWS 4 C.F.S. OR LESS)

³²United States Department of Agriculture, Natural Resources Conservation Service, *Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement*, prepared for the Illinois EPA by Illinois NRCS.

2.3.6.1 Layout Requirements

Level spreaders shall be located and designed so that the runoff water can be released in sheet flow down a stabilized slope and will not re-concentrate after release from the level spreader until it reaches an outlet designed for concentrated flow (see Section 2.2.2.2 for guidance on allowable overland flow lengths). Areas immediately downstream of level spreaders should be densely vegetated with a slope of less than 10 percent to avoid gully formation. Level spreaders shall be located in areas where the level lip of the spreader is not likely to be compromised by the settlement of unstable soils or traffic loadings.

2.3.6.2 Level Spreader Sizing

The length and depth of the spreader shall be determined from **Table 2-18**³³. The minimum width (W) is in the direction that is perpendicular to the level weir. The minimum depth (D) of the level spreader shall be at least 0.5 feet measured down from the level lip. The depth may be greater to increase temporary storage capacity, improve trapping of debris, and enhance settling of any suspended solids.

Table 2-18
Level Spreader Dimensions

Flow Rate (cfs)	Minimum Depth – D (ft)	Minimum Width – W (ft)
0 – 10	0.5	10
11 – 20	0.6	20
21 – 30	0.7	30

The level lip of the spreader must be constructed at zero percent grade to ensure uniform spreading of the runoff over the entire length of the spreader. The ends of the spreader shall be tied into higher ground to prevent flow around the spreader. Side slopes within the spreader shall be 2 to 1 (horizontal to vertical) or flatter.

2.3.6.3 Level Spreader Materials

Depending on the expected design flow, the level spreader lip may be constructed of vegetated or rigid, non-erodible materials. The following defines the appropriate application and requirements for each³⁴:

Vegetated Level Spreaders

For peak design flows less than or equal to 4 cfs, the level spreader lip may be vegetated. The spreader lip shall be constructed on undisturbed soil and protected using an erosion control

³³ Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement, prepared for the Illinois EPA by Illinois NRCS.

³⁴ Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement, prepared for the Illinois EPA by Illinois NRCS.

blanket (jute mesh or excelsior blanket). The erosion control blanket shall be installed according to the manufacturer's recommendations. The blanket shall start a minimum of 4 feet above the lip and extend at least 1 foot downstream over the spreader lip. The blanket shall be secured with heavy duty staples, and the downstream and upstream sides shall be buried at least six inches in a vertical trench.

Rigid Level Spreaders

For design flows greater than 4 cfs, the level spreader lip must be constructed of a rigid, durable, non-erodible material (e.g., pressure-treated timber, concrete, precast block, or geosynthetic materials) anchored securely at least four inches below existing ground to prevent displacement. An apron of coarse aggregate shall be placed adjacent to and downstream from the rigid lip. The top of the aggregate shall be at the same elevation as the top of the lip.

Transition Zone of Level Spreader for Concentrated Flow

When used to convert concentrated flow into sheet flow (e.g., below a storm sewer or detention basin outlet), the transition zone must be stabilized using an appropriate form of outlet protection (Section 2.3.5).

2.3.6.4 Maintenance

A maintenance plan shall be established to maintain the level spreader, its capacity, vegetative cover, and other connected structural components such as inlets, outlets, and tile lines which are tied to the same stormwater management system. Owners of level spreaders will be held responsible for damage to downstream or nearby property as a result of poorly designed or maintained level spreaders. Maintenance program items for level spreaders are summarized in Appendix E.

Easements shall be provided around level spreaders that are to be publicly owned and maintained. The width of easements shall include the area of the structure plus 10 feet around the structure's perimeter.

2.3.7 Open Watercourses

The requirements in this section are applicable to newly constructed open watercourses that are intended to convey flow to stormwater inlets, stormwater control facilities, Tier I/II streams, lakes, wetlands, or other water bodies during precipitation events. A constructed channel shall be shaped or graded to the required dimensions and established with a suitable lining as necessary to convey stormwater runoff without allowing channel erosion. The following guidance documents may be used for evaluation, planning, and design of constructed open watercourses to supplement the design criteria provided in the Manual:

- 1) NRCS Ohio Practice Standard 412, Grassed Waterways,
- 2) NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7 - Grassed Waterways,
- 3) Agricultural Handbook 667, Stability Design of Grass-lined Open Channels, and

- 4) Federal Highway Administration, 1988, Design of Roadside Channels with Flexible Linings. Hydraulic Engineering Circular No. 15.

2.3.7.1 Channel Hydrology Requirements

The hydrologic computation methods specified in Section 2.2.1 shall be used to design open watercourses in the City. In most cases, open watercourses shall be designed according to the same method used to design other onsite drainage facilities.

2.3.7.2 Channel Hydraulic Requirements

Design Storm Frequency

Constructed open watercourses shall be designed to convey the 10-year design storm without causing erosion, sedimentation, or overbank flooding within and along the channel. Criteria in Section 2.4 shall be used if the channel will also serve as a flood routing channel for the 100-year design storm. Open watercourses may also be designed for stormwater quality control using criteria provided in Section 3.3.6. ODOT's L&D Manual, Drainage Design aids may be used for sizing open conveyances (at various side slopes). A ditch computation sheet (included in Appendix C) shall be used to present open channel calculations.

Cross Section Shape

Parabolic and trapezoidal channel shapes (**Figure 2-10**) shall be used for open watercourses within development projects. Side slopes shall be 3(H) to 1(V) or milder, with a minimum 2-foot bottom width for trapezoidal channels, unless alternative dimensions are approved by the City due to specific project conditions. Channel cross sections shall be designed such that erosion and sediment deposition is minimized.

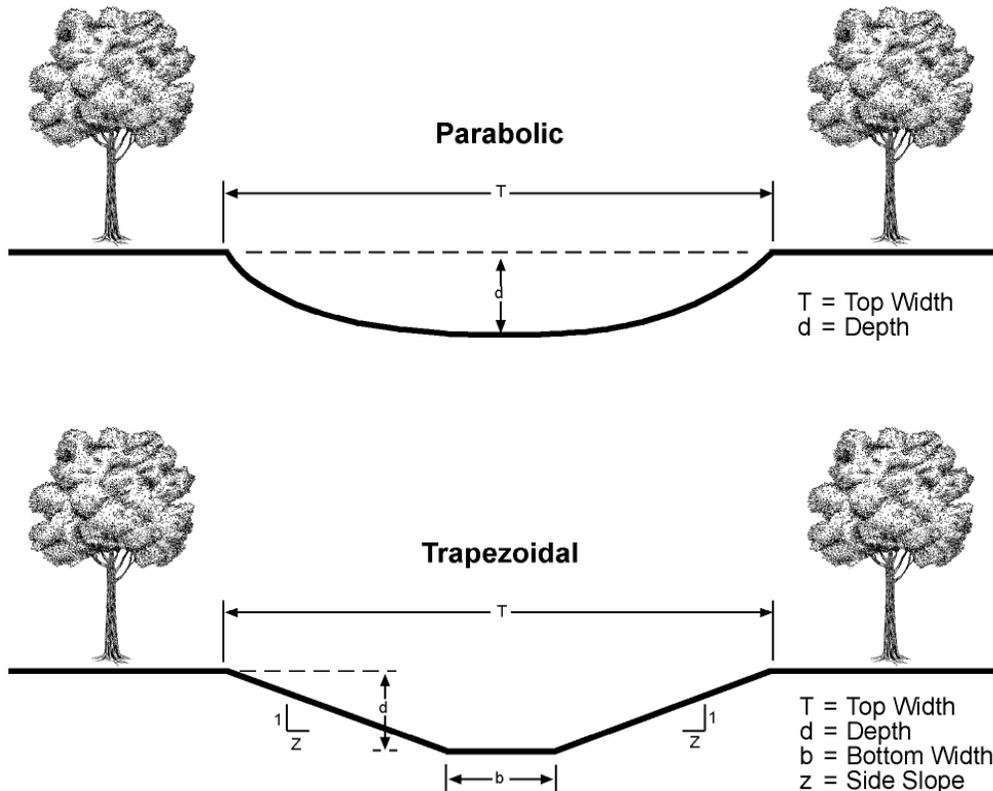
Design Velocity

An open channel is categorized by its lining. There are three main types of channel linings: vegetated, flexible, and rigid. A vegetative lining, such as grass with mulch and sod and lapped sod, is required where site constraints and flow velocity conditions allow. Flexible linings include rock channel protection and cellular soil retaining mats and are typically less expensive than a rigid lining. The use of flexible linings, however, may require the installation of a filter fabric or other means to protect the underlying soil, prevent washout, and prevent soil piping through the rock when using channel protection. Rigid linings include concrete and rigid block and are usually used where high velocities are unavoidable.

Final design of constructed open channels should be consistent with velocity limitations for the selected channel lining. Maximum velocity values for selected vegetated and non-vegetated lining categories are presented in Table 2-17. The Manning's Equation shall be used to design an open channel that satisfies the maximum velocity criteria in the previous sections:

Figure 2-10

Parabolic and Trapezoidal Channel Shapes for Open Watercourses



$$v = (1.49/n) R^{2/3} S^{1/2}$$

where:

- v = average channel velocity (ft/s)
- n = Manning's roughness coefficient
- R = hydraulic radius (ft)
= A/P
- A = cross-sectional area of the channel (ft²)
- P = wetted perimeter of the channel (ft)
- S = slope of the energy grade line (ft/ft)

Recommended Manning's "n" values for open channels with vegetated and non-vegetated linings are provided in **Table 2-19**.

Critical Flow

Open channels shall be designed to flow under subcritical flow conditions at all times. A subcritical flow regime is characterized by a Froude Number less than 1:

Table 2-19

Manning's Roughness Coefficients (n) for Vegetative and Artificial Channels ³⁵

Channel Lining Category	Roughness Coefficient
Vegetated Lining:	
Seeded	0.03 (for velocity determination only without erosion control matting on all channels) 0.04 (for depth determination along roadside channels only) 0.06 (for depth determination, except along roadside channels)
Sod	0.04 (for velocity determination on all channels) 0.04 (for depth determination along roadside channels only) 0.06 (for depth determination, except along roadside channels)
Flexible Lining:	
Slope Erosion Protection	0.04
Erosion Control Matting	0.04
Grouted riprap	0.02
Rock channel protection (Typical for Type C/D*)	
Small channels/ditches	0.06
Large channels	0.04
Rigid Lining:	
Concrete	0.015
Bituminous	0.015
Concrete block mat (tied)	0.021

* Note: Increase roughness coefficient by 15% for Type B RCP.

$$F = V / (gD)^{0.5} < 1$$

where:

- F = Froude Number
- D = hydraulic depth (ft)
= A / T
- A = cross-sectional area of flow (ft²)
- T = top width of water surface (ft)
- V = flow velocity (ft/sec)
- g = acceleration due to gravity
= 32.2feet/sec²)

³⁵ Adapted from Federal Highway Administration, *Hydraulic Engineering Circular 15*, 1998. Reported in Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

The Stormwater Management Report shall demonstrate that the calculated Froude Number is less than 1 over the anticipated range of flow conditions within the channel.

Rock Channel Protection Shear Stress Analysis³⁶

Type B, C or D rock channel protection shall be provided in accordance with CMSC Section 601.08. Type B, C or D rock channel protection shall only be placed outside of guardrails, barriers or other unobstructed areas provided outside of the traveled way for vehicles to stop safely or regain control. The actual shear stress (τ_{ac}) must be less than or equal to the allowable shear stress (τ_a) listed in **Table 2-20** for the rock channel protection type used. The actual shear stress shall be determined for the channel slope and the depth of flow during a 10-year design storm. The following equation is valid for discharges less than 50 cfs and with slopes less than 10%:

$$\tau_{ac} = 62.4 * D * S$$

where:

D = depth of flow (feet)

S = channel slope (feet/feet)

τ_{ac} = actual shear stress (lbs/feet²)

Table 2-20

Allowable Shear Stress for Rock Channel Protection

Type of Rock Channel Protection	τ_a (lbs/feet ²)
B	6
C	4
D	2

In extreme site conditions, Type B or C rock channel protection shall be utilized for lining channels with steep grades (slopes 10%-25%) that carry flow from the end of a cut section down to the lowest elevation on the bottom of the channel. FHWA’s HEC-15 procedures for steep gradient channels shall be used with a safety factor of 1.5. The Division of Sewerage and Drainage shall be consulted if rock channel protection is proposed in instances where the peak flow during the 10-year design storm is greater than or equal to 50 cfs.

Outlets

All constructed open watercourses shall have a structurally sound and stable outlet with adequate capacity to prevent ponding or flooding damage. Portions of open water courses affected by back water from Tier I or Tier II streams during dry weather flow conditions shall be provided with a stable outlet as specified in Section 2.3.5.

2.3.7.3 Constructed Open Watercourse Easement Requirements

Constructed open watercourses that are to be publicly owned and maintained and lie outside the public right-of-way, shall be provided with an easement that includes:

- 1) The full width of the channel as measured from top-of-bank to top-of-bank plus ten feet on one side, or
- 2) A minimum width of 20 feet centered along the watercourse, whichever is greater.

³⁶ Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*.

Where onsite constructed open channels are designed to serve as a major flood routing path for offsite flows through the development, easement widths shall be extended to include the total flow width for the 100-year event.

2.4 Design of Major Stormwater Routing Systems

Major storm routing paths shall be provided to convey stormwater runoff that exceeds the capacity of the minor drainage system through the development to a Tier I or Tier II stream. The major storm routing path shall be designed such that the peak flood stage during the 100-year design storm is at least one-foot below the first floor elevation of the structures within and adjacent to the development. The major storm routing path shall begin along swales located between structures that drain individual properties, be directed to either roads, other public rights-of-way, or constructed open watercourses through the development, to the stormwater detention facility serving the development. This detention facility shall be designed to control the 100-year event without overtopping its embankment, according to criteria in Section 3.1.

A hydraulic analysis shall be required to verify that the peak water surface elevation during the 100-year design storm meets the design criteria cited in this section. For preliminary design purposes, the flow in the minor drainage system during the 100-year design storm event shall equal the design capacity of the minor system.

Where streets are designated as the major routing path, the depth of water shall not exceed 18 inches (to allow access for emergency vehicles) at gutter line for local and collector streets³⁷. The depth of water shall not exceed a 6-inch depth at the crown for arterial streets. This maximum depth criterion shall also apply where a major storm routing path crosses a street. The use of normal flow depths derived using the Manning's Equation will suffice for estimating inundation limits along streets. At culverts, the major storm shall be designed to flow across streets at low areas or in sags of vertical curves. Street elevations shall be set to permit the major storm to flow across the street and to prevent damage to any existing or proposed building structure. Backwater calculations shall be performed along Tier I or Tier II streams where a roadway crossing over these streams is proposed as part of the development. The backwater analysis shall proceed upstream from the roadway crossing to the boundary of the development site.

Where a major drainage way is located outside of a street right-of-way, easements shall be provided as defined in Section 2.3.7.3. The 100-year flood routing path shall be shown on the master drainage plan that is to be submitted with the Stormwater Management Report, as described in Section 6. Routing path illustrations shall include elevations along the routing path and other elevations necessary to show that the major storm is contained within the planned area and dedicated easements.

³⁷ Water Environment Federation & American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992.

A downstream analysis conducted according to the criteria in Section 2.1.3 shall be used to define the major storm routing path between the development and the nearest Tier I or Tier II stream. The City may, at its discretion, require additional detention and/or downstream improvements to provide an adequate major storm routing path downstream of the development.

Stormwater Drainage Manual



Part I
Section 3

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Section 3

Stormwater Controls

This section provides criteria and guidance for the successful design of facilities that control stormwater discharges from development and redevelopment projects to prevent flooding, streambank erosion, and water quality impairment in downstream areas. Separate design criteria are provided for stormwater quantity and quality control facilities; however, in many cases quantity and quality controls are integrated into a single facility. This section provides criteria in five major sections:

- 3.1 General Criteria
- 3.2 Stormwater Quantity Controls
- 3.3 Post-Construction Stormwater Quality Controls
- 3.4 As-Built Surveys
- 3.5 Construction Stormwater Quality Controls

3.1 General Criteria

Stormwater runoff generated from onsite areas shall be controlled before it is released from the development site. Stormwater management reports or construction plans will not be approved until it is demonstrated that the onsite runoff will be controlled in a manner that is consistent with the criteria in this section. At a minimum, the following criteria shall apply to all stormwater controls described in Sections 3.2 and 3.3.

- 1) Stormwater control facilities shall not be located within the Stream Corridor Protection Zone defined using criteria in Section 1.3 of the Manual.
- 2) Stormwater control facilities shall not be located within designated Federal Emergency Management Agency (FEMA) floodplain boundaries
- 3) Discharges from stormwater control facilities shall be directed into an approved Tier I or Tier II stream, either directly as sheet flow from a level spreader, or via a storm sewer or open channel conveyance system, according to criteria in Section 2.1 of the Manual.
- 4) Stormwater runoff shall not be diverted from an existing naturally occurring wetland that is preserved according to City criteria in Section 1.5 and that is not approved for filling and/or removing (as necessary) via an approved Section 404 permit issued by the U.S. Army Corps of Engineers. Wetland hydrology shall be sustained to the extent possible. The quantity and quality of this runoff shall be controlled prior to its release to the wetland system according to criteria in Section 3.2 and 3.3 of the Manual.

3.2 Stormwater Quantity Controls

Stormwater quantity control facilities shall be designed to control runoff from small, moderate, and large storm events before it is discharged offsite. The design criteria provided in this section are intended to minimize flooding downstream of the development site and to reduce streambank erosion. The stormwater management report for the project, prepared according to

the guidelines and criteria in Section 6, shall show the location of the stormwater quantity control facilities and calculations defining how they were sized.

3.2.1 Stormwater Quantity Control Exemptions

Stormwater quantity controls will not be required in the following instances:

- 1) The construction, enlargement, or location, on a permanent foundation, of one single-family residence, one two-family residence, one three-family residence or an accessory structure appurtenant to either a single-family or two-family residence, on a single lot that is not part of a larger common plan of development.
- 2) Single-family residential development sites that are less than one (1) acre in size and not part of a larger common plan of development.
- 3) Runoff from a development is controlled by a regional stormwater facility in place at the time of development and adequately sized to serve the development area.

See Section 3.3.1.1 to determine if the development is exempt from stormwater quality controls.

3.2.2 Hydrologic Requirements

The volume and distribution of rainfall for the storm events to be used for quantity control calculations shall be developed using the 24-hour rainfall intensity from Figure 2-1. This intensity shall be converted into a rainfall volume by multiplying it times 24 hours. The design rainfall hyetograph shall be developed by distributing this volume over the 24-hour period with the SCS Type II distribution (Table 2-3), as described in Section 2.2.2.1. Stormwater quantity control facilities shall be designed using one of the hydrograph methods defined in Section 2.2.4.

Unless otherwise exempted under the criteria in Section 3.1, onsite facilities to control post-development stormwater runoff from residential, commercial, and industrial development sites shall be designed according to the methodology presented below, which is derived from the critical storm method.¹ Under this methodology the percent increase in post-development runoff volume from a site during a 1-year storm event shall be calculated in the following manner to determine the critical storm event:

- 1) 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, using the methodology in Section 2.2.4.
- 2) Determine the percent of increase in runoff volume due to development. Using this percentage, select the critical storm from **Table 3-1**.

¹ Mid-Ohio Regional Planning Commission, "Stormwater Design Manual", June 1977.

Table 3-1
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

Runoff from storm events less than or equal to the critical storm event shall be released from the site at a rate no greater than the peak runoff during a 1-year storm event under pre-developed conditions². Additionally, the peak runoff rate during the 100-year storm event shall be released at a rate less than or equal to the peak runoff rate during the 10-year storm event under pre-developed conditions (where the critical storm is more frequent than a 100-year storm).

The Administrator, or the Administrator's designee, reserves the right to require more stringent stormwater controls if it is determined that flood control benefits can be achieved in downstream portions of the watershed where flooding problems have been identified as existing prior to the proposed development. To encourage the redevelopment of existing developed parcels within the City, the Division of Sewerage and Drainage will consider less stringent stormwater quantity controls than those required in this section so long as the volume of stormwater generated from the site after redevelopment is not increased. The SWMS will work with Applicants on a case-by-case basis to identify opportunities where a reduction in stormwater flow can be achieved on redevelopment projects while allowing the parcel to be utilized for its intended purpose.

² For development sites discharging into a field tile system, the release rate for any storm up to and including the critical storm event shall be the equal to the development's fair-share of the field tile's full-flow capacity. Refer to Section 2.1.4 for more information. In no instance shall the release rate for any storm, up to and including the critical storm event, exceed the 1-year storm event under pre-developed conditions.

3.2.3 Acceptable Methods and Criteria

Stormwater quantity controls provide temporary onsite storage to detain runoff and control downstream flooding. The City allows the following stormwater quantity control facilities:

- 1) Dry Detention Basins (those that drain completely dry after a precipitation event),
- 2) Wet Detention Basins (i.e., those with a permanent pool),
- 3) Parking Lot Storage,
- 4) Underground Tank Storage, and
- 5) Green Roof Technologies.

The general criteria presented in Section 3.1 apply to all of these types of controls. In addition, the following specific criteria apply to each type of facility. Where a single facility is designed to provide stormwater quantity and quality control, appropriate criteria from this section and Section 3.3 shall apply. The Division of Sewerage and Drainage may give consideration to the use of other stormwater quantity control technologies provided they meet the requirements of this section.

3.2.4 Dry and Wet Detention Basins

Detention basins are one method used to meet the peak flow control (allowable post-development runoff rate) requirements for a site. Their design may also include features to control water quality, as defined in Section 3.3.4. In instances where detention basins are utilized to provide water quantity and water quality controls, peak flow rate and drawdown time criteria for both water quantity and water quality shall be met.

3.2.4.1 General Requirements for All Detention Basins

All proposed dry and wet detention basins shall be designed according to the general criteria in this section, as well as the specific criteria for stormwater quantity basins (in Sections 3.2.4.2 and 3.2.4.3), stormwater quality basins (in Section 3.3.4), or both.

Layout and Geometry Requirements

The following criteria shall be used to define the layout and geometry of all stormwater quantity and quality detention basins in the City:

- 1) Detention basins shall not be located on uncompacted fill, on slopes 2 (H) to 1 (V) or greater, or where infiltrating groundwater could adversely impact slope stability.
- 2) Detention basins shall be designed such that they readily accommodate flow from a site's major flood routing path(s) (see Section 2.4). Overland flow from a site shall be directed to a site's detention basin(s), to ensure that site runoff is controlled.

- 3) The basin shall be designed with an emergency spillway for storms that exceed the 100-year, 24-hour storm event. The emergency spillway shall be designed to direct the flow to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet other pertinent Ohio Dam Safety requirements.
- 4) The basin shall be designed so that the peak water surface elevation in the basin does not overtop the basin embankment or flood structures around the basin. **Table 3-2** provides the peak water surface requirements for basins with different design intent.
- 5) Side slopes within and adjacent to the basin shall be 4 (H) to 1 (V) or flatter to prevent bank erosion and minimize safety risks when the basin is full. The maximum cross slope for the vehicle access way shall be 10 (H) to 1 (V).
- 6) Detention basins shall be designed to limit the migration of groundwater from the basin towards sanitary sewers and building basements. In these cases, the City may require that a geotechnical analysis of the area be performed where the basin is proposed so that groundwater controls may be properly incorporated into the design. If the geotechnical analysis determines that exfiltration from the basin may increase infiltration into sanitary sewers or basements, then the facility design shall include compacted clay or a synthetic liner.
- 7) The Applicant shall submit preliminary design information to ODNR as necessary to determine the regulatory classification (Class I through Class IV) of any impoundment structures (e.g., dams, berms, embankments, levies) under Ohio dam safety regulations, and shall provide the City with documentation of ODNR’s determination of the

Table 3-2

Peak Basin Water Surface Elevation Requirements

Basin Design Criteria	Peak Water Surface Elevation(1)
Water Quality Only – Larger Storms Bypassed	Peak water surface elevation during WQ _v must be 1 foot below the basin embankment elevation and the first floor elevations of structures near the basin.
Water Quantity – No Dam Safety Requirements (2)	Peak water surface elevation during the 100-year design event must be 1 foot below the basin embankment elevation and the first floor elevations of structures near the basin.
Basins Subject to Dam Safety Requirements (2)	Peak water surface elevation must satisfy Ohio dam safety requirements and be 1 foot below the floor elevation of structures during the 100-year design event. Refer to ODNR requirements.

Note:

(1) Requirements for a 1-foot freeboard will be waived if the detention basin is to outlet directly to a Tier I or Tier II stream. In such instances, the first floor elevations of structures near the basin must be at least 1 foot above the top of the basin embankment.

(2) Section 1521.06 of the Ohio Revised Code lists those dams and embankments that are exempt from dam safety requirements.

structure's classification All impoundment structures that require a dam safety permit from ODNR (Class I through III impoundment structures) shall provide sufficient design information in the Stormwater Management Report to demonstrate that dam safety permit requirements will be satisfied, including a description of the fill materials, required compaction, and other features provided to satisfy ODNR dam safety requirements, limit seepage through the impoundment structure, and protect the integrity of the structure. An as-built certification of the fill compaction shall be provided when construction is complete.

- 8) All inflow pipes to the detention basin that are not entirely submerged below the permanent pool elevation shall be designed with headwalls or endwalls according to criteria in Section 2.3.4. Rock channel protection designed according to criteria in Section 2.3.5 shall be used to minimize erosion around the headwall or endwall, as well as along the side slopes of the basin under each inflow pipe or open channel.
- 9) If inflow to the facility is conveyed through an open watercourse, including a major storm routing path (Section 2.4), the open channel conveyance system shall be designed in accordance with Sections 2.3.5 and 2.3.7. Channel protection shall be provided along any reaches within 20 feet of the 100-year high-water mark of the basin, or to the edge of the easement (for publicly maintained basins) surrounding the basin, whichever is wider. Channel protection shall be designed according to criteria in Section 2.3.5 and shall be used where the peak flow velocity during the 10-year, 24-hour design storm exceeds the criteria for grass watercourses as presented in Section 2.3.7. Such protection shall extend to the basin's bottom or 2 feet below the normal water elevation of any permanent pool.
- 10) Woody vegetation may not be planted or allowed to grow on the embankment, within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the basin is encouraged to provide shade and moderate surface water temperatures.
- 11) Permanent stormwater quantity control basins, as defined herein, may be used as temporary sedimentation basins designed to control sedimentation during construction as long as collected sediments are removed, the design grade of the facility is restored, permanent vegetation is established, the temporary outlet is removed, and permanent outlet structure is constructed as designed. In instances where vegetation is not established, additional measures shall be taken to ensure that the area is stabilized, including providing additional topsoil, additional seeding and mulching, or providing sodding in the areas where sparse ground cover occurs.

Debris Control Requirements

Debris control structures (trash racks) for both wet and dry basins may be required at the basin outlet if the potential exists for large debris to enter the detention basin through an open watercourse or large diameter inlet pipe. Debris control structures shall be designed using Hydraulic Engineering Circular No. 9, available from the U.S. Department of Transportation, Federal Highway Administration.

Outlet Facility and Outfall Protection Requirements

- 1) The detention basin shall be designed with an outlet control structure sized to meet the stormwater quantity control requirements presented in Section 3.2.2, the stormwater quality control requirements presented in Section 3.3, or both.
- 2) Seepage along any structure that extends through the embankment to the downstream slope shall be controlled using an anti-seep collar or drainage diaphragm. The collar/diaphragm shall be aligned approximately parallel to the centerline of the stormwater basin or approximately perpendicular to the direction of seepage flow, extending horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation. Appropriate criteria for establishing the minimum horizontal and vertical distances from the surface of the conduit may be obtained from NRCS Technical Release 60, Amendment 1 pg 6-7, dated January 1991, or NRCS Technical Note 709 - Dimensioning of Filter-Drainage Diaphragms for Conduits According to TR-60, dated April 1985.
- 3) Open channels receiving discharges from the facility shall be protected with rock channel protection designed according to criteria in Section 2.3.5 of the Manual.
- 4) The outlet structure shall be sized to achieve the release rates required under Section 3.2.2 and 3.3.4. This outlet shall be designed to resist plugging by meeting the following criteria. The City shall not allow a single orifice outlet to be used for a dry detention basin that is less than 4 inches in diameter. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller orifice diameter shall be permitted upon City approval if acceptable design practice is proven for site conditions. For basins that do not have micropools or permanent pools, single orifices shall be adequately protected from clogging by an acceptable external trash rack.
- 5) The detention basin outlet structure shall be designed to retain floatables, such as debris, oil, and grease within the basin up through and including the 100-year design storm event. Acceptable floatables control devices are illustrated in Section 3.3.4, including perforated pipes (Figure 3-3), skimmers, baffles, inverted pipes (Figure 3-5) and other devices that the City determines to be suitable.

It is recommended that detention basins be provided with an emergency drain, where practicable, so that the basin may be emptied if the primary outlet becomes clogged and/or to drain the permanent pool to facilitate maintenance. If an emergency drain is used, the emergency drain should be designed to drain by gravity where possible. Where used, gravity pipes shall be made of approved materials as specified in Item 901 of the CMSC. If site conditions prevent gravity flow, the basin may be designed to drain by pumping. Basins requiring pumping may be provided with an emergency drain made of ductile iron pipe with mechanical joints and a quick connect coupling extended to the bottom of the basin at a point near the outlet structure. It is suggested that emergency drains have an elbow within the basin to prevent sediment deposition, and a diameter capable of draining the basin within 24 hours.

The emergency drain should include an operable gate, plug valve, mud valve, ball valve, or sluice gate, which should be set and locked in the closed position. Valves or gates should be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.

3.2.4.2 Additional Layout Requirements for Dry Detention Basins

In addition to the requirements in Sections 3.2.2 and 3.2.4.1, the following shall apply to the design of dry detention basins for stormwater quantity control:

- 1) Dry detention basins shall be designed to drain toward the outlet or micropool in order to minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility.
- 2) Dry detention basins that will be publicly maintained shall include a paved low flow channel from each inlet pipe or open channel to the basin's outfall. Paved low flow channels are recommended for privately maintained detention facilities. The maintenance plan for dry basins that do not include a paved low flow channel shall describe how the basin will be maintained and drain efficiently. Low flow channels shall be designed per the following requirements:
 - a. **Bottom width** - minimum width shall be 6 feet (to allow access for maintenance equipment such as a Bobcat),
 - b. **Side slopes** - shall not be steeper than 4 (H) to 1 (V),
 - c. **Channel slope** - minimum slope toward the basin outlet shall be 0.5 percent for channels with paved bottoms, and
 - d. **Channel depth** - minimum depth of channel shall be 1 foot

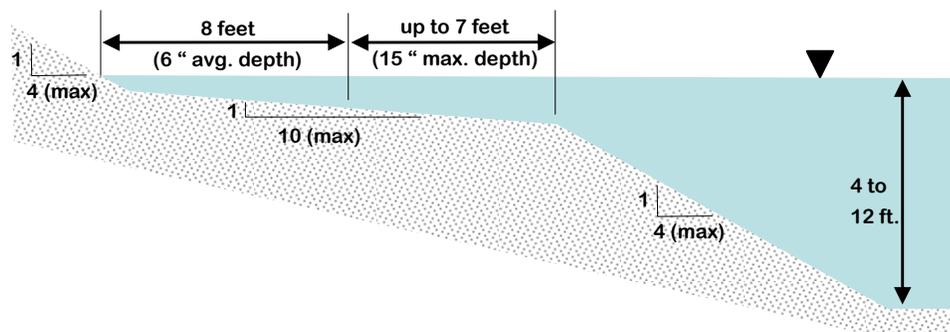
The bottom and side slopes of the channel shall be 6 inch minimum thickness, concrete reinforced with steel mesh (per CMSC Section 509) to accommodate temperature stresses, and composed of air-entrained Class C concrete (per CMSC Section 499); weep holes shall be designed in the concrete side walls.

- 3) The minimum bottom width for dry detention basins, other than the low flow channel, shall be 12 feet to allow for vehicular access for maintenance. The detention basin bottom shall be sloped to drain, and such slopes shall be sufficient to mitigate against "flat spots" developing due to construction errors and soil conditions. The minimum transverse slope for the bottoms of such facilities shall be 2.0 percent.
- 4) Dry detention basins shall be provided with topsoil, and shall be seeded and mulched to prevent erosion (per CMSC Sections 653 and 659). Grasses seeded within the basin should be able to survive 48 hours under water. Jute and Excelsior matting shall be used as required to stabilize slopes and prevent erosion.

3.2.4.3 Additional Layout Requirements for Wet Detention Basins

In addition to the requirements in Sections 3.2.2 and 3.2.4.1, the following shall apply to the design of wet detention basins.

- 1) The depth of wet detention basins shall be no more than 12 feet below the basin's normal water elevation. The City may approve deeper ponds that are to be privately owned and operated where practices (e.g. aeration) are proposed to prevent thermal stratification. The minimum bottom width of wet basins shall be 12 feet.
- 2) The perimeter of all permanent pool areas deeper than 4 feet shall be surrounded by an aquatic bench that extends at least 8 feet and no more than 15 feet outward from the normal water edge, as illustrated in the following figure. The portion of the aquatic bench within 8 feet of the shoreline shall have an average depth of 6 inches below the permanent pool to promote the growth of aquatic vegetation. The remainder of the aquatic bench shall be no more than 15 inches below the permanent pool to enhance public safety, and to limit growth of dense vegetation in a manner that allows waves and mosquito predators to pass through the vegetation. The maximum slope of the aquatic bench shall be 10 (H) to 1 (V).



- 3) The designer shall prepare a landscaping plan for the aquatic bench. Plantings along the aquatic bench shall be selected from the shallow water-emergent species in the list of Native Plant Species for Central Ohio is provided in Appendix B. These plants must be able to withstand prolonged inundation and be tolerant to road salts if receiving runoff from areas that are expected to be treated with salt-based deicing materials.
- 4) Side slopes for wet basins shall be 4 (H) to 1 (V) from the maintenance berm (see maintenance access requirements Section 4.1.1) down to the aquatic bench, and from the aquatic bench to the bottom of the basin.
- 5) At a minimum, wet detention basins shall be provided with topsoil, seeded and mulched (per CMSC Sections 653 and 659), in all areas that are above the basin's permanent pool. Appropriate species listed in Appendix B shall be specified in areas along the perimeter of the basin at elevations higher than the permanent pool that are periodically inundated after storms.

- 6) The City recommends that wet detention basins and stormwater wetlands not be constructed any closer than 10,000 feet from the aircraft movement areas, loading ramps, or aircraft parking areas of a public-use airport (i.e., a publicly or privately owned airport open to public use) serving turbine-powered aircraft, or 5,000 feet from these areas of a public-use airport serving piston-powered aircraft as recommended by the Federal Aviation Administration (FAA), Advisory Circular Number 150/5200-33. As an alternative, dry detention facilities and green roofs are stormwater best management practices that do not maintain a permanent pool of water and are not as likely to attract large numbers of waterfowl

3.2.5 Parking Lot Storage

Parking lot storage is a stormwater quantity control method allowing shallow ponding within paved portions of the parking lot during the design storm event. Parking lot storage is a convenient multi-use structural control method where impervious parking lots are planned. The following criteria shall apply to parking lot storage facilities:

- 1) Ponding in parking or traffic areas shall be designed for a maximum ponding depth of twelve (12) inches for all storms up to and including the 100-year event. Flood routing or overflow to a designed conveyance system must occur after the maximum depth is reached.
- 2) Runoff from specific graded areas within a parking lot shall be controlled by orifices. The release rate of the flow from a parking lot storage facility shall meet the allowable post-development runoff criteria presented in Section 3.2.2. The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter shall be permitted upon City approval.
- 3) A site with a parking lot storage facility shall employ a separate water quality treatment BMP that meets the water quality treatment criteria presented in Section 3.3. This BMP may be located either downstream of the parking lot or integrated into the medians, landscaping, or other pervious areas of the parking lot.

3.2.6 Tank Storage

Tank storage is a stormwater quantity control method that employs an underground tank or chamber, either prefabricated or constructed in place, and has a designed release feature to control stormwater discharge. This method is most applicable where land is valuable or the site is constrained, such as in industrial, commercial, and redevelopment areas. Construction costs and operation costs, which may include pumps, make this method relatively expensive.

- 1) Tank storage facilities shall not be used in instances where the City is to own or operate the facility.
- 2) If storage tanks are to be used for a site, a plan for long term maintenance of the facility shall be provided to the City, including a health and safety plan for confined space entry.

- 3) The release rate of the flow from a tank storage facility shall meet the allowable post-development runoff criteria presented in Section 3.2.2.
- 4) A site with a tank storage facility shall employ a separate water quality BMP that meets the water quality treatment criteria presented in Section 3.3.
- 5) The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter shall be permitted upon City approval.
- 6) Air-tight lids shall be used on all access structures, and traps shall be provided on inlet and outlet pipes to limit mosquito access to standing water.

3.2.7 Green Roof Technologies

Green roofs are systems used to control runoff volume, improve air and water quality, and promote energy conservation. They typically include layers of drainage material and planting media on a high-quality membrane to minimize leakage. These systems use foliage and lightweight soil mixtures to potentially absorb, filter, and detain rainfall. There are two types of green roofs:

- 1) Extensive green roofs, illustrated in **Figure 3-1**, typically use drought tolerant roof covers of succulents, grasses and mosses which require little to no maintenance. These roofs are not intended for recreation, are generally less expensive than intensive green roofs, and are typically not designed for public access.
- 2) Intensive green roofs are typically more elaborately designed roof landscapes, such as roof gardens, that are intended for human interaction and need to be engineered to conform to the additional load requirements for such activities. Alternative or intensive green roofs will only be approved upon City review and must be justified by the Applicant.

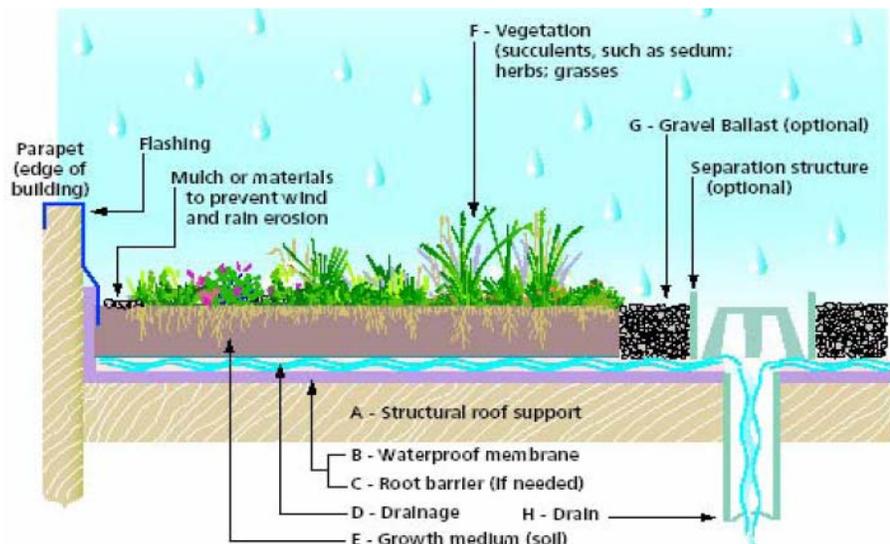


Figure 3-1. Schematic of Typical Extensive Green Roof

3.2.7.1 Design Guidelines and Performance Standards

Developers may use green roof technology on new development and redevelopment projects as a best management practice (BMP) to assist in satisfying the City's stormwater quantity and quality control requirements. The City will accept submittals with green roof components if they are designed to retain at least 50 percent of the average annual precipitation in the Columbus area (approximately 19 inches per year) and satisfy the design criteria and monitoring requirements defined in this section. **Table 3-3**³ presents general guidelines and performance standards that shall be used to design green roofs for redevelopment projects in Columbus. These criteria are based on a review of recent literature about green roof installations in North America and Europe and may be revised as industry-wide design and material standards develop. More guidance on the design of green roof systems is available in the Guidelines for the Planning, Execution, and Upkeep of Green-Roof Sites, 2002.

3.2.7.2 Maintenance Requirements

While green roofs should be designed to minimize maintenance requirements, some maintenance is necessary to ensure its continued stormwater management performance. **Table 3-4**⁴ presents the minimum maintenance requirements that shall be provided for green roof installations. The developer shall include specific requirements in a maintenance plan, as defined in Section 4.

3.2.7.3 Monitoring Requirements

Currently, field data documenting the effectiveness of green roofs at reducing stormwater quantity and quality are under development. Since green roofs are an emerging technology, they may be used on new development and redevelopment projects as a best management practice to assist in satisfying the City's stormwater quantity and quality control requirements, if the developer agrees to monitor their performance for three years after the project is complete. Monitoring is required to gain a better understanding of a number of highly-variable factors that control the stormwater benefits of green roofs, namely:

- 1) The antecedent moisture content of the growing media,
- 2) Criteria for establishment of the vegetation layer,
- 3) Species of plants and soil which make up the vegetation layer,
- 4) How control levels vary with the intensity of the rainfall,

³ Adapted from *Stormwater Management Manual*, pgs. 2-37:24, City of Portland – Clean River Works, Environmental Services, September 2004. General information also from the *Introductory Manual for Greening Roofs*, Public Works and Government Services of Canada, December 2002.

⁴ Adapted from *Stormwater Management Manual*, pgs. 3-11, City of Portland – Clean River Works, Environmental Services, September 2004.

Table 3-3
Extensive Green Roof System Components

Major Green Roof Component	Design Requirement
Structural roof support (for both existing and new construction)	Adequate to hold an additional 10 – 25 psf (pounds per square foot) of saturated soil weight (in addition to snow load requirements)
Waterproof Membrane (Impermeable Material)	Acceptable material includes modified asphalts (bitumens), synthetic rubber (EPDM), hypolan (CPSE), and reinforced PVC
Protection Boards or Materials	Composed of soft fibrous materials; used to protect the waterproof membrane
Root Barrier (as needed)	Typically required for roofs with modified asphalt waterproof membranes while not required for EPDM and PVC membranes. (Check with waterproof membrane manufacturer to determine if required)
Drainage Layer	Range of acceptable manufactured products from plastic to gravel layers; minimum recommended thickness is 20mm
Growth Medium (Soil)	3– 6 inches of well-draining material weighing 10 – 25 psf when saturated
Vegetation	<ul style="list-style-type: none"> ▪ Drought and extreme-weather (heat, cold, high winds) tolerant ▪ Mature plant growth patterns which cover at least 90% of the overall surface within 2 years ▪ Self-sustaining, low-maintenance, fire resistant perennials or self-sowing species ▪ Four methods recommended to install the vegetation: vegetation mats, plugs/potted plants, sprigs, & seeds ▪ Acceptable vegetation includes mosses, succulents, or grasses which are shown to thrive in plant hardiness Zone 5⁵.
Gravel Ballast (as needed)	Dependent upon operational and structural design issues
Drain	Must safely drain runoff from the roof to an appropriate stormwater conveyance system
Leak Detection	Some companies recommend the incorporation of an electronic leak detection system between or underneath the waterproof membrane to pinpoint the exact location of water leaks. ⁶
Minimum Roof Slope	Chapter 15 of the Ohio Building Code provides minimum roof slope criteria for various roof materials. Minimum slopes shall also comply with recommendations provided by the green roof manufacturer.
Maximum Roof Slope	25%

⁵ Zone 5, as defined by the U.S. Department of Agriculture falls within most of Ohio and includes areas with average annual minimum temperature ranges between -10 and -20 degrees Fahrenheit.

⁶ *Design Guidelines for Green Roofs*, Peck, S., Kuhn, M., and Arch, B – Ontario Association of Architects.

Table 3-4
Green Roof Maintenance Requirements

Major Green Roof Component	Maintenance Requirements
Soil Substrate/Growing Medium	Inspected annually for evidence of erosion from wind or water
Structural Components	Operated & maintained in accordance with manufacturer's requirements; drain inlets kept unrestricted
Debris & Litter	Remove after major storms to prevent clogging of inlet drains and interference with plant growth
Vegetation	Maintain as needed to provide 90% plant cover
Irrigation	Regularly irrigate during first two years of installation until 90 percent plant cover is achieved. Irrigate as necessary to maintain 90 % plant cover through hand watering or automatic sprinklers
Spill Prevention	Use preventative measures for mechanical systems when handling substances that could potentially contaminate stormwater
Training and/or Written Guidance Information	Provide to all Property Owners and tenants
Aesthetics	Maintained as an asset to the Property Owner/community
Insects	Prevent infestation that prevent maintenance of 90 percent plant cover criteria.
Inspections	Recommended twice annually

- 5) How control levels vary by season, and
- 6) Limits on roof pitch

The maintenance plan for the project shall define a monitoring program consisting of visual inspections, rainfall monitoring, flow monitoring, pollutant sampling, and reliability testing to demonstrate that the City's performance standards are achieved. The City will work with the Applicant to define an acceptable monitoring program for the project. The City plans to use the data collected, along with data from similar climatic regions, to contribute toward establishing design criteria for green roofs in future editions of the Manual.

3.3 Post-Construction Stormwater Quality Controls

Stormwater quality control facilities shall be designed to control runoff from small storm events before discharged offsite. The design criteria provided in this section, or alternative criteria approved by the City, are intended to reduce pollutants contained in stormwater runoff and to reduce streambank erosion during frequent storm events. The Stormwater Management Report for the project, prepared according to the guidelines and criteria in Section 6, shall include the rationale for selecting appropriate stormwater quality controls, a master drainage plan (if applicable) showing their location, and calculations defining how they were sized.

3.3.1 General Requirements

3.3.1.1 Stormwater Runoff Quality Control

Unless otherwise exempted, all runoff from development sites shall be directed to one or more stormwater quality controls designed according to:

- 1) Ohio EPA's Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit), latest version
(http://www.epa.state.oh.us/dsw/permits/CGP_renewal_final_s.pdf),
- 2) Ohio EPA's Post-Construction Q&A Document, latest version
(<http://www.epa.state.oh.us/dsw/storm/CGP-PC-Q&A.html>), and
- 3) Criteria provided in this section, as well as Section 3.1.

Additional criteria are presented in this section to assist Applicants in:

- 1) determining the size of stormwater quality control facilities,
- 2) laying out stormwater quality controls within the site, and
- 3) specifying features of stormwater facilities that will ensure proper function and maintenance in a manner that is acceptable to the City.

As they apply to post-construction water quality controls, the definitions, exemptions, variances, and stormwater quality criteria applicable to new development, redevelopment, small construction sites, and large construction sites, as referenced in the Construction General Permit and attending Q&A document, shall apply unless otherwise noted in the Manual. In instances where conflicts exist between OEPA criteria and the criteria presented in this section, the more stringent standards shall apply.

All stormwater quality control facilities shall be sized to completely capture and treat the WQ_v determined for the entire contributing drainage area, according to the criteria contained in Section 3.3.2. Stormwater quality control facilities may be integrated with the stormwater quantity controls addressed under Section 3.2. If not integrated, flows exceeding the capacity of the stormwater quality control shall be conveyed to a stormwater quantity control facility before being discharged offsite.

3.3.1.2 Illicit Discharge and Illegal Dumping Control

An illicit discharge is any discharge into the storm drainage system that is not composed entirely of stormwater⁷. It is the policy of the City that no person shall:

- 1) Construct, maintain, operate, and/or utilize any illicit connection,
- 2) Cause or allow any prohibited discharge, and
- 3) Act, cause, or permit any agent, employee, or independent contractor to construct, maintain, operate or utilize any illicit connection, or cause, allow or facilitate any prohibited discharge.

All development in the City shall be constructed in a manner that does not result in an illicit discharge into the City's stormwater system. Discharges allowable under the terms of an NPDES permit are not considered illicit discharges.

3.3.2 Water Quality Volume (WQ_v) Determination

The following formula shall be used to determine the design water quality volume (WQ_v)⁸:

$$WQ_v = C * P * (A/12)$$

where:

WQ_v = water quality volume in acre-feet

C = runoff coefficient appropriate for storms less than 1 inch

P = precipitation depth = 0.75 inch, and

A = drainage area in acres

3.3.2.1 Runoff Coefficients for Water Quality

Runoff coefficients appropriate for the various single family residential and Traditional Neighborhood Development (TND) types in Columbus are presented in **Table 3-5**. Runoff coefficients for non-single family residential and non-TND type developments shall be determined using the following equation⁹:

$$C=0.858i^3 - 0.78i^2 + 0.774i + 0.04.$$

⁷ U.S. EPA and Ohio EPA regulations allow certain non-stormwater discharges to enter the storm drainage system that are commonly not a source of pollution. Applicants should refer to the latest Ohio Environmental Protection Agency (OEPA) NPDES permit issued to the City of Columbus to determine authorized non-stormwater discharges.

⁸ Ohio Environmental Protection Agency, Authorization for Stormwater Discharges Associated with Construction Activity Under the National Pollutant Discharge Elimination System. OEPA Permit No. OHC000002

⁹ ASCE/WEF, "Urban Runoff Quality Management", 1997.

where:

i = fraction of the drainage area that is impervious

Per OEPA criteria¹⁰, the minimum runoff coefficient for commercial (non-TND) and industrial developments shall be 0.8. A minimum runoff coefficient of 0.5 for non-TND multi-family developments shall be used. Detailed criteria for using the WQ_v to design each accepted type of stormwater quality control facility is found in subsequent sections of the Manual.

3.3.2.2 Minimum Drawdown Requirements

With the exception of swales and proprietary flow-through devices, stormwater quality controls proposed for new development and redevelopment projects that disturb one (1) acre or more, shall meet the minimum drawdown times specified in Sections 3.3.4 and 3.3.5.

The minimum drawdown times provided in Section 3.3.6.3 are applicable where vegetated swales are proposed to provide runoff treatment for projects that disturb five (5) acres or more. For vegetated swales, filter strips, or proprietary flow-through devices intended to serve project sites that disturb less than five (5) acres, the water quality flow (WQ_f) criteria as presented in Section 3.3.6.1 may be used to size these facilities.

Table 3-5
Runoff Coefficients for Determining WQ_v

Land Use	Runoff Coefficient for WQ_v
Commercial/Business (TND-TC) and Industrial Multi-family (TND-NC)	0.8
1/12 – 1/8 acre lots (TND-NG)	0.6
1/8 acre lots (TND-NE)	0.5
1/4 acre lots	0.4
1/2 acre lots	0.3
Undeveloped	0.2

3.3.3 Stormwater Quality Control – Acceptable Methods and Criteria

Four general categories of stormwater quality control facilities have been approved for use in the City:

- 1) Group 1 – Stormwater Basins
- 2) Group 2 – Media Filters
- 3) Group 3 – Vegetated Swales and Filter Strips
- 4) Group 4 – Controls for Commercial Activity Areas and Redevelopment

Table 3-6 presents guidance information that may be used to select appropriate control facilities for the site. The designer shall present written documentation in their Plan supporting selection of appropriate control measures based upon site conditions.

¹⁰ Ohio Environmental Protection Agency, Authorization for Stormwater Discharges Associated with Construction Activity Under the National Pollutant Discharge Elimination System. OEPA Permit No. OHC000002

Table 3-6
Major Selection Criteria for Stormwater Quality Controls

Criteria	Group 1: Stormwater Basins	Group 2: Media Filters	Group 3: Vegetated Swales and Filter Strips	Group 4: Controls for Commercial Activity Areas
Drainage Area	> 10 ac	<5 ac	<5 ac	<5 ac
Land Required	2-3%	> 5%	> 5%	Varies
Cold Weather Issues	<ul style="list-style-type: none"> ▪ Impacts of Pavement Deicers 	<ul style="list-style-type: none"> ▪ Impacts of Pavement Deicers ▪ Clogging from Icing 	<ul style="list-style-type: none"> ▪ Impacts of Pavement Deicers 	<ul style="list-style-type: none"> ▪ Clogging from Icing
Locational Conflicts	<ul style="list-style-type: none"> ▪ Separation from buildings and sanitary sewers 	<ul style="list-style-type: none"> ▪ Separation from buildings and sanitary sewers ▪ Minimum elevation difference across filter 	<ul style="list-style-type: none"> ▪ Requires mild slopes 	<ul style="list-style-type: none"> ▪ Varies
Mosquito and Vector Control Issues	<ul style="list-style-type: none"> ▪ Excessive aquatic vegetation ▪ Habitat for mosquito predator species 	<ul style="list-style-type: none"> ▪ Media clogging causes stagnant water 	<ul style="list-style-type: none"> ▪ Zero slopes, rutting, impermeable soils causing standing water 	<ul style="list-style-type: none"> ▪ Sediment debris buildup causes stagnant water
Pollutant Removal	<ul style="list-style-type: none"> ▪ Meets Ohio EPA Criteria for New Development 	<ul style="list-style-type: none"> ▪ Meets Ohio EPA Criteria for New Development 	<ul style="list-style-type: none"> ▪ Meets Ohio EPA Criteria for New Development 	<ul style="list-style-type: none"> ▪ Pretreatment for Commercial Activity Areas

Within each group, detailed design criteria are presented in subsequent sections that govern feasibility, conveyance, pretreatment, treatment, environmental/landscaping and maintenance requirements. The following major design considerations shall be addressed during design and documented in the Plan:

- 1) **Drainage Area** – The drainage area sizes provided in Table 3-6 are based on literature review of demonstrated design criteria, and are provided for guidance purposes only. Significant departures from this guidance may require that the designer provide additional information, upon request, to demonstrate that the facility will function properly if the actual drainage area varies significantly from this guidance. Designers should keep in mind, however, that stormwater basins serving areas smaller than 10 acres may require extremely small outlets that are prone to clogging. Wet basins and stormwater wetlands typically require larger drainage areas or alternative water sources to sustain a permanent pool and maintain aquatic vegetation. An acceptable alternative to treating runoff from the entire site using a single BMP is to divide the development into smaller catchment areas where treatment can be provided by several smaller BMPs located throughout the development site.

- 2) **Hydraulics** – Design the facility with an outlet to control release rates and prevent clogging, provide storage for intense rain events, and install an observable high-flow bypass.
- 3) **Sediment Management** – Design the facility with pre-treatment for coarse sediments and a sediment storage volume for finer sediments.
- 4) **Health & Safety** – Design facilities containing a permanent pool with a healthy aquatic habitat for mosquito control and an aquatic bench with a maximum slope of 10 (H) to 1 (V) to increase public safety.
- 5) **Aesthetics** – Provide features that “hide” accumulated silt & debris and integrate the facility with overall site design.
- 6) **Maintainability** – Design the facility to minimize the amount and frequency of maintenance, to ease required maintenance activities, and to eliminate emergency / extraordinary maintenance requirements. Design criteria in the Manual are intended to facilitate maintenance, are required for facilities that will be maintained by the City, and are recommended for other facilities. If a design is proposed that does not include some or all of these features, the maintenance plan shall explain how maintenance activities shall be performed.
- 7) **Accessibility** – Design the facility to eliminate physical barriers (e.g., curbs and steep slopes) to entry for maintenance or emergency access, use strong, lightweight, noncorroding materials at access points (e.g., manhole covers and doors) to underground facilities, and provide legal right of entry for publicly maintained basins.
- 8) **Durability** – Design the facility to include strong, light-weight materials for “removable” features, reinforced concrete structures for “permanent” features, and hardy, disease-resistant vegetation.
- 9) **Separation from buildings and sanitary sewers** – Keep water quality controls that allow infiltration of runoff into the ground away from buildings, sanitary sewers, and building laterals to minimize infiltration/inflow into sanitary sewers.
- 10) **Cold Weather Issues** – Stormwater quality control facilities shall be designed to operate effectively under cold weather conditions. Design considerations include use of outlets that will not clog when frozen, additional pre-treatment and/or sediment storage/disposal in areas where sand or other solids are used for pavement deicing, and salt-tolerant plants in controls that incorporate vegetation.
- 11) **Mosquito and Vector Control** – Design criteria are included in the Manual that minimize conditions causing mosquito breeding without significantly compromising the effectiveness of controls that rely upon permanent pools of water and vegetation. The following guiding principals apply:

- a. Areas of facilities outside the permanent pool shall be designed to drain completely toward the outlet or permanent pool within 72 hours of a precipitation event. Small depressions in paved, rip-rap, and/or vegetated areas shall not be allowed, and shall be eliminated if they form.
- b. Wet detention basins and wetlands shall be designed to maximize habitats that promote colonization of the facility by mosquito predators (i.e., dragonflies, diving beetles, and mosquito fish). These facilities shall also incorporate large areas of open water to allow waves to propagate through vegetated areas, drowning mosquito larvae.
- c. Underground and enclosed vaults containing certain stormwater quality controls are particularly susceptible to mosquito breeding. Facilities not intended to include a permanent pool of water shall be designed to drain without allowing standing water to remain, and shall not permit any trapped debris or sediment to create standing water. Air-tight lids shall be used on all access structures, and traps shall be provided on inlet and outlet pipes to limit mosquito access to standing water.
- d. The maintenance plan for the facility shall address mosquito monitoring and control activities, including periodic harvesting of aquatic vegetation, removal of invasive/exotic and/or emigrant vegetation, removal of trash, debris sediment accumulation, and cleaning/rejuvenation of media filters.

3.3.4 Group 1 – Stormwater Basins

Stormwater basins typically provide a combination of a permanent pool and/or extended detention to treat the entire WQ_v . Acceptable design variants include:

- 1) Extended dry detention basin,
- 2) Extended wet detention basin, and
- 3) Constructed stormwater wetland.

Stormwater quality design features can be readily incorporated into stormwater basins that are designed to function as quantity control facilities, making them an attractive choice for stormwater controls. Stormwater basins that are intended to provide stormwater quantity as well as stormwater quality control shall be designed in accordance with the criteria presented in both this section and Section 3.2.

At a minimum, all stormwater basins shall be designed according to the general criteria in Sections 3.1 and 3.2.4.1. Additional design requirements are specified in the following sections. **Table 3-7** summarizes the major design criteria for the three types of stormwater basins. Major differences in design criteria are the required facility size, the use of permanent pools, and the required drawdown time for a basin at design capacity. If a dam or spillway is part of the basin's design, the design and construction of the basin are required to follow Ohio law

Table 3-7
Major Design Criteria for Stormwater Basins

Type of Basin	Permanent Pool Volume ¹	Extended Detention Volume	
		Volume	Drawdown
Extended Dry Detention	Micropool ²	WQv	48 hrs
Extended Wet Detention	0.75*WQv	0.75*WQv	24 hrs
Wetland	Wetland ³	WQv	24 hrs

¹Facility volumes should be increased 20 percent for sediment storage

²Equals 0.20(WQv)

³Equals twice the 30-day summertime evaporation rate or 0.75 WQv, whichever is greater

pertaining to dam design (Section 1521 of the Ohio Revised Code and Chapter 1501:21 of the Ohio Administrative Code) and safety requirements.

3.3.4.1 Extended Dry Detention Basins

Extended dry detention basins are designed to capture stormwater during small to moderate rain events and slowly release the captured volume over a specified period of time. **Figure 3-2** provides schematic drawings of two types of extended dry detention basins: one incorporating a micropool near the outlet, and one that does not. The following criteria shall be used to design extended dry detention basins intended to serve as water quality BMPs.

General Criteria

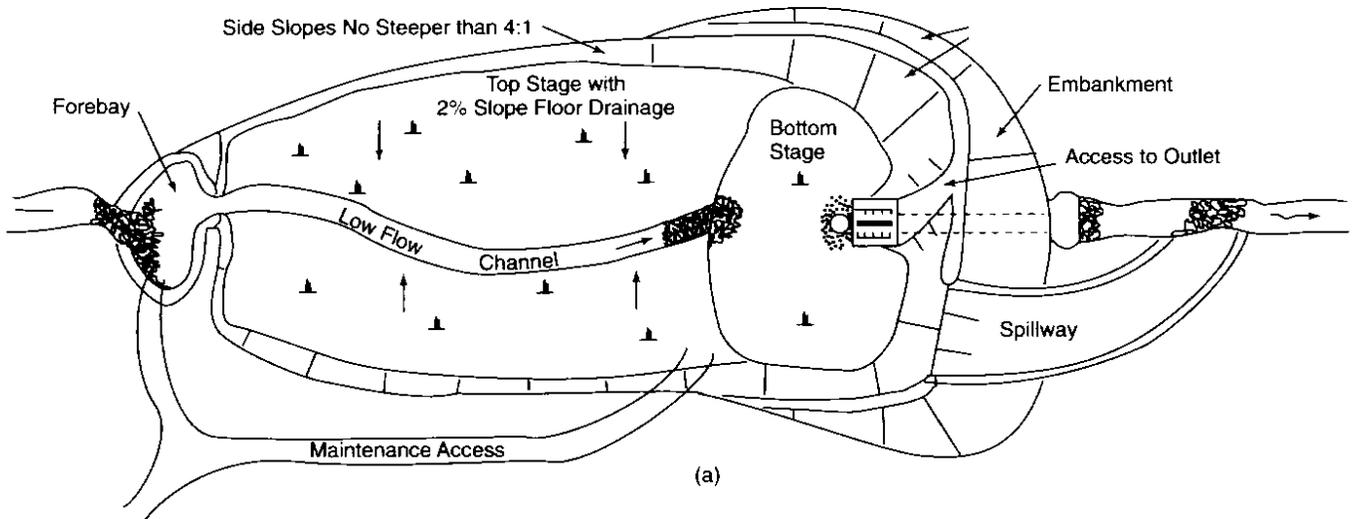
All extended dry detention basins shall be designed according to the following criteria:

- 1) The general criteria for stormwater controls in Section 3.1,
- 2) The general criteria for stormwater detention basins in Section 3.2.4.1,
- 3) The criteria for dry stormwater quantity control detention basins in Section 3.2.4.2, and
- 4) Specific criteria in this section.

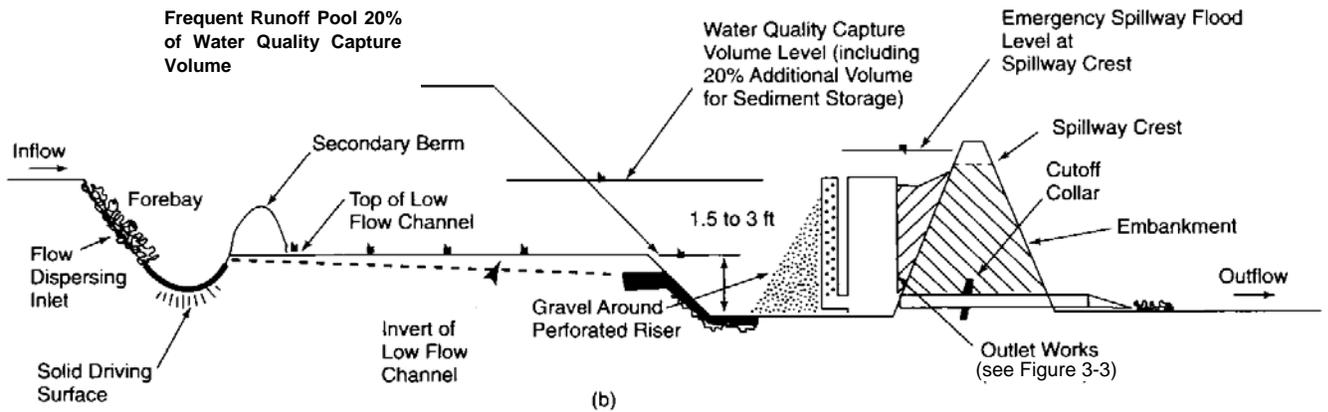
Hydrology Requirements

The extended dry detention basin shall be sized to capture the WQ_v calculated according to the methodology in Section 3.3.2. A minimum drawdown time of 48 hours shall be used to size the facility outlet, as described under the Outlet Facility and Outfall Protection Requirements later in this section. If a stormwater quality control basin is incorporated within a stormwater quantity control basin, the entire stormwater quantity design storm, as defined in Section 3.2, shall be routed through the stormwater quality portion of the basin when sizing the facility.

Type 1. No Micropool at Outlet.



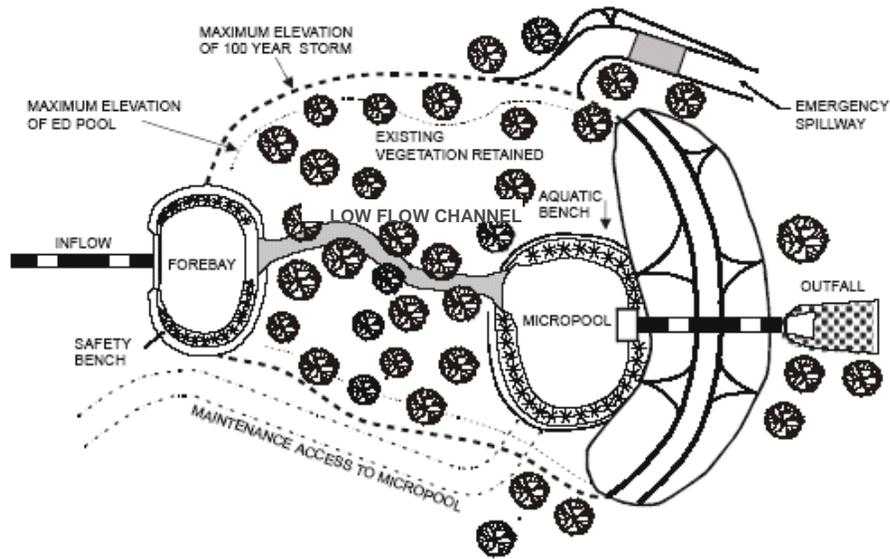
a) Plan View



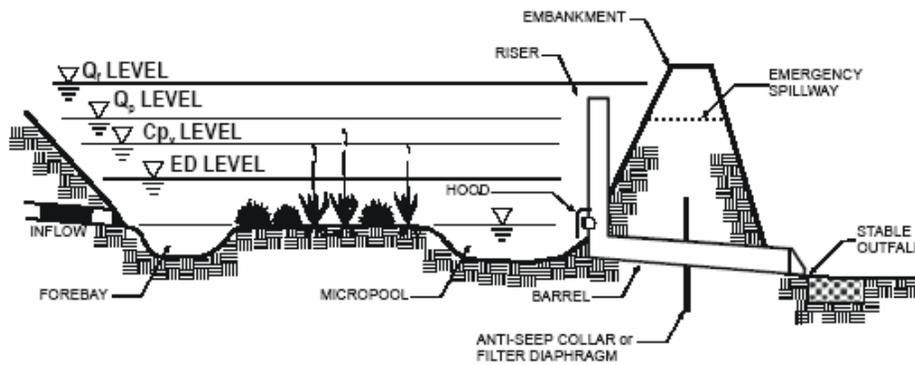
b) Profile View

Figure 3-2. Schematics of Extended Dry Detention Basins

Type 2. Micropool at Outlet



a) Plan View



b) Profile View

Figure 3-2 (continued). Schematics of Extended Dry Detention Basins

Layout and Geometry Requirements

The layout and general requirements of extended dry detention basins shall meet the minimum requirements stipulated in this section:

- 1) The recommended minimum drainage area of 10 acres is proposed to avoid outlets with extremely small orifices prone to clogging. Alternative stormwater quality control facilities specified in the Manual are generally preferred for drainage areas smaller than 10 acres.
- 2) Additional storage equal to at least 20 percent of the WQ_v shall be provided within the basin to account for sediment deposition. This sediment storage volume shall be placed at a lower stage surrounding the outlet control structure of the basin. This area shall be designed to minimize aesthetic and other impacts associated with sediment and debris accumulation and saturated soils in this portion of the basin. Design features to address these concerns include a micropool, rock landscaping, or other treatments that obscure sediments and debris accumulation. If a micropool is incorporated into the basin, its size shall be at least equal to the sediment storage volume.
- 3) The minimum length-to-width ratio for extended dry detention basins shall be 2:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.
- 4) If water quantity control is provided by parking lot storage, the WQ_v shall not extend onto paved surfaces.

Pretreatment Requirements

A forebay or other pretreatment feature shall be provided at all inlets of basins that are to be publicly maintained and are recommended for basin inlets that are to be privately owned and operated. Basin forebays provided on publicly maintained basins shall meet the following minimum requirements:

- 1) Basin forebays shall provide at least 10 percent of the WQ_v . The storage volume provided within the forebay will count toward the total WQ_v requirement.
- 2) The forebay shall consist of a separate cell, formed by an acceptable barrier such as a rock and/or vegetated weir.
- 3) Direct maintenance access shall be provided to the forebay at a slope no steeper than 10 (H) to 1 (V).
- 4) Forebay side-slopes shall not exceed 4 (H) to 1 (V).
- 5) To make sediment removal easier, the bottom and side slopes of the forebay shall be lined

with Class C concrete (per CMSC Section 499) having a minimum thickness of 6 inches. The concrete shall be reinforced with steel mesh (per CMSC Section 509) to accommodate temperature stresses.

- 6) A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.
- 7) Forebays of basins that are privately owned and operated may be constructed upon the City's approval with alternative bottom material, provided that an access point of sufficiently compacted material is available to support equipment necessary to perform the necessary routine maintenance for cleaning the structure.

Outlet Facility and Outfall Protection Requirements

Outlet designs shall provide the necessary drawdown time, route flood flows, resist clogging, and facilitate maintenance. **Figure 3-3** illustrates the accepted outlet for extended dry detention basins without micropools. For extended dry detention basins with micropools, the outlet designs for extended wet detention basins may be used (see Section 3.3.4.2 and Figure 3-5 for design criteria). The following criteria shall be used to design outlet facilities and outfall protection:

- 1) The outlet shall be designed to release 50 percent of the WQ_v in 18 to 24 hours, and 100 percent of the WQ_v in 48 hours.
- 2) If a single orifice outlet is used, it shall be designed with the following equation:

$$Q = A * C * (64.4 * H)^{1/2}$$

where:

Q = orifice discharge rate, cfs

A = area of the orifice, ft²

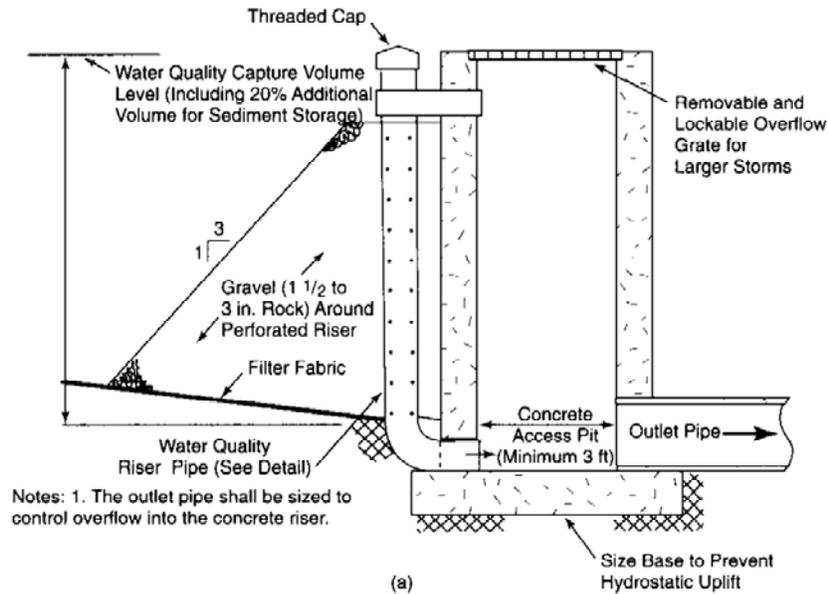
C = orifice coefficient

= 0.66 for material thicknesses less than the orifice diameter

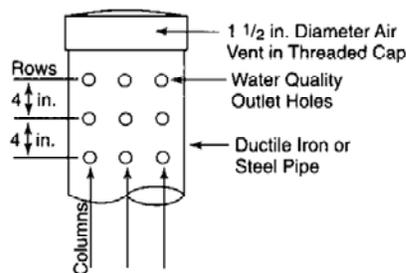
= 0.80 for material thicknesses thicker than the orifice diameter

H = head, measured from the centerline of the orifice, ft

- 3) Single orifice outlets with diameters of at least 4 inches shall be used as the water quality outlet for extended dry detention basins without a micropool. An external trash rack and hood that protects against clogging shall be provided. Alternative outlet designs (e.g., V-notch weir, perforated riser) shall be permitted upon City approval.
- 4) If a perforated riser is used as the water quality outlet control facility for the basin, then the perforations shall be designed according to criteria shown on Figure 1116-13 of the



Notes: 1. Minimum number of holes = 8.
2. Minimum hole diameter = 1/8 in. diameter.



Riser Diameter, in.	Hole Diameter, in.			
	1/4 in.	1/2 in.	3/4 in.	1 in.
4	8	8	±	±
6	12	12	9	±
8	16	16	12	8
10	20	20	14	10
12	24	24	18	12
Hole Diameter, in.	Area of Hole, sq in.			
1/8	0.013			
1/4	0.049			
3/8	0.110			
1/2	0.196			
5/8	0.307			
3/4	0.442			
7/8	0.601			
1	0.785			

Figure 3-3. Perforated Riser Design for Extended Dry Detention Basins without Micropools

Ohio Department of Transportation's (ODOT's) Location and Design (L&D) Manual¹¹.

- 5) The principal spillway for flows in excess of the WQ_v shall be designed according to criteria in Section 3.2 and equipped with a removable trash rack.
- 6) Extended dry detention basins that are intended to serve as a stormwater quality control only, must be designed to safely bypass all storms larger than the WQ_v , up to and including the 100-year storm event (Section 2.2) to an appropriately sized stormwater quantity control facility.

¹¹ Ohio Department of Transportation, "Location and Design Manual, Volume Two, Drainage Design".

3.3.4.2 Extended Wet Detention Basins

Extended wet detention basins provide a permanent pool of water overlain with an extended detention volume that drains following rainfall events. Basins designed according to the criteria in this section will provide settling for suspended solids entrained in the stormwater. **Figure 3-4** provides a schematic drawing of an extended wet detention basin. The following criteria shall be used to design extended wet detention basins.

General Criteria

Extended wet detention basins shall be designed according to the following criteria:

- 1) The general criteria for stormwater controls in Section 3.1,
- 2) The general criteria for stormwater detention basins in Section 3.2.4.1,
- 3) The criteria for wet stormwater quantity control detention basins in Section 3.2.4.3, and
- 4) Specific criteria in this section.

Hydrology Requirements

The volume of the extended wet detention basin shall be 150 percent of the WQ_v , calculated according to the methodology in Section 3.3.2.

- 1) This volume shall be split, with approximately 75 percent of the WQ_v placed in the permanent pool, and 75 percent of the WQ_v placed in the extended detention volume overlaying the permanent pool.
- 2) If a stormwater quality control basin is incorporated within a stormwater quantity control basin, the entire stormwater quantity design storm, as defined in Section 3.2, shall be routed through the stormwater quality portion of the basin when sizing the facility.

Layout and Geometry Requirements

The layout and general requirements of extended wet detention basins shall meet the minimum requirements stipulated in this section:

- 1) The recommended minimum drainage area of 20 acres is proposed to avoid basins where the permanent pool partially or completely evaporates during dry weather conditions. Alternative facilities specified in the Manual are generally preferred for drainage areas smaller than 20 acres.
- 2) Extended wet detention basins shall only be allowed under the following conditions:
 - a. Where existing soils are categorized as hydrologic soil group C (HSG-C) or hydrologic soil group D (HSG-D),
 - b. Where gravelly sands or fractured bedrock are not present, or

- c. Where a liner is installed to sustain the permanent pool of water thereby avoiding basins where the permanent pool partially or completely infiltrates into the ground.
- 3) The minimum length-to-width ratio for extended wet detention basins shall be 2 (L) to 1 (W). Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by

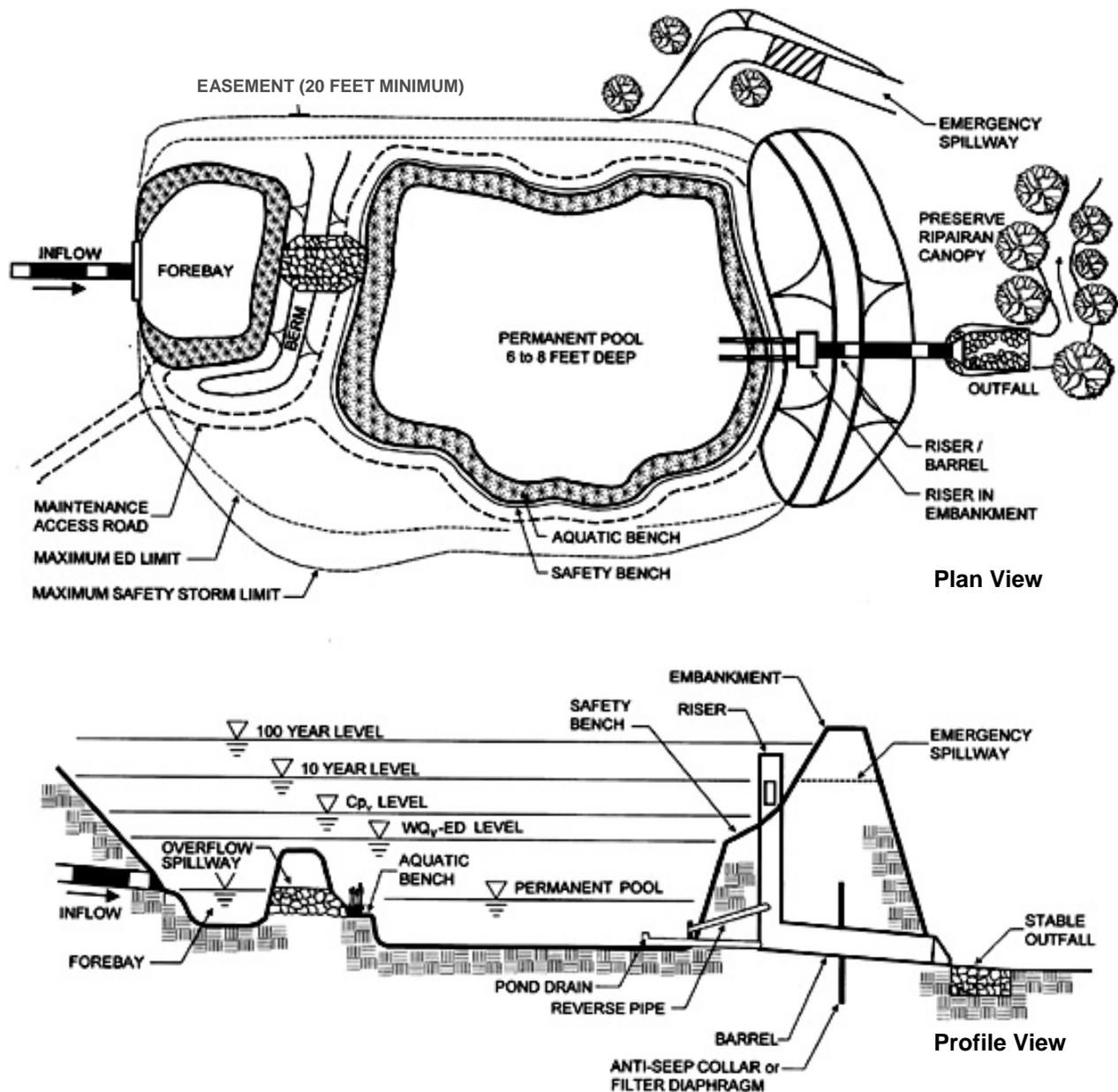


Figure 3-4. Schematic of a Typical Extended Wet Detention Basin

relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.

- 4) The depths of open water areas within the basin shall be between 4-feet and 12-feet on average to prevent thermal stratification. The perimeter of all deep pool areas (four feet or greater in depth) shall be surrounded by an aquatic bench meeting the design criteria in Section 3.2.4.3.
- 5) Wherever possible, wetland plants shall be incorporated into the basin design. A landscaping plan for the basin shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. A list of recommended Native Plant Species for the Central Ohio area is provided in Appendix B.
- 6) Additional storage equal to at least 20 percent of the WQ_v shall be provided within the basin to account for sediment deposition.

Pretreatment

A forebay or other pretreatment feature shall be provided at the inlets of all basins that are to be publicly maintained, and is recommended for basin inlets that are to be privately owned and operated. Basin forebays provided on publicly maintained basins shall meet these minimum requirements:

- 1) Basin forebays shall be sized to provide at least 10 percent of the WQ_v . The storage volume provided within the forebay will count toward the total WQ_v requirement.
- 2) The forebay shall consist of a separate cell, formed by an acceptable barrier such as a rock weir.
- 3) Direct maintenance access shall be provided to the forebay at a slope no steeper than 10 (H) to 1 (V).
- 4) Forebay side-slopes shall not exceed 4:1.
- 5) To make sediment removal easier, the bottom and side slopes of the forebay shall be lined with Class C concrete (per CMSC Section 499) having a minimum thickness of 6 inches. The concrete shall be reinforced with steel mesh (per CMSC Section 509) to accommodate temperature stresses.
- 6) A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.
- 7) Forebays of basins that are privately owned and operated may be constructed upon the City's approval with alternative bottom material, provided that an access point of sufficiently compacted material is available to support equipment necessary to perform the necessary routine maintenance for cleaning the structure.

Outlet Facility and Outfall Protection Requirements

Outlet designs shall provide extended drawdown time, route flood flows, resist clogging, and facilitate maintenance. **Figure 3-5** illustrates accepted outlets for extended wet detention basins and extended dry detention basins with micropools. The outlet for extended wet detention basins shall be designed to release the extended detention volume in no less than 24 hours. Regardless of the design drawdown time, the outlet shall be designed according to the following criteria:

- 1) The principal spillway for flows in excess of the WQ_v shall be designed according to criteria in Section 3.2 and equipped with a removable trash rack.
- 2) Extended detention basins that are intended to serve as a water quality BMP only, must be designed to safely bypass all storms up to and including the 100-year storm event to an appropriately sized flood control facility.
- 3) City-approved orifices (smaller than 4 inches in diameter) shall be adequately protected from clogging by an acceptable external trash rack or hood.
- 4) The use of a submerged reverse-slope pipe that extends downward from the riser to an inflow point one foot below the normal pool elevation of the permanent pool is a recommended method to reduce clogging of the WQ_v discharge pipe.

3.3.4.3 Stormwater Wetlands

Similar in design to wet basins, constructed wetlands treat stormwater by providing an extended detention zone (above shallow permanent pools) sized to capture and release the calculated WQ_v over a minimum time of 24 hours. Stormwater wetlands, illustrated in **Figure 3-6**, are depressed, heavily planted areas that are designed to maintain flow during dry periods in order to support aquatic vegetation. The amount of surface area required for a stormwater wetland is typically larger than that of a wet basin due to the limited allowable depths required for wetland design. The following criteria shall apply to the design of stormwater wetlands.

General Criteria

All stormwater wetlands shall be designed according to the following criteria:

- 1) The general criteria for stormwater controls in Section 3.1,
- 2) The general criteria for stormwater detention basins in Section 3.2.4.1,
- 3) The criteria for wet stormwater quantity control detention basins in Section 3.2.4.3,
- 4) Owners of wetland systems must agree to provide a mosquito monitoring and control plan within the maintenance plan for the BMP, and
- 5) Specific criteria in this section.

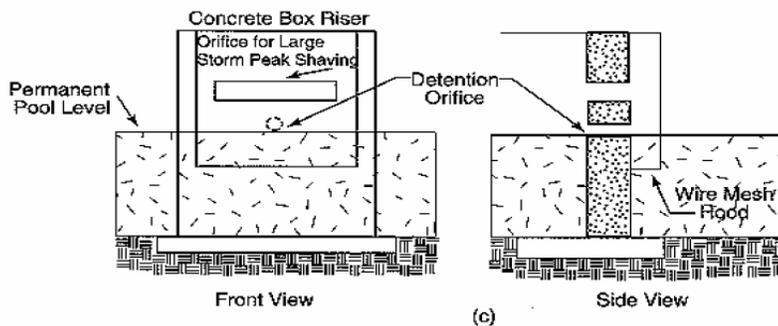
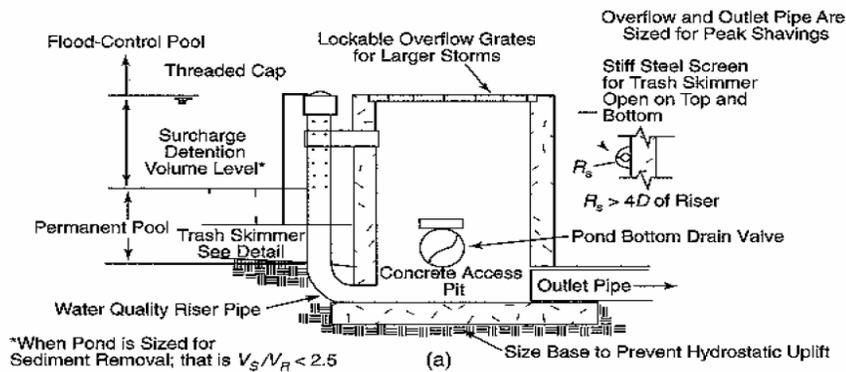
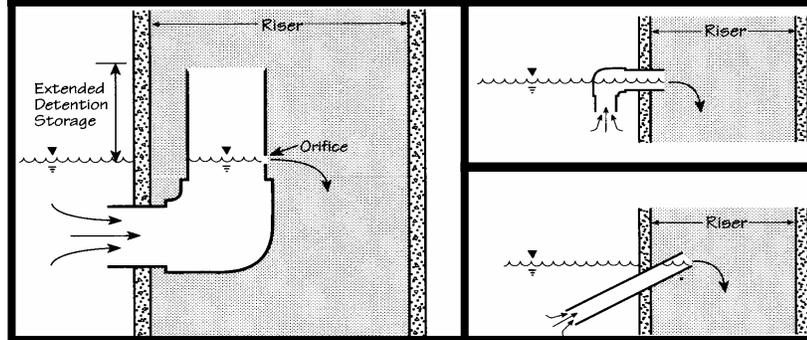
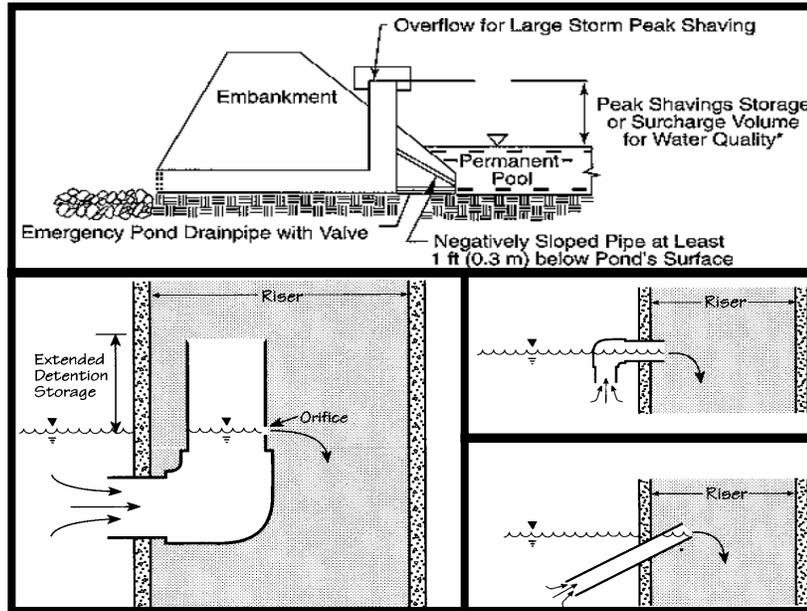


Figure 3-5. Accepted Outlet Designs for Extended Wet Detention Basins and Micropools within Extended Dry Detention Basins

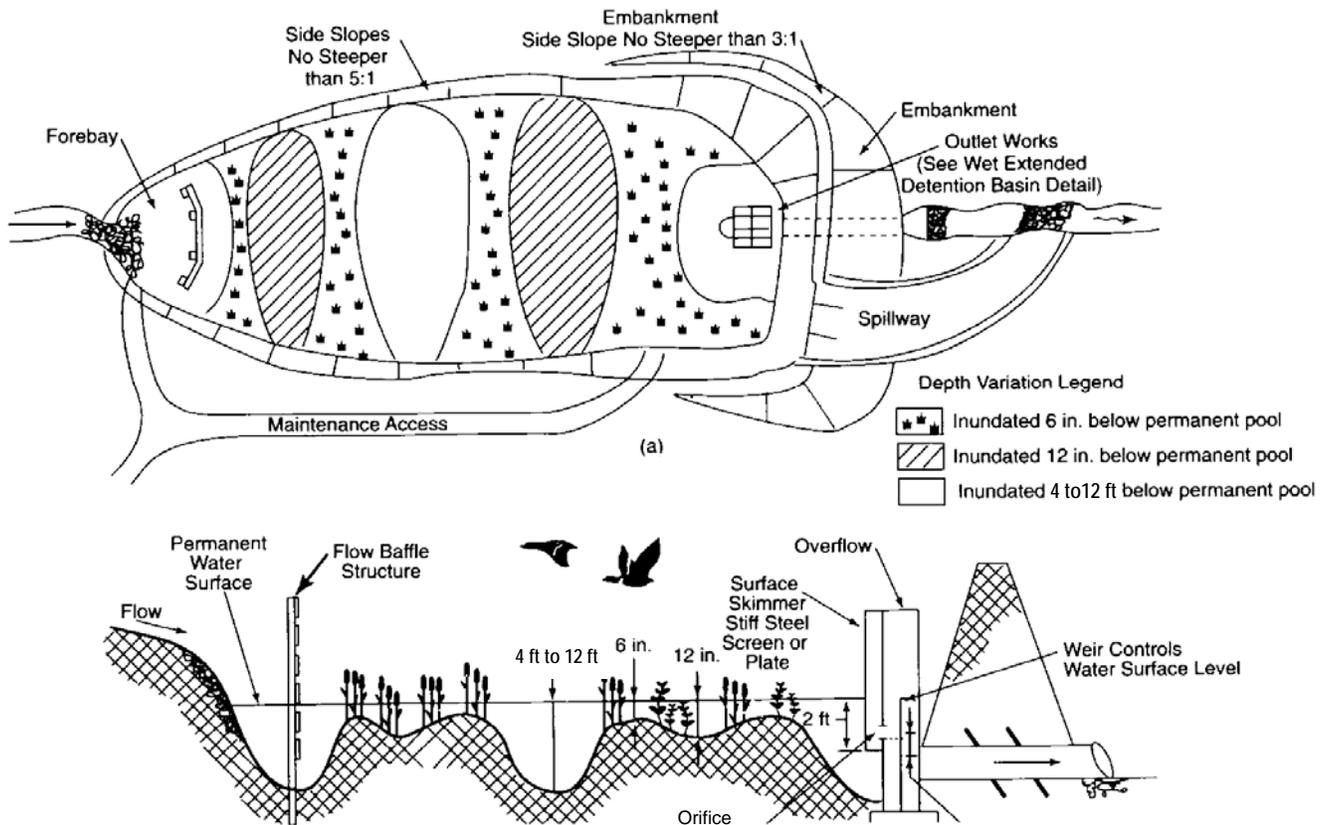


Figure 3-6 Schematic of a Typical Stormwater Wetland

Layout and Geometry Requirements

The layout and geometric requirements of stormwater wetlands shall meet the following minimum requirements:

- 1) The recommended minimum drainage area of 20 acres is proposed to avoid wetlands where the permanent pool completely evaporates during dry weather conditions. Alternative facilities specified in the Manual are generally preferred for drainage areas smaller than 20 acres.
- 2) Constructed wetlands shall only be allowed where soils categorized by the NRCS as HSG-C or HSG-D exist, where gravelly sands or fractured bedrock are not present, or where a liner is installed to sustain the permanent pool of water and avoid permanent pools that partially or completely infiltrate into the ground.
- 3) The permanent pool of any proposed stormwater wetland shall be at least two times the volume of evapotranspiration during a thirty day drought at summer evaporation rates or $0.75WQ_v$, whichever is greater. In cases where subsurface infiltration into and exfiltration out of the wetland are negligible, the summer evapotranspiration rates may be estimated¹²

¹² Kadlec, Robert and Robert Knight, *Treatment Wetlands*, CRC Lewis Publishers, 1996, pp. 184-185.

as 0.75 times the pan evaporation rate of 0.2 inches/day reported for Columbus during June, July and August¹³. More rigorous water balance calculations may be required by the City where these simplifying assumptions are not valid and/or in all cases where the drainage area to the wetland is less than 20 acres. **Appendix D** provides an example water balance calculation.

- 4) An extended detention volume equal to the WQ_v shall be provided above the permanent pool of the stormwater wetland. The outlet structure of the stormwater wetland shall be designed to release the entire extended detention volume in no less than 24 hours.
- 5) The minimum length-to-width ratio for a constructed wetland shall be 2:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet, to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.
- 6) Stormwater wetlands shall be provided with a drain so that the facility can be emptied to allow maintenance activities and to dry bottom sediments (allowing natural oxidation of built-up organics). The drain shall be designed in accordance with the emergency drain systems required for detention basins as described in Section 3.2.4.1.
- 7) Approximately 50 percent of the permanent pool volume defined in item 3, plus a sediment storage volume equal to at least 20 percent of the WQ_v , shall be placed in deep water zones (areas with depths between 4- and 12-feet) to sustain fish communities and provide wave action to control mosquito populations. At a minimum, deep water zones shall be placed within the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations.
- 8) The remainder of the facility shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) should vary depending on the vegetation selected. Permanent pool depths shall be 6 inches or less within at least 35 percent of the shallow water zone.
- 9) The bottom of the permanent pool between the deep and shallow water zones shall be sloped no steeper than 4 (H) to 1 (V).
- 10) The maximum depth of the extended detention zone above the permanent pool shall not exceed 2 feet to reduce stress on herbaceous wetland plants.
- 11) Permanent pool areas of wetlands that are deeper than 4 feet be provided with an aquatic bench per Section 3.2.4.3.

¹³ National Oceanographic and Atmospheric Administration, Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States, NOAA Technical Report NWS 34, Washington DC, 1982.

- 12) Wetland plants shall be placed along the aquatic bench and other shallow pool areas (less than 4 feet). In instances where the basin is designed to support aquatic vegetation, a landscaping plan for the wetland shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. Woody vegetation may not be planted or allowed to grow on the embankment within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the wetland facility is encouraged to provide shade and moderate surface water temperatures. A list of recommended Native Plant Species for Central Ohio is provided in Appendix B.

Pretreatment

Due to the sensitivity of wetland vegetation to sedimentation, a forebay, or other pretreatment feature, shall be provided at the inlets of all stormwater wetlands that are to be either publicly or privately owned. Wetland forebays shall be three feet to six feet in depth and shall meet the following minimum requirements:

- 1) Wetland forebays shall be sized to provide at least 10 percent of the WQ_v . The storage volume provided within the forebay will count toward the total WQ_v requirement.
- 2) The forebay shall consist of a separate cell, formed by an acceptable barrier such as a rock weir.
- 3) Direct maintenance access shall be provided to the forebay at a slope no steeper than 10 (H) to 1 (V).
- 4) Forebay side-slopes shall not exceed 4:1.
- 5) To make sediment removal easier, the bottom and side slopes of the forebay shall be lined with Class C concrete (per CMSC Section 499) having a minimum thickness of 6 inches. The concrete shall be reinforced with steel mesh (per CMSC Section 509) to accommodate temperature stresses. These criteria apply to forebays that are to be publicly maintained, and are recommended for forebays that are to be privately owned and operated.
- 6) A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.
- 7) Forebays of basins that are privately owned and operated may be constructed upon the City's approval with alternative bottom material, provided that an access point of sufficiently compacted material is available to support equipment necessary to perform the routine maintenance for cleaning the structure.

Landscape Requirements

- 1) A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of appropriate plant species, planting plan, sequence for preparing the wetland bed (including soil amendments, if needed), and sources of plant

material. The width of the vegetation zones and amount of emergent vegetation shall be limited to no more than 50 percent of the wetland area in order to control mosquitoes.

- 2) If a minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required.
- 3) All landscaping and reinforcement plans shall be signed by a registered engineer or registered landscape architect, with direction provided by an experienced wetland scientist.

Outlet Facility and Outfall Protection Requirements

The outlet design requirements provided in Section 3.3.4.2 for extended wet detention basins shall apply to stormwater wetlands. In addition, the outlet structure shall be designed to conduct continuous dry weather flow through the wetland system while maintaining normal pool elevations.

3.3.5 Group 2 – Media Filters

Media filters remove pollutants by passing stormwater through a bed of sand, soil peat, or other media that filters particulate matter and/or absorbs the trapped pollutants. Two types of media filters are allowed by the City:

- 1) Bioretention Facility
- 2) Sand Filter

Media filter shall only be permitted where a private entity will assume maintenance responsibility.

3.3.5.1 Bioretention Facilities

A bioretention system consists of a soil bed planted with native vegetation located above an underdrained gravel layer. Stormwater runoff entering the bioretention system is filtered first through the vegetation and then the soil bed before being conveyed downstream through the underdrain system, slowing the runoff velocity and treating stormwater runoff by absorption, decomposition, and filtration¹⁴. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Sites utilizing bioretention facilities for water quality control must also meet the stormwater quantity control requirements of Section 3.2. Stormwater quantity controls may either be integrated into the bioretention system or provided in a separate downstream facility. A schematic of a bioretention facility is shown in **Figure 3-7**.

¹⁴ New Jersey Department of Environmental Protection, *New Jersey Stormwater Best Management Practices Manual*, Chapter 9.1 Standard for Bioretention Systems, 2004

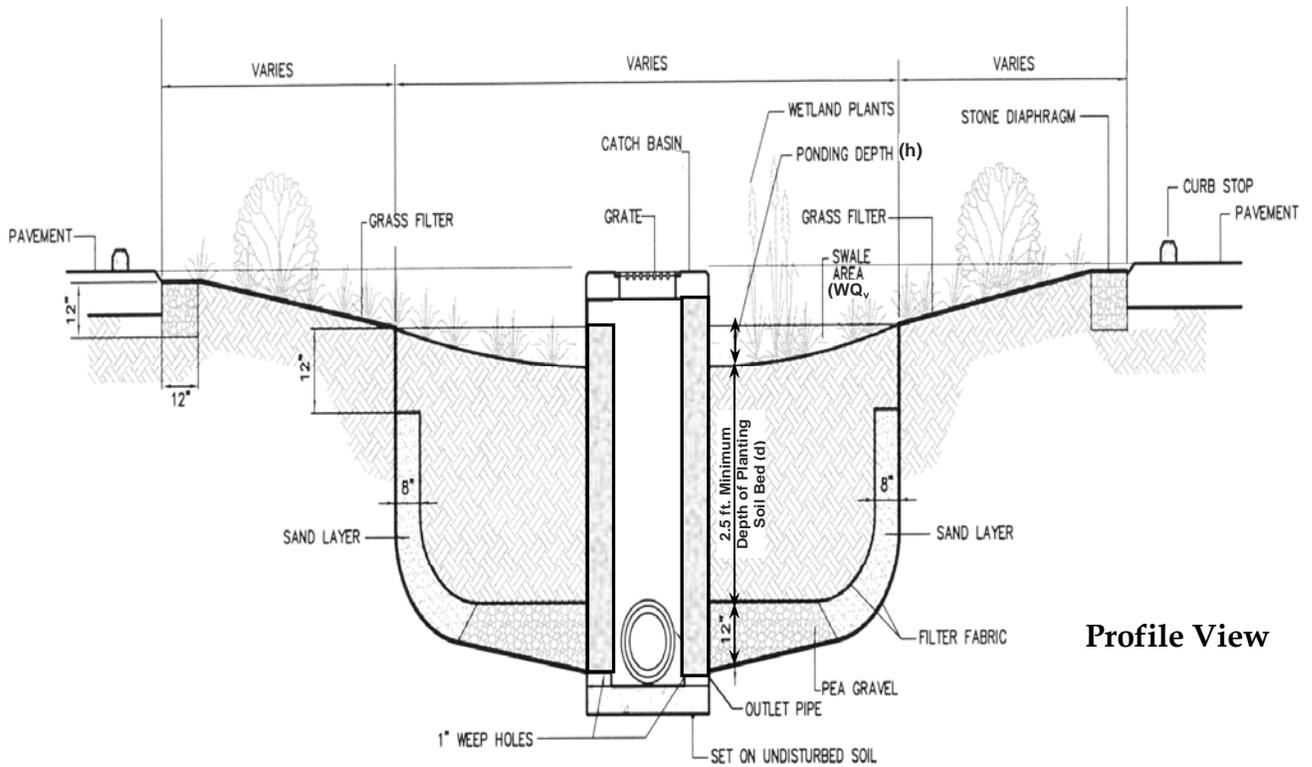
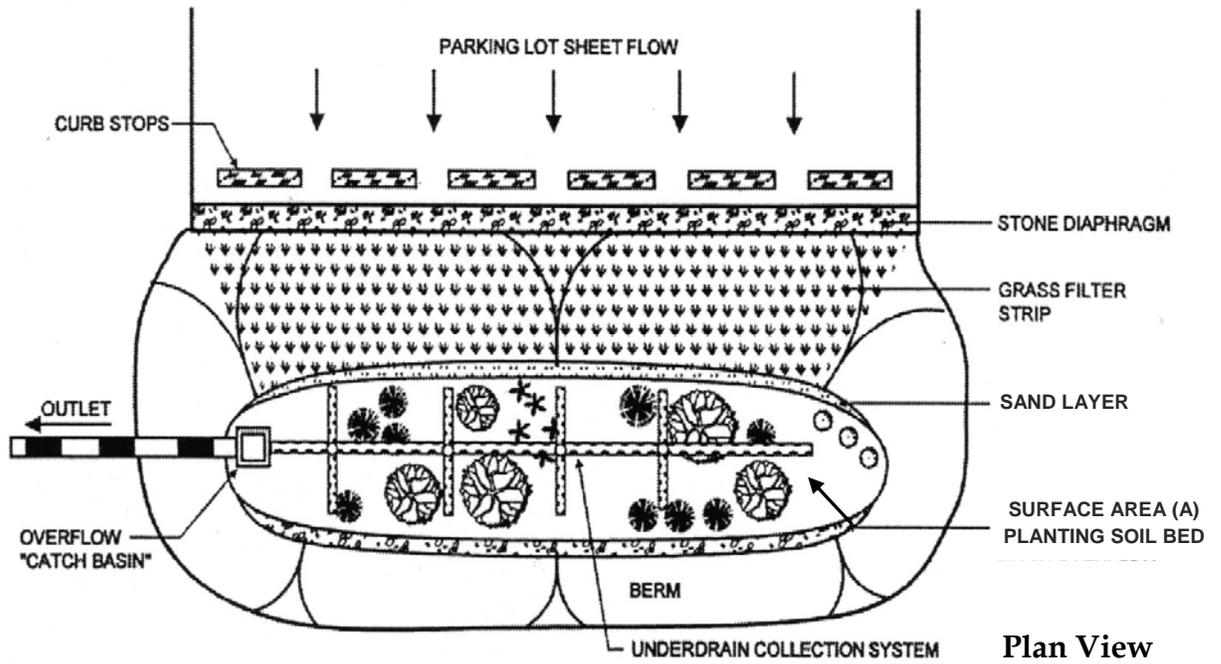


Figure 3-7. Schematic of a Typical Bioretention Facility

Hydrology Requirements

Bioretention facilities shall be designed to capture and store the WQ_v prior to filtration and shall provide a filtration time of no less than 24 hours (when the filter media is new) and no more than 40 hours (when the filter media is clogged and requires maintenance). A drawdown time of 40 hours shall be used for facility design. The following criteria shall apply to the design of bioretention facilities.

Layout and Geometry Requirements

- 1) The recommended maximum total drainage area of a bioretention facility is 5 acres, with drainage areas of one acre or less preferred in order to maximize sheet flow into the facility and to minimize ponding depth.
- 2) Bioretention systems may be constructed on-line or off-line. On-line systems receive runoff from all storms, providing treatment of the WQ_v , with runoff from larger storms conveyed and/or stored within the bioretention system and discharged through an overflow. In off-line bioretention systems, most of the runoff from storms larger than the WQ_v bypasses the system through an upstream diversion and is directed toward a stormwater quantity control device designed according to criteria in Section 3.2.
- 3) Bioretention facilities shall not be allowed in areas where the water table or bedrock is above the invert of the underdrain system.
- 4) In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.
- 5) Runoff from the tributary area of the bioretention facility shall be directed into a swale or other storage area sized to contain the entire WQ_v . This swale shall partially or completely overlay the bioretention facility, as long as the maximum depth of water over the filtering media is no more than 12 inches. Water shall not cover the media longer than 72 hours after a precipitation event.
- 6) The surface area of the bioretention soil bed shall be determined based on the following equation:

$$A = (WQ_v \cdot d) / [3600 \cdot K \cdot T \cdot (h + d)]$$

where:

- A = surface area of the bioretention planting soil bed (acre)
- WQ_v = water quality volume (acre-ft)
- d = depth of the planting soil bed (ft)
- T = drawdown time (hours)
= 40 hours
- K = permeability of the planting soil within the soil bed (feet/sec)
= 1.2×10^{-5} feet/sec (minimum), which is equivalent to 0.5 inches/hr
- h = average depth of water above filter bed (ft)
= half the maximum depth of water (maximum depth = 12 inches)

- 7) The minimum dimensions of the bioretention facility shall be 15 feet wide by 40 feet long, with facility widths of 25 feet preferred. These width criteria are established to allow enough space for a dense, randomly-distributed area of trees and shrubs to become established, enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations.
- 8) The side slopes for bioretention facilities shall not exceed 4 (H) to 1 (V).

Planting Soil (Filter Media) Requirements

The function of a bioretention facility is largely dependent on the characteristics of the planting soil (filter media) through which the runoff passes. The following criteria shall be used:

- 1) The planting soil for bioretention facilities shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates no less than 0.5 inches per hour, achieved through the following standards¹⁵:
 - a. 4 parts sand (per CMSC 703.06),
 - b. 2 parts topsoil (per CMSC 653.02), and
 - c. 2 parts compost (per ODOT CMSC 659.06). Note: Com-Til Compost from DOSD's Compost Facility is acceptable for use in bioretention facilities.

Additional recommendations for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts¹⁶.

- 2) If the existing soil does not meet the above characteristics, then it shall either be adjusted to meet the criteria or removed and replaced with an acceptable planting soil. Soil tests shall be performed for every 500 cubic yards of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area.
- 3) To prevent root intrusion into the underdrain system, the depth of the planting soil shall be no shallower than the root zone of the vegetation planted in the bioretention cell. The minimum depth shall be 2.5 feet. In addition, the depth shall be at least 4 inches below the largest root ball.
- 4) Planting soil depths of greater than 4 feet may require additional construction practices such as shoring measures. Planting soil shall be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached.

¹⁵ ODOT, "Location and Design Manual, Volume 2, Drainage Design", Section 1116.7

¹⁶ California BMP Handbook (Section 5-7, TC-32)

- 5) An 8-inch thick sand layer shall be placed along the sides of the trench, starting 12 inches below the final grade level and extending to the gravel layer in the bottom of the trench. The sand shall comply with CMSC 703.06, and shall be surrounded with a filter fabric.
- 6) Bioretention facilities shall be planted with a mixture of grass and other hardy, vegetation that can withstand prolonged periods in a wet environment, and be tolerant to road salts if receiving runoff from areas to be treated with deicing materials. Vegetation shall be selected from the list of Native Plant Species for Central Ohio is provided in Appendix B. Vegetation may include a mix of grasses and woody species, or may include woody species only with bare ground covered with mulch. Approximately one tree or shrub per 50 ft² (or 1000 per acre) of bioretention area should be included. It is recommended that three species each of both trees and shrubs are planted. Trees with high branching or open habits of growth are recommended to avoid shading and loss of grass cover. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. The shrub-to-tree ratio shall be 2:1 to 3:1.
- 7) A mulching layer 2 to 3 inches thick shall be provided above the planting soil when grass is not used, and shall be composed of shredded hardwood material to avoid floating. Mulch plays an important role in the bioretention facility. It helps maintain soil moisture, prevents erosion and helps to trap finer sediments.

Underdrain and Outlet Requirements

- 1) A perforated pipe underdrain shall be provided beneath the planting soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 4 or 6 inches and shall meet the requirements of CMSC Section 720.07 or 720.12. A granular backfill of durable No. 57 aggregate, in accordance with CMSC Section 703.01, shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.
- 2) An overflow designed to convey all storms up to and including the 100-year event shall be provided. Use of a vertical stand pipe or catch basin is recommended. For on-line facilities, this overflow may be designed to achieve the water quantity control criteria specified in Section 3.2.

Pretreatment

Flow entering the bioretention facility shall be limited to sheet flow to prevent eroding the side slopes of the facility. If flow has been concentrated prior to entering the bioretention facility, it shall be converted to sheet flow using a level spreader designed according to criteria in Section 2.3.6. In addition, the frequency of maintenance for bioretention facilities may be reduced by providing vegetated swales or filter strips around the facility. The purpose of the filter strip is to trap coarse sediments before they reach filter media, thereby reducing maintenance and increasing media longevity. Vegetated swales and filter strips can also be used as holding areas for the WQ_v prior to filtration. The design of vegetative swales and filter strips is presented in Section 3.3.6.

3.3.5.2 Sand Filters

Stormwater sand filters are usually two-chambered facilities that include a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. The two most common examples of sand filters used in the United States are the Austin sand filter¹⁷ (**Figure 3-8**) and the Delaware sand filter¹⁸ (**Figure 3-9**). The Austin sand filtration system is built at grade and is most commonly used for larger drainage areas that have both impervious and pervious surfaces. Delaware sand filter systems are installed underground, and thus are most commonly used for highly impervious areas where land available for structural controls is limited.

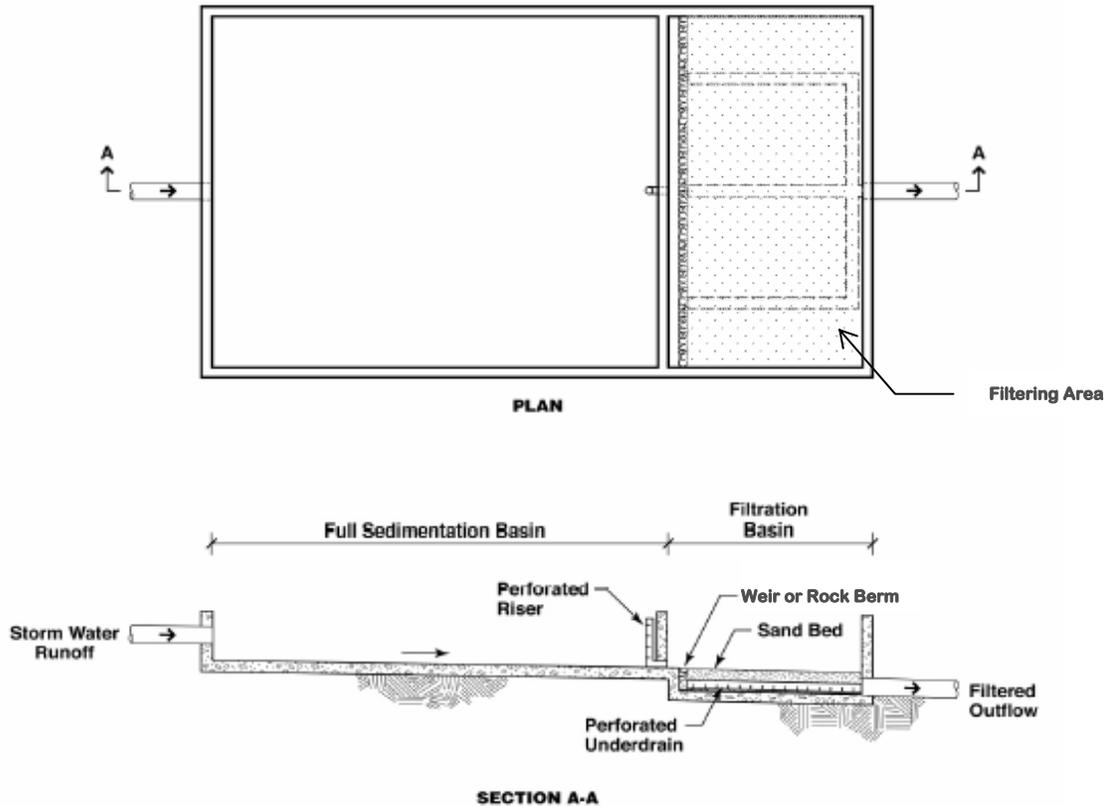


Figure 3-8. Schematic Representation of an Austin Sand Filter

¹⁷ City of Austin, TX. "Design of Water Quality Controls". 1996.

¹⁸Young, G.K., et al., "Evaluation and Management of Highway Runoff Water Quality", Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning, 1996.

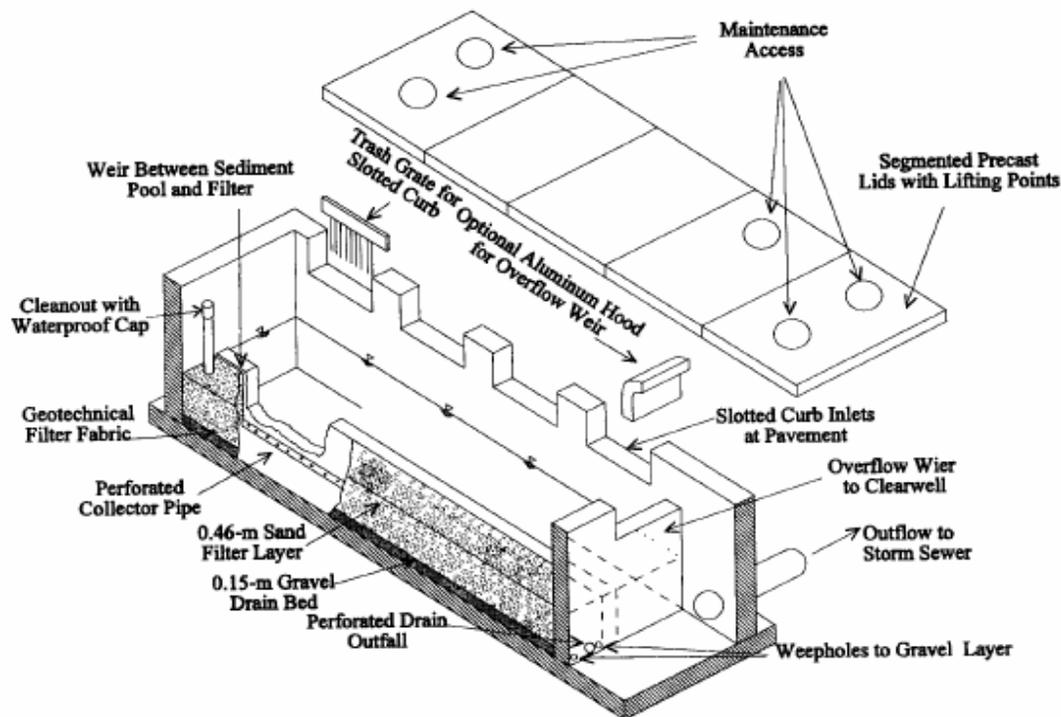


Figure 3-9. Schematic Representation of a Delaware Sand Filter

Hydrology Requirements

Sand filters shall be designed to capture and store the WQ_v prior to filtration and shall provide a filtration time of no less than 24 hours (when the filter media is new), and no more than 40 hours (when the filter media is clogged and requires maintenance). A drawdown time of 40 hours shall be used for facility design.

Layout and Geometry Requirements

- 1) The recommended maximum total drainage area of a Delaware sand filter is 1 acre, and the recommended maximum total drainage area of an Austin sand filter is 5 acres.
- 2) Sand filters require a significant amount of hydraulic head (about 4 feet), to allow flow through the system.
- 3) Sand filters shall be constructed with impermeable basin or chamber bottoms, which help to collect, treat, and release runoff to a storm drainage system or directly to surface water with no contact between contaminated runoff and groundwater.
- 4) A maintenance ramp shall be included in the design to facilitate access to the sedimentation and filter basins for maintenance activities (particularly for the Austin design).
- 5) Designs that utilize covered sedimentation and filtration basins must be accessible to vector control personnel via air-tight access doors to facilitate vector surveillance and control of the basins if needed.

Filter Media Requirements

- 1) The filter bed shall be sized to discharge the capture volume over a period of 40 hours using Darcy's Law, which relates the velocity of fluids to the hydraulic head and the coefficient of permeability of a medium¹⁹. The resulting equation, as derived by the City of Austin, Texas, (1996), is:

$$A_f = WQ_v d / [k t (h+d)]$$

where:

A_f = area of the filter bed (ft²)

d = depth of the filter bed (feet)
= 1.5 feet

k = coefficient of permeability of the filtering medium (ft/ day)
= 3.5 ft/ day for sand satisfying CMSC 703.02(A)

t = time for the WQ_v to filter through the system (days)
= 1.67 days,

h = average water height above the sand bed (feet)
= one-half of the maximum head.

- 2) The sand filter shall be constructed with 18 inches of sand (CMSC 703.02(A)) overlying 6 inches of gravel (CMSC 703.04(A)). The sand and gravel media shall be separated by permeable geotextile fabric (CMSC 712.09, Type A), and the gravel layer shall be placed on geotextile fabric. Four-inch perforated PVC pipe (CMSC 720.07) shall be used to drain captured flows from the gravel layer. A minimum of 2 inches of gravel must cover the top surface of the PVC pipe. **Figure 3-10** presents a schematic representation of a standard sand bed profile.
- 3) The sand grain size distribution shall be comparable to that of "washed concrete sand," as specified for fine aggregate in CMSC 703.02(A).

Underdrain and Outlet Requirements

- 1) In an Austin filter, the underdrain piping shall consist of a main collector pipe and two or more lateral branch pipes, each with a minimum diameter of 4 inches. The pipes shall have a minimum slope of 1% (1/8 inch per foot) and the laterals shall be spaced at intervals of no more than 10 feet. There shall be no fewer than two lateral branch pipes.
- 2) All piping shall be Schedule 40 PVC per CMSC 720.07.
- 3) The maximum spacing between rows of perforations shall not exceed 6 inches.
- 4) Each individual underdrain pipe shall have a cleanout access location.

¹⁹ City of Austin, TX. "Design of Water Quality Controls". 1996.

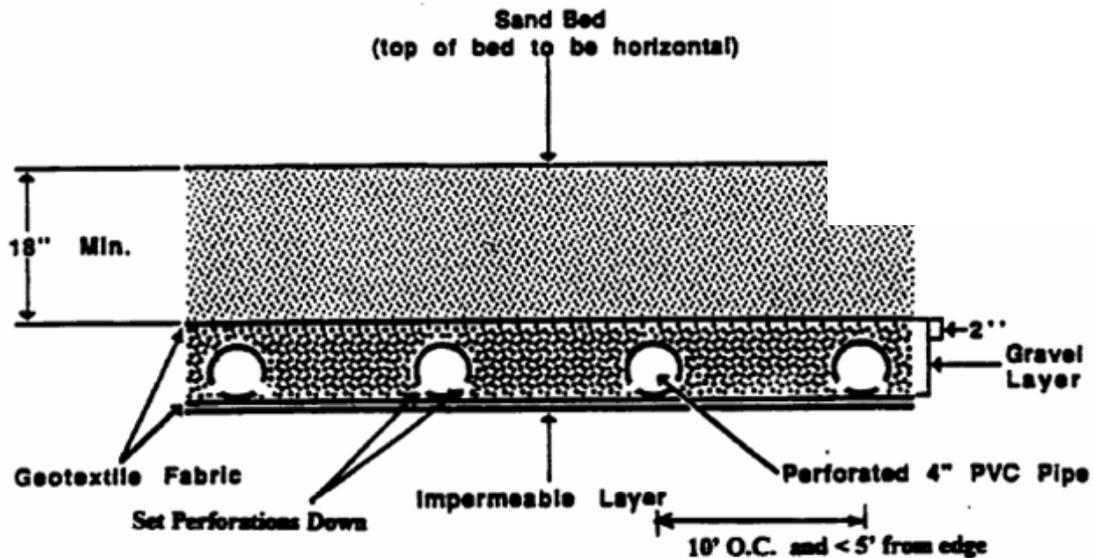


Figure 3-10. Sand Bed Profile with Gravel Filter

Pretreatment

- 1) A sedimentation basin shall pretreat runoff before entering the sand filter. The sedimentation basin shall be designed to capture the entire WQ_v and discharge it over 40 hours.
- 2) The water depth in the sedimentation basin when full should be at least 2 feet and no greater than 10 feet.
- 3) A fixed vertical sediment depth marker should be installed in the sedimentation basin to indicate when 20% of the basin volume has been lost because of sediment accumulation.
- 4) The inflow structure to the sedimentation chamber shall incorporate a flow-splitting device capable of isolating the capture volume and bypassing the peak flow of larger storms around the facility when the sedimentation/filtration basin is full.
- 5) Energy dissipation is required at the sedimentation basin inlet. Flows entering the basin shall be distributed uniformly and at maximum allowable velocities of 2 ft/sec in order to prevent re-suspension and encourage calm conditions necessary for deposition of solids.
- 6) The outflow structure from the sedimentation chamber shall be either a weir or a riser pipe through a concrete wall. Any weirs shall extend across the full width of the facility such that no short-circuiting of flows can occur.
- 7) The receiving end of the sand filter shall be protected (splash pad, riprap, etc.) such that erosion of the sand media does not occur and flow is spread across the entire filter bed.

- 8) If a riser pipe is used to connect the sedimentation and filtration basins (example²⁰ in **Figure 3-11**), a valve shall be included to isolate the sedimentation basin in case of a hazardous material spill in the watershed. The control for the valve must be accessible at all times, including when the basin is full. The riser pipe shall have a minimum diameter of 6 inches with four 1-inch perforations per row. The vertical spacing between rows should be 4 inches (on centers).

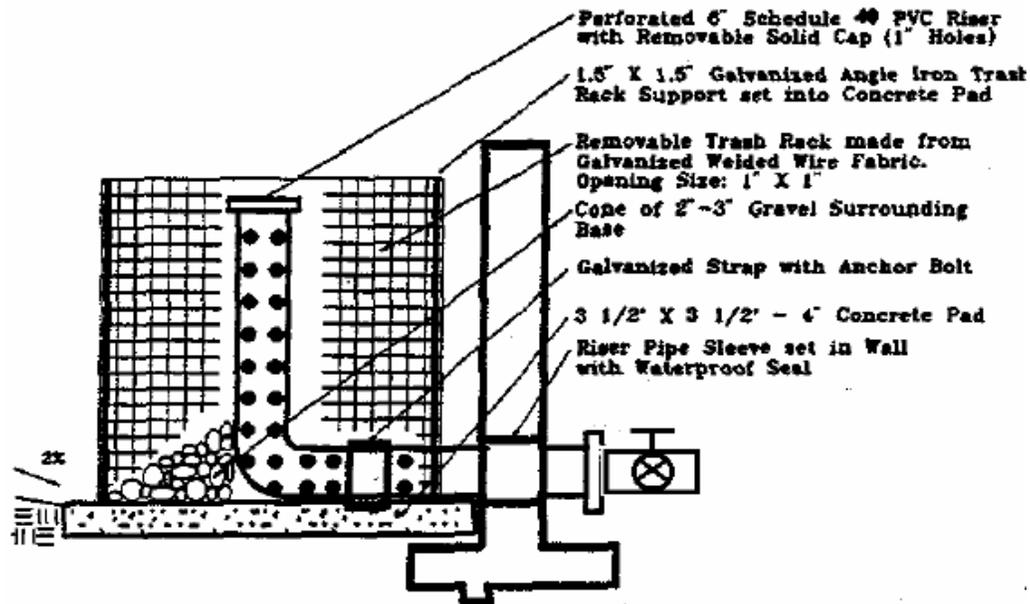


Figure 3-11. Schematic Representation of a Perforated Riser for Discharging the Sedimentation Basin into the Sand Filter

3.3.6 Group 3 – Swales and Filter Strips

Swales are shallow, mildly sloped trapezoidal channels, and filter strips are sloped surfaces with a relatively mild longitudinal slope. The surface of both are typically composed of dense turf grass, and are effective at reducing runoff peaks and removing pollutants. They are designed to convey and/or store the water quality volume (WQ_v) at shallow depths, preferably as sheet flow, with peak depths significantly less than the height of the grass. Under these conditions, vegetated swales, vegetated filter strips, and dry extended detention swales allow opportunities for infiltration and trapping of solids in the vegetation. Criteria in Ohio EPA's Construction General Permit limit use of vegetated swales and vegetated filter strips to projects that disturb less than 5 acres. Dry extended detention swales may be used for projects of any size.

²⁰ California Stormwater Quality Association, "California Stormwater BMP Handbook - New Development and Redevelopment", TC-40, 2003.

3.3.6.1 Vegetated Swales ²¹

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. **Figure 3-12** shows a schematic diagram²² of a typical vegetated filter strip and swale.

Hydrology Requirements

Vegetated swales are designed to treat the entire WQ_v from the tributary area. Since treatment occurs as stormwater “flows through” the swale, it is necessary to develop a design peak flow for the WQ_v representative of flow conditions that maximize treatment and retard flow. The following procedure shall be used to develop the design peak flow:

- 1) Determine the time of concentration for the area draining into the swale, using the methodology in Section 2.2.2.2.
- 2) Define the peak intensity of the design storm producing the WQ_v using the intensity-duration-frequency curve for Central Ohio (Figure 2-1). For example, a basin with a time of concentration of 10 minutes would have a peak rainfall intensity of approximately 1.5 inches/hour.
- 3) Use the rational method (Section 2.2.3.1) and the runoff coefficients in Table 3-3 to determine the peak flow through the swale.

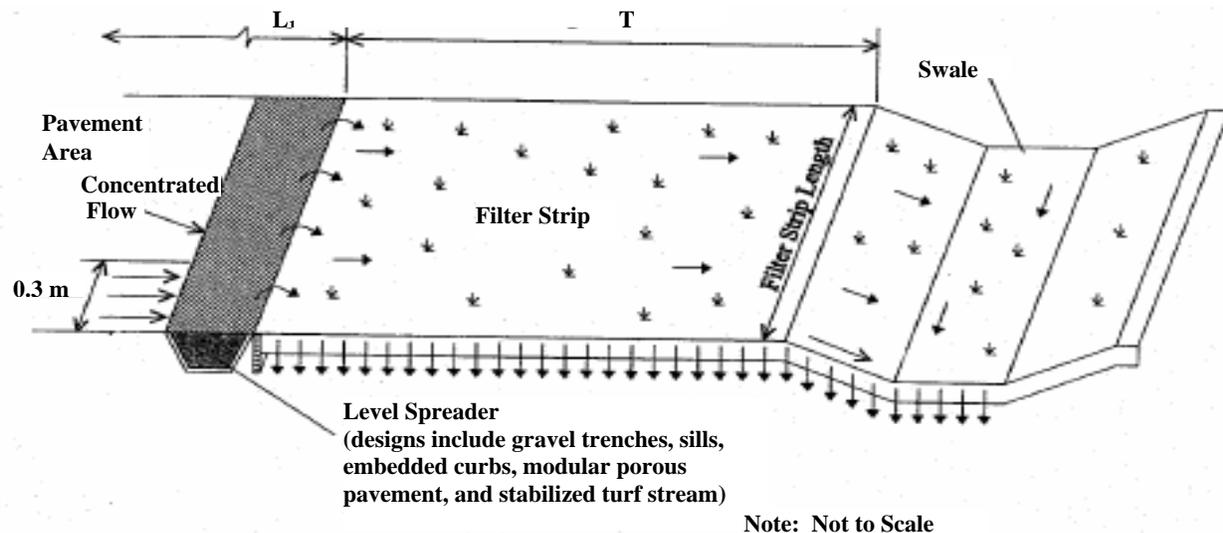


Figure 3-12. Typical Vegetated Swale and Vegetated Filter Strip

²¹ California Stormwater Quality Association, “California Stormwater BMP Handbooks, New Development and Redevelopment Handbook”, TC-30, January 2003.

²² California Stormwater Quality Association, “California Stormwater BMP Handbook - New Development and Redevelopment”, TC-30, 2003.

Appendix D provides an example of how to calculate a peak flow for designing vegetated swales.

Layout and Geometry Requirements

The topography of the site shall be used or re-graded as needed to design a channel with appropriate slope and cross-sectional area. Site topography may also dictate a need for additional structural controls.

- 1) Swales are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2 acres preferred.
- 2) Trapezoidal channels are normally recommended, but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.
- 3) If the design peak for the WQ_v calculated per the requirements of Section 3.3.6.1 is larger than 1 cfs, then more than one swale shall be provided in order to maintain sheet flow and shallow flow depths within the swale. Flow shall be distributed among the swales to keep peak flows during the WQ_v design event less than 1 cfs in each.
- 4) Use Manning's Equation to design the swale under peak WQ_v design storm conditions, using criteria within this section to establish design limits for the swale.
- 5) The swale shall be designed so that the water level does not exceed 3 inches at the design peak flow for the WQ_v .
- 6) It is recommended that longitudinal slopes along the swale shall not exceed 2.5 percent, and shall be milder if necessary to keep the peak velocity within the swale less than 0.9 feet/second. However, longitudinal slopes may range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.
- 7) The width of the swale should be determined using Manning's Equation, at the peak flow during the water quality design storm, using a Manning's "n" of 0.25. The maximum bottom width shall not exceed 10 feet unless a dividing berm is provided.
- 8) The swale shall have a length that provides a minimum hydraulic residence time, or the time it takes for the water to pass through the swale, of at least ten minutes. Regardless of the hydraulic residence time, the length of the swale shall not be less than 100 feet.
- 9) Swales may be designed to safely convey storms generating more than the WQ_v according to criteria provided in Section 2.3.7. The peak velocity of the 10-year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See

Table 2-17 for maximum allowable velocities). Three inches of freeboard should be provided.

- 10) The side slopes of the swale shall be no steeper than 4 (H) to 1 (V).

Vegetation Requirements

Swales must be vegetated in order to provide adequate treatment of runoff. It is important to maximize water contact with vegetation and the soil surface. For general purposes, select fine, close-growing, water-resistant grasses, per CMSC Section 659 on seeding and mulching and CMSC Section 653 on topsoil. Where possible, one or more of these grass seeds shall be in the seed mixes specified by CMSC. If possible, divert runoff (other than necessary irrigation) during the period of vegetation establishment. Where runoff diversion is not possible, cover graded and seeded areas with suitable erosion control materials.

The surface shall be graded flat prior to placement of vegetation. Initial establishment of vegetation shall receive attentive care, including appropriate watering, fertilization, and prevention of excessive flow, until vegetation completely covers the area and is well established. Use of a permanent irrigation system to keep the vegetation alive and healthy during droughts may help provide maximal water quality performance.

Pretreatment Requirements

Runoff shall enter swales as sheet flow. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc.) designed according to criteria in Section 2.3.6 to facilitate overland sheet flow may be allowed by the Division of Sewerage and Drainage, but is not normally recommended because of maintenance considerations and the potential for standing water.

3.3.6.2 Vegetated Filter Strips²³

Grassed filter strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and allowing sediment and other pollutants to settle and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. In addition, the public views them as landscaped amenities and not as stormwater infrastructure.

Filter strips consume a large amount of space relative to other BMPs. They are best suited to treating runoff from roads and highways, roof downspouts, small parking lots, and pervious surfaces. They are also ideal components of the "outer zone" of the Stream Corridor Protection Zone, or as pretreatment to a structural practice. Filter strips are generally impractical in ultra-urban areas where little pervious surface exists.

²³ California Stormwater Quality Association, "California Stormwater BMP Handbooks, New Development and Redevelopment Handbook", TC-31, January 2003.

Hydrology Requirements

Vegetated filter strips are designed to treat the entire WQ_v from the tributary area. Since treatment occurs as stormwater “flows through” the filter strip, it is necessary to develop a design peak flow for the WQ_v representative of flow conditions that maximize treatment and retard flow. The following procedure shall be used to develop the design peak flow.

- 1) Determine the time of concentration for the area draining into the filter strip, using the methodology in Section 2.2.2.2.
- 2) Define the peak intensity of the design storm producing the WQ_v using the intensity-duration-frequency curve for Central Ohio (Figure 2-1). For example, a basin with a time of concentration of ten minutes would have a peak rainfall intensity of approximately 1.5 inches/hour.
- 3) Use the rational method (Section 2.2.3.1) and the runoff coefficients in Table 3-3 to determine the peak flow through the swale or filter strip.

Appendix D provides an example peak flow calculation for designing vegetated swales.

Layout and Geometry Requirements

Filter strips shall be gently sloping areas between 1 and 15 percent with a robust and diffuse vegetative cover. Concentrated flow shall not be allowed to occur along filter strips, as it causes erosion that effectively eliminates water quality benefits.

- 1) Filter strips are generally recommended for drainage areas less than 5 acres , with a total drainage area of 1 to 2 acres preferred.
- 2) Use Manning’s Equation to design the filter strip under peak WQ_v design storm conditions, using criteria within this section to establish design limits for the strip. A wide channel assumption shall be used for determining cross-sectional parameters of the filter strip.
- 3) Only sheet flow shall be allowed to enter the filter strip. The maximum length “ L_1 ” of the overland flow path (see Figure 3-12) shall be no longer than 100 ft to prevent flow from concentrating, unless a level spreader is used to convert concentrated flow to sheet flow prior to entering the filter strip.
- 4) The filter strip shall be designed so that the water level does not exceed 1 inch at the design peak flow for the WQ_v .
- 5) Runoff flow velocities shall not exceed 1 foot/second across the filter strip.
- 6) The vegetative surface shall extend across the full width of the filter strip area. The upstream boundary of the filter strip shall be located contiguous to the developed area.

- 7) Maximum length "T" on Figure 3-12, measured in the direction of flow shall comply with the criteria for determining the maximum length of sheet flow provided in Section 2.2.2.2.
- 8) Minimum length of the filter strip (in the direction of flow) shall be 15 feet.
- 9) The width of the filter strip shall be the same as the tributary area (i.e., no concentration of flow from the contributing area is allowed).
- 10) Both the top and toe of the slope shall be as flat as possible to encourage sheet flow and prevent erosion. The top of the filter strip shall be installed 2 to 5 inches below the adjacent pavement, so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering.
- 11) Filter strips shall be designed to drain between storms and not allow pollutants to migrate into the groundwater. To satisfy this requirement, filter strips may only be installed in areas where the seasonal groundwater level is at least 2 feet below the filter strip, based on the Franklin County Soil Survey or a soils report prepared to support project design.

Vegetation Requirements

The vegetation requirements for filter strips shall be identical to those provided for vegetated swales in Section 3.3.6.2.

Pretreatment Requirements

Runoff shall enter filter strips as sheet flow. Use of a level spreading device (vegetated berm, sawtooth concrete border, rock trench, etc.), designed according to criteria in Section 2.3.6 to facilitate overland sheet flow, may be allowed by the Division of Sewerage and Drainage, but is not normally recommended because of maintenance considerations and the potential for standing water.

3.3.6.3 Dry Extended Detention Swales

Dry extended detention swales incorporate a combination of dry cells formed by check dams or other means and filtering media to treat stormwater runoff by settling, absorption, decomposition, and filtration. The practical applications for dry extended detention swales are low density residential projects or for very small impervious areas. Sites utilizing dry extended detention swales for water quality control may incorporate additional storage and outlet structures to meet the stormwater quantity control requirements of Section 3.2. A schematic of a dry extended detention swale is shown in **Figure 3-13**.

Hydrology Requirements

Dry extended detention swales shall be designed to capture and store the entire WQ_v and release it in no less than 24 hours and no longer than 40 hours. Water retained within the swale may be released through an outlet at the downstream end of the swale and/or by infiltration into the soil. The native soils shall be replaced with a 30-inch deep layer of permeable soils underlain with an underdrain system. The following criteria shall apply to the design of dry extended detention swales.

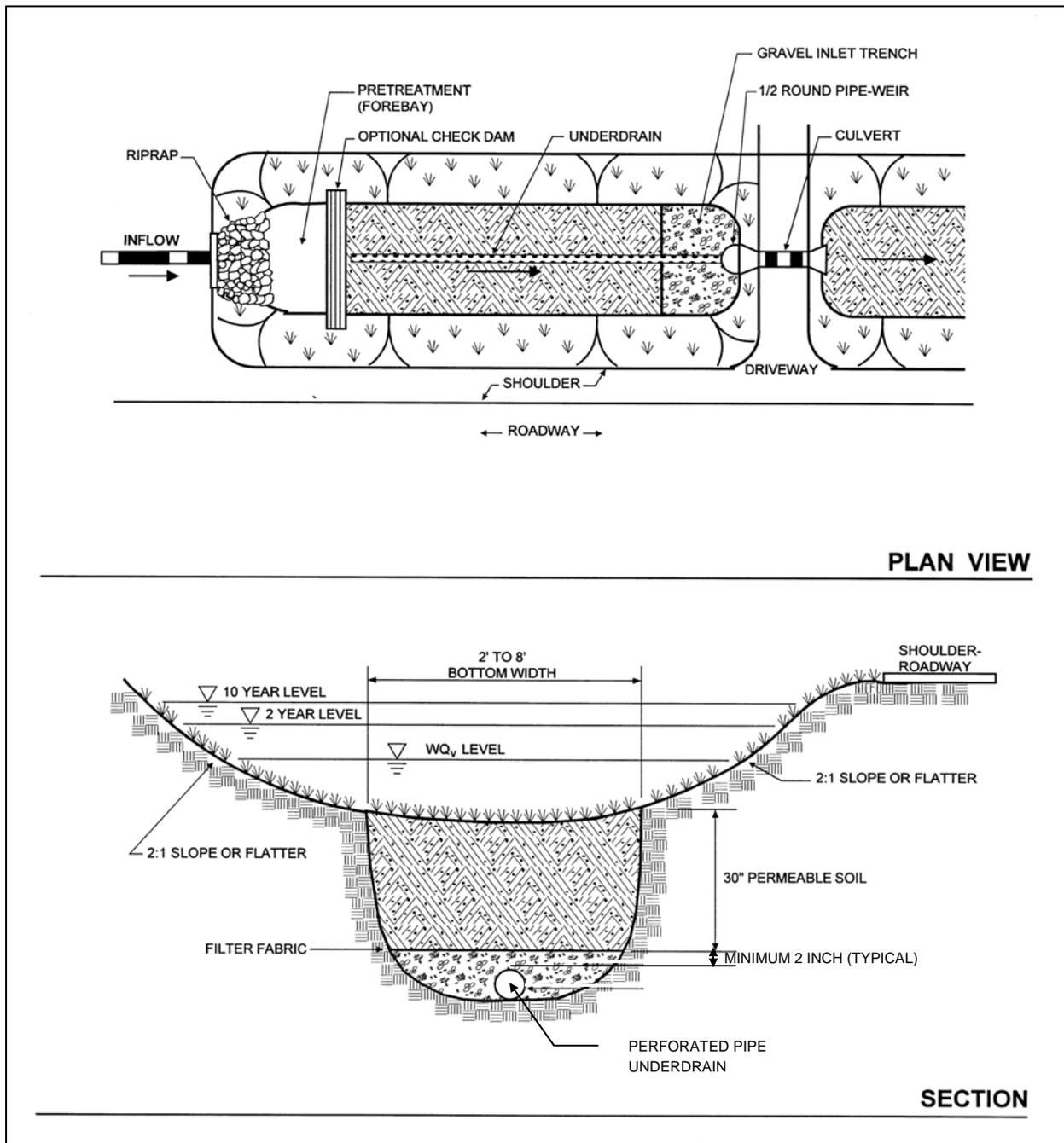


Figure 3-13. Schematic of Typical Dry Extended Detention Swale²⁴

²⁴ Maryland Department of the Environment, *Maryland Stormwater Design Manual, Volume I*, 2000, pg. 3.43

Layout and Geometry Requirements

- 1) The total recommended drainage area of a dry extended detention swale is 5 acres, with a total drainage area of 1 to 2 acres preferred. Multiple cells should be considered to distribute the flow and facilitate proper drainage of the facility.
- 2) Dry extended detention swales shall not be allowed in areas where the water table or bedrock is above the invert of the underdrain system.
- 3) In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.
- 4) Dry extended detention swales should maintain a maximum ponding depth of one foot at the "mid-point" of the channel's longitudinal profile, and a maximum depth of 18 inches at the downstream end point of the channel for storage of the WQ_v. Check dams or similar structures may be installed along the longitudinal profile to meet this criteria.
- 5) The side slopes for dry extended detention swales shall not exceed 4 (H) to 1 (V).
- 6) Swales may be designed to safely convey storms generating more than the WQ_v according to criteria provided in Section 2.3.7. The peak velocity of the 10-year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See Table 2-17 for maximum allowable velocities). Three inches of freeboard should be provided.

Permeable Soil Requirements

The function of a dry extended detention swale is largely dependent on the characteristics of the soils underlying the swale. The soil underlying the swale shall be replaced with a 30-inch layer of permeable soil underlain with an underdrain system in order to provide proper drainage of the swale. The following criteria shall be used:

- 1) The permeable soil for dry extended detention swales shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates greater than 0.5 inches per hour when saturated, achieved through the following standards²⁵:
 - a. 4 parts sand (per CMSC 703.06)
 - b. 2 parts topsoil (per CMSC 653.02)
 - c. 2 parts compost (per ODOT CMSC 659.06). Note: Com-Til Compost from DOSD's Compost Facility is acceptable for use in dry extended detention swales.
- 2) Soil tests shall be performed for every 500 cubic yards of soil, with the exception of pH and organic content tests, which are required only once per dry extended detention swale.

²⁵ ODOT, "Location and Design Manual, Volume 2, Drainage Design", Section 1116.7

- 3) The minimum depth of the filter media shall be at least 30 inches.
- 4) Dry extended detention swales shall be planted with grass that can withstand prolonged periods in a wet environment. No vegetation with a deeper root zone shall be allowed within the swale.

Underdrain and Outlet Requirements

- 1) A perforated pipe underdrain shall be provided beneath the permeable soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 4 or 6 inches, and shall meet the requirements of CMSC Section 720.07 or 720.12. A granular backfill of durable No. 57 aggregate in accordance with CMSC Section 703.01 shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.
- 2) The swale shall be designed to convey or divert all storms larger than the WQ_v up to and including the 100 year event. Storms larger than the WQ_v may be directed into a storm sewer system. Use of a vertical stand pipe or catch basin is recommended.

Pretreatment

Flow entering the dry extended detention swale shall be limited to sheet flow to prevent eroding the side slopes of the facility. If flow has been concentrated prior to entering the swale, it shall be converted to sheet flow using a level spreader designed according to criteria in Section 2.3.6. In addition, the frequency of maintenance for dry extended detention swales may be reduced by providing filter strips around the facility. The purpose of the filter strip is to trap coarse sediments before they reach permeable soil thereby reducing maintenance and preserving infiltration capacity. The design of filter strips is presented in Section 3.3.6.

3.3.7 Group 4 – Water Quality Controls for Commercial Activity Areas

The three groups of approved stormwater quality controls defined in the previous sections are appropriate for most commonly-occurring stormwater pollutants. Some pollutant sources, however, are not effectively controlled by the BMPs in the other three categories because they involve activities, materials, and/or wastes that are atypical of the commonly-occurring stormwater pollutants, in either the type or the concentration of the constituents found. These “high risk” pollutant sources must be either controlled separately or “pretreated” before being conveyed to one of the other three categories of BMPs.

A high-risk pollutant source is one possessing pollutant loads and/or concentrations that are different than typical urban runoff, as characterized by the USEPA National Urban Runoff Program (NURP), presenting an immediate threat to water quality, and/or interfering with the successful operation of other approved stormwater controls. These sources most commonly occur within commercial activity areas associated with commercial and industrial land uses. This section defines the types of businesses where such pollutants commonly are found, the specific activities known to generate these pollutants, and controls required in order to receive necessary development approvals from the City.

3.3.7.1 Businesses Subject to Controls for High-Risk Pollutant Sources

The controls in this section shall apply to the following business categories and/or activities:

- 1) Any business considered by U.S. EPA and Ohio EPA to involve industrial activities and require an NPDES permit for stormwater discharges from industrial activities. Such businesses are defined by Standard Industrial Classification (SIC) under 40 CFR 122.26. A comprehensive list of these businesses is not provided here, but largely falls within the following SIC Divisions:
 - a. Division B: Mining
 - b. Division C: Construction
 - c. Division D: Manufacturing
 - d. Division E: Transportation, Communications, Electric, Gas, and Sanitary Services
 - e. Division F: Wholesale Trade

Any development containing an industrial activity, as defined by Ohio EPA, shall meet all applicable requirements of Ohio EPA's permit for stormwater discharges from industrial activities. To obtain coverage, a discharger must complete and submit the NOI form available from Ohio EPA along with the appropriate fee to the following address:

**Ohio Environmental Protection Agency
Office of Fiscal Administration
Post Office Box 1049
Columbus, Ohio 43216-1049**

A copy of the NOI shall be submitted to SWMS as part of the Stormwater Management Report.

- 2) Businesses involved in the sale, resale, recycling, repair, fueling, or cleaning of automobiles and other vehicles:
 - a. Major Group 50: Wholesale Trade Durable Goods (including 5015 - Used Motor Vehicle Parts and 5093 - Scrap and Waste Materials)
 - b. Major Group 51: Wholesale Trade Non-durable Goods (including 5171 - Petroleum Bulk Stations and Terminals)
 - c. Major Group 55: Automotive Dealers and Gasoline Service Stations
 - d. Major Group 75: Automotive Repair, Services, and Parking

- 3) Businesses that involve the preparation or sale of food:
 - a. Major Group 54: Food Stores
 - b. Major Group 58: Eating and Drinking Places
- 4) Other businesses that store or handle materials outdoors:
 - a. Major Group 52: Building Materials, Hardware, Garden Supply, and Mobile Home Dealers
 - b. Other businesses identified by the City with significant outdoor material or waste storage, handling, or disposal

3.3.7.2 Commercial Activity Areas Requiring Control

The control requirements in this section of the manual only apply to commercial activity areas of the businesses in the previous section, defined as outdoor areas where the following activities are conducted or are otherwise exposed to stormwater:

- 1) Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas,
- 2) Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed, and
- 3) Areas where the high-risk materials defined in **Table 3-8**²⁶ are handled and stored, including but not limited to loading docks, fuel and other liquid storage/dispensing facilities; material bins, containers, stockpiles, and other storage containers; and waste dumpsters, bins, cans, tanks, stockpiles, and other waste containers.

3.3.7.3 Requirements for Commercial Activity Areas

Commercial activity areas that, in the judgment of the Administrator cannot be conducted indoors, shall be conducted within specified areas of the site designed to control stormwater quality. The Construction Drawings shall delineate commercial activity areas and show the location of any stormwater control measure. The Stormwater Management Report shall describe the commercial activity, the rationale for the control measure selected, and design information about the control measures. Stormwater runoff from each commercial activity area shall be controlled in the following manner:

- 1) Non-stormwater discharges from commercial activity areas, including discharges from any indoor areas, the lower floors of a multi-level parking structure, and/or areas under a roof, shall not be allowed to co-mingle with stormwater runoff from the remainder of the site.

²⁶ City of Portland, OR, "Stormwater Management Manual", Adopted July 1, 1999, Revised September 1, 2004

Table 3-8
Control Requirements for Materials Handling Areas

High Risk Materials	Low-Risk Materials	Exempt Materials
<p>Required controls: Conduct activities indoors, as allowed by City regulations, or outdoors with controls defined in this section.</p>	<p>Required controls: Use temporary covers of plastic film or sheeting, with runoff directed to approved BMPs for the site.</p>	<p>Required controls: Direct runoff to approved BMPs for the site.</p>
<p>Materials to control:</p> <ul style="list-style-type: none"> • Recycled materials with potential effluent • Corrosive materials (i.e. lead-acid batteries) • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Asphalt • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human waste 	<p>Materials to control:</p> <ul style="list-style-type: none"> • Recycled materials with potential effluent • Scrap or salvage goods • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products with potential effluent • Unwashed gravel/rock • Compost 	<p>Materials to control:</p> <ul style="list-style-type: none"> • Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Glass products (new, non-recycled) • Inert products • Materials with no measurable solubility or mobility in water • Materials with no hazardous, toxic, or flammable properties • Gaseous materials

- 2) The area shall be paved with asphalt or concrete unless otherwise approved by the Division of Sewerage and Drainage.
- 3) Non-stormwater discharges from commercial activity areas shall be directed to separate treatment systems approved by the Administrator that are able to adequately control stormwater pollutants generated within these areas. These systems include, but are not limited to the following:
 - a. The City's separate sanitary sewer system, providing the discharge is permitted by the City, meets all applicable pretreatment requirements (determined by contacting the City's Industrial Waste Pretreatment Program at 614-645-5876), and is regulated with a shutoff valve.
 - b. An oil/water separator to remove uncharacteristically high concentrations of oil and grease, with treated effluent discharged to the separate sanitary sewer system.
 - c. A system appropriate for the containment of hazardous material spills, designed as specified in Ohio Fire Prevention Code Section 1301 : 7-7.
 - d. An industrial treatment system covered by a discharge permit issued by Ohio EPA.
- 4) The following basic principles for integrated stormwater/wastewater management for commercial activity areas shall be followed:

- a. Only stormwater (i.e., runoff directly caused by a precipitation event) should enter storm drains (e.g., no wash water, spills, leaks, etc.) unless specifically allowed under the City's NPDES stormwater permit. Clean rinse waters (no cleaning agents but with potable water chlorine residual) may be allowed to run onto grassed areas to infiltrate.
 - b. Stormwater/wastewater management strategies must be consistent with existing codes (e.g., building, plumbing, fire), sanitary sewer regulations, (e.g., pretreatment), and environmental regulations (e.g., HAZMAT, SPCC).
 - c. Outdoor material cleaning, storage, handling, and disposal should be minimized.
- 5) Minimize potential exposure of commercial activity areas to stormwater by the following methods²⁷:
- a. Minimize the size of the commercial activity area.
 - b. Prevent rainfall from entering the area using a cover or roof, with a minimum overhang of 3 feet on each side for covers 10 feet high or less, a minimum overhang of 5 feet on each side for covers higher than 10 feet, and rooftop drainage directed to the storm drainage system.
 - c. Surround above ground liquid containers with a containment device with enough capacity to capture at least 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.
 - d. Isolate high-risk pollutant areas from stormwater run-on by berming or providing grade breaks around the area perimeter.
- 6) Where wash waters are unavoidable, the Applicant shall propose one of the following disposal options depending upon the nature of the activity, the constituents involved, and other pertinent Federal, State, or City regulations:
- a. Dispose in a sanitary sewer, with appropriate restrictions and/or pretreatment.
 - b. Direct to sump/containment, allow to evaporate, and sweep up residual.
 - c. Direct to sump/containment, pump out, and haul to appropriate disposal facility.
- 7) When contamination of stormwater runoff from commercial activity areas is unavoidable (according to building codes, etc.), it may be directed to a sanitary sewer at the discretion of the Stormwater and Regulatory Management Section

²⁷ City of Portland, OR, "Stormwater Management Manual", Adopted July 1, 1999, Revised September 1, 2004

3.3.8 Applicant-Proposed Stormwater Controls

There are many types of commercially-available proprietary systems for stormwater quality control. These systems include:

- 1) Hydrodynamic systems such as gravity and vortex separators,
- 2) Filtration systems,
- 3) Catch basin media inserts,
- 4) Chemical treatment systems,
- 5) Package treatment plants, and
- 6) Prefabricated detention structures .

This section provides stormwater treatment and quantity control criteria for vendors and/or Applicants requesting approval of these systems for use in the City. Stormwater controls proposed in lieu of those defined in this section must, at a minimum, meet the performance standards established in this section.

Performance Standards for New Development Controls

The pollutant removal effectiveness for total suspended solids (TSS) that is achieved by the other stormwater quality controls in the Manual establish the required performance standard for alternative or manufactured facilities. Total suspended solids are defined as “matter suspended in stormwater, excluding litter, debris, and other gross solids exceeding 1 millimeter in diameter (larger than coarse sand)”. Typical urban runoff contains about 100 mg/L TSS,²⁸. Extended dry and wet detention basins, vegetated swales, and sand filters designed according to the criteria in the Manual are effective at removing very small particles down to the range of 10 microns to 20 microns, achieving effluent TSS concentrations of 15 to 30 mg/l, on average ²⁹. Based on these statistics, the Applicant must demonstrate that the BMP is able to remove all particles larger than 15 microns and yield a maximum effluent concentration of 20 mg/L.

Controls for new development shall also achieve an equivalent level of stormwater quantity control during the WQ_v event as is achieved by the controls included in the Manual. This involves controlling the increase in the peak flow rate of stormwater runoff during the WQ_v event, either by preventing volume increases and/or reducing the post-development peak flow:

- 1) Preventing runoff volume increases typically is achieved with stormwater infiltration, defined as a control that discharges the entire WQ_v either into the ground or through evapotranspiration. Infiltration controls are generally not feasible in the hydrologic soil groups C and D that predominate most of the City. Infiltration controls may be approved

²⁸ U.S. EPA, Section 403 Report to Congress, 1995.

²⁹ California Stormwater BMP Handbook, New Development and Redevelopment, MP-51.

by the City if the applicable NRCS soil survey indicates that the site contains hydrologic soil group A or B soils required for infiltration controls, or if the site will be modified using amended soils that yield infiltration rates and volumes equivalent to those achieved by hydrologic soil group A or B soils. Applicants shall submit appropriate information to demonstrate that stormwater infiltration is achievable in these situations.

- 2) Other controls recommended in the Manual control the post-development peak flow. Such decreases maintain the erosive energy of stream flow that causes stream erosion. Applicants must demonstrate that alternative controls are able to achieve this same decrease in the energy of post-development stormwater flows. This is done by demonstrating that the entire WQ_v will be released from the device in no less than 24 hours.

Performance Standards for Redevelopment Controls

Ohio EPA has established reduced stormwater quality management criteria for redevelopment projects as presented in Section 3.3.7.2. Alternative or manufactured stormwater control facilities will be considered as an acceptable alternative for redevelopment sites if the Applicant demonstrates that they are able to remove all particles larger than 100 microns and yield a maximum effluent concentration of 45 mg/L.

Required Standards Other than Treatment Performance

Applicants must demonstrate that alternative or manufactured controls meet the following additional performance standards:

- 1) ***Site Conditions*** – The facility design shall be appropriate for site conditions in central Ohio. The Applicant shall demonstrate that the control has operated successfully for at least three (3) years in conditions similar to central Ohio, including soils, groundwater, head loss, and climate.
- 2) ***Durability*** – The control must be made of materials able to withstand climatic and land use conditions in central Ohio, including exposure to stormwater, exposure to light, freeze-thaw cycles, and vandalism. The expected life of the major structural components of the control shall be at least 20 years.
- 3) ***Access*** – The design of the control shall facilitate maintenance. Access and/or inspection ports shall be provided to all portions of the facility where debris or sediment may collect, or maintenance shall be required. The design shall allow access for a single individual to conduct required maintenance and inspection activities using conventional sewer maintenance equipment.
- 4) ***Large Storms*** – The facility design shall accommodate storm events larger than the WQ_v by either bypassing its flow around the facility or passing the flow through the facility without re-suspending pollutants and other materials previously captured within the facility.

- 5) **Operation and Maintenance** – A maintenance history shall be provided for at least three (3) years of continuous operation. This history shall illustrate that the level of maintenance required for the facility is equivalent to the other facilities in the Manual.
- 6) **Mosquito and Vector Control** – The Applicant shall demonstrate that the control is designed to minimize and/or control conditions that breed mosquitoes or other vectors, defined in Section 3.3.3 of the Manual.

Testing and Submittal Requirements

The Applicant shall provide the City with studies or other documentation that the recommended control facility meets the requirements of this section. BMP performance must be conducted or prepared by an independent third-party and not by the BMP manufacturer. Final approval for the use of any alternative stormwater quality BMP will be given at the discretion of the Administrator. The testing and submittal requirements shall be based on the Protocol for Stormwater Best Management Practice Demonstrations, current edition, developed by The Technology Acceptance Reciprocity Partnership. More information on this publication can be found at the following website:

<http://www.dep.state.pa.us/dep/deputate/pollprev/techservices/tarp/>

3.4 As-built Surveys

As-built surveys will be required from the developer or property owner responsible for constructing stormwater facilities and conveyance systems. At a minimum, the developer shall field survey the location of each stormwater outfall and the outfall structure of each stormwater (quantity and quality) control structure that is constructed as part of the development site. Only stormwater outfalls that discharge directly into an open watercourse need to be located. **Exhibit A** and **Exhibit B**, provided in **Appendix G**, shall be complete and submitted to the Division of Sewerage and Drainage for each outfall and stormwater control structure that were constructed as part of the project.

As a condition of final acceptance, the property owner shall be responsible for providing as-built surveys to verify the final grades and elevations of stormwater detention basins and wetlands that are to be owned and operated by the City. The City reserves the right to require as-built surveys on privately owned stormwater facilities if, in the opinion of the Division of Sewerage and Drainage:

- 1) The construction of the privately owned stormwater system may affect the performance of a publicly owned stormwater system, or
- 2) Final grading within a stormwater control facility or conveyance system appears to conflict with the approved grading plans.

The purpose of as-built surveys is to demonstrate conclusively that the facilities are constructed to the elevations, slopes, grades, and volumes shown on the approved plans on file with the City.

When ordered by the City to ensure that design grades and volumes within stormwater control facilities are achieved, an as-built survey shall be conducted once:

- 1) All structures on surrounding lots of a stormwater control facility are constructed and final lot grading for each lot is established, and
- 2) The conversion of a temporary sediment basin to a permanent stormwater control facility is complete after the site is built-out to the point where the temporary sediment basin is no longer needed. As-built surveys will only be accepted if they are conducted after the sediment in the temporary basin has been removed and regraded, vegetation has been established, and the permanent riser structure(s) is in place.

As-built surveys shall be conducted by a Professional Surveyor registered in the State of Ohio and shall employ standard survey techniques. The Professional Surveyor performing the as-built survey shall be responsible for reduction of notes and any plotting necessary to make the notes interpretable. A final report and original field notes shall be furnished to the City for review and record purposes. A minimum of two bench marks that are referenced to the same vertical datum as the construction plans shall be provided on the as-built survey drawings. As-built surveys shall be in addition to, and separate from, other construction surveys which the City or its agents may conduct. The developer, contractor, or other entity constructing the stormwater facilities shall correct the discrepancies necessary to ensure that the stormwater facility will function as designed. The as-built surveys shall be re-performed as necessary to demonstrate plan conformance.

3.5 Construction Stormwater Quality Controls

Construction stormwater quality control facilities shall be designed to control runoff from construction sites during storm events before being discharged into watercourses, lakes, and/or wetlands. The requirements for construction best management practices (BMPs) are intended to adequately reduce sediment and related pollutants contained in construction stormwater runoff. In general, a Stormwater Pollution Prevention Plan (SWPPP) is required for qualifying development sites and must be submitted with the construction plans as part of the plan approval process. Projects that are not required to submit a SWPPP are still required to implement construction BMPs regardless of size. The City's Erosion and Sediment Pollution Control Regulation (Regulations) sets forth the runoff control and erosion and sediment control standards as well as the plan requirements for SWPPPs. A copy of the City's Regulations is provided in Appendix A.

3.5.1 Additional Requirements

Over the years it has been necessary for the Division of Sewerage and Drainage to adopt additional standards for the design and placement of construction site BMPs. Changes in technology and regulatory requirements have made it necessary to develop additional criteria intended to supplement the standards provided in the Regulations. The following additional criteria shall apply to development projects planned within the City of Columbus:

- 1) The City of Columbus utilizes the ODNR (Ohio Department of Natural Resources) manual: Rainwater and Land Development, latest edition, as the principal reference for erosion and sediment control practices and standards.
- 2) Stormwater Pollution Prevention Plans – Stormwater Pollution Prevention Plans are required for sites that will disturb at least one acre or more. SWPPPs are not required on sites smaller than one acre, however, the implementation of construction stormwater BMPs is required. For sites with less than one acre of disturbance, a general note is required and provided in **Appendix F, Exhibit E**.
- 3) Sediment Basins – Sediment basins and appropriately sized risers are required to control sediment discharges for locations receiving runoff from tributary areas of 5 acres or more.
- 4) The use of straw bales for catch basin and curb inlet protection is not an approved practice in the City of Columbus.

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Stormwater Drainage Manual



Part I
Section 4

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Section 4

Operation and Maintenance of Stormwater Controls

This section provides requirements to ensure successful performance of stormwater control facilities once they have been constructed. Included in this section are requirements for as-built surveys, facility inspection and maintenance, and maintenance and access easement requirements to allow for maintenance in and around stormwater facilities.

4.1 Stormwater Control Facility Maintenance Responsibilities

It is essential that any approved stormwater control facility be properly maintained in order to assure its performance. The City will maintain eligible onsite detention basins and constructed wetlands designed to serve single-family residential developments. To be eligible for City maintenance services, the owner of the stormwater detention basin or wetland must:

- 1) Have established vegetation within and around the facility, if applicable,
- 2) Have designed and constructed the facility in accordance with City standards and proven by As-built Surveys,
- 3) Have the facility in proper working order at the time the City accepts maintenance responsibilities, and
- 4) Provide to the City specific, dedicated easement rights sufficient to perform required maintenance.

Onsite facilities, other than stormwater detention basins and constructed wetlands in single-family residential developments, shall be maintained by the Property Owner or, if applicable, a homeowners association. Onsite facilities constructed to serve privately-owned non-single family residential developments (i.e., multi family, commercial, industrial, etc.) shall be maintained by the Property Owner.

4.1.1 Stormwater Control Facility Easement and Access Requirements

For stormwater control facilities that are to be operated and maintained by the City, the Property Owner shall provide the City with an easement that includes the area of the control facility when flooded during the 100-year event, appurtenances to the facility such as forebay(s), benches, risers, outlet pipes, etc., and a minimum width of 20 feet around the perimeter of the facility. For basins that are to be publicly maintained, the Property Owner shall provide an easement extending 20 feet beyond the maximum flood limits of the facility around the basin and its appurtenances. A dedicated access easement, having a minimum width of 20 feet, shall also be provided that extends from the facility easement to the nearest public right-of-way.

For facilities that are to be maintained by a homeowners association, the developer shall provide to the City a minimum 20-foot wide easement for such inlet and outlet pipes, etc., conveying stormwater to a public conveyance system.

For stormwater control facilities that are to be operated and maintained by the City or a designated homeowners association, the Property Owner shall provide the City with a maintenance vehicle accessway having a minimum width of 20 feet. The accessway shall be located around the perimeter of each facility, into the bottoms of detention basins, and to each inlet structure and outlet structure. Vehicle accessways shall have a cross slope no steeper than 10 (H) to 1 (V) (and shall be sloped toward the direction of detention basin facilities). The vehicle accessway shall be stabilized with suitable materials (e.g., concrete, gravel, articulated block, geogrids, or other means of stabilization) adequate to prevent rutting by the maintenance vehicles. All access routes shall be designed to allow the turn-around of maintenance vehicles. (Note: These criteria are recommended for basins that will be privately owned and operated. The basin's maintenance plan shall discuss how maintenance access and operations will be performed if alternatives are used).

4.1.2 Stormwater Control Facility Maintenance Plan

A maintenance plan for privately-owned stormwater controls and for stormwater controls other than detention basins or constructed wetlands that are to be maintained by a homeowners association must be prepared and submitted for review and approval by the City for the Applicant during the Plan approval process. At a minimum, maintenance plans for stormwater controls shall include a method and frequency for the following activities:

- 1) Inspection of all permanent structures,
- 2) Debris/clogging control through appropriate removal and disposal ,
- 3) Vegetation control (mowing, harvesting, wetland plants),
- 4) Erosion repair,
- 5) Non-routine maintenance should include pollutant and sediment removal and the "rejuvenation" or replacement of filters and appropriate soils,
- 6) Disposal of collected pollutants, sediments, and filter media in accordance with local, state and federal regulations, and
- 7) Mosquito monitoring and abatement, encompassing inspections for conditions conducive to mosquito breeding, routine (e.g., vegetation control, debris and sediment removal) and non-routine (e.g., restoration of grade to eliminate ponding) activities to address these conditions, and conditions where the use of insecticides may be warranted.

Appendix E provides guidance for the preparation of maintenance plans that summarize the maintenance requirements for each type of stormwater control structure presented in the Manual. Submitted stormwater control maintenance plans shall be customized to appropriately suit the individual facility(s) that are to be constructed. Methods and frequencies for inspections and maintenance activities for stormwater control facilities that are not presented in the Manual shall be provided by the Applicant.

4.1.3 Maintenance Inspection and Reporting Requirements

The Property Owner, its administrators, executors, successors, heirs or assigns shall maintain the stormwater control facility or facilities in good working condition acceptable to the City and in accordance with the schedule of long term maintenance activities provided in the approved stormwater control facility maintenance plan for the stormwater control facility or facilities. Maintained infrastructure shall include all pipes and channels built to convey stormwater to the facility, as well as all structures, improvements, and vegetation provided to control the quantity and quality of the stormwater from the facility. "Maintain" is herein defined as good working condition so that these facilities are performing their design functions.

The purpose of maintenance inspections is to assure safe and proper functioning of the stormwater control facilities. The Property Owner shall perform periodic inspections of the stormwater control facility and its appurtenances at a frequency stipulated in the approved stormwater control facility maintenance plan. Inspections shall cover all elements for the stormwater control facility as defined in the stormwater control facility maintenance plan. Inspections shall include the completion of dated and signed inspection checklists provided in the stormwater control facility maintenance plan and the notation of all deficiencies observed during the inspection. The Property Owner shall maintain copies of complete dated and signed inspection checklists in a maintenance inspection log, along with recorded dates and descriptions of maintenance activities performed by the Property Owner to remedy the deficiencies observed during prior inspections. The maintenance inspection log shall be kept on the property and shall be made available to the City upon request. A copy of the Maintenance Inspection Log shall be submitted annually by December 31st of each year to the Division of Sewerage and Drainage. Maintenance Inspection Logs shall be submitted to:

City of Columbus
Division of Sewerage and Drainage
Stormwater and Regulatory Management Section
1250 Fairwood Avenue
Columbus, Ohio 43206

Where applicable, language explaining the maintenance, inspection, and reporting responsibilities in accordance with approved stormwater control facility maintenance plans shall be provided on the plat and recorded with all deeds to the property.

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Stormwater Drainage Manual



Part II Introduction

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Part II – Submittal Requirements

Part II – Submittal requirements of the Manual contains guidelines and standards necessary to successfully navigate the City’s process for review and approval of proposed development with regard to stormwater management. Section 5 discusses the City’s approval process from the various departments prior to construction. Section 6 defines the information that shall be provided in a stormwater management plan (Plan) accompanying required submittals. Finally, Section 7 presents stormwater management report submittal requirements. Additional questions covering these sections should be directed to the administrator.

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Stormwater Drainage Manual



Part II Section 5

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Section 5

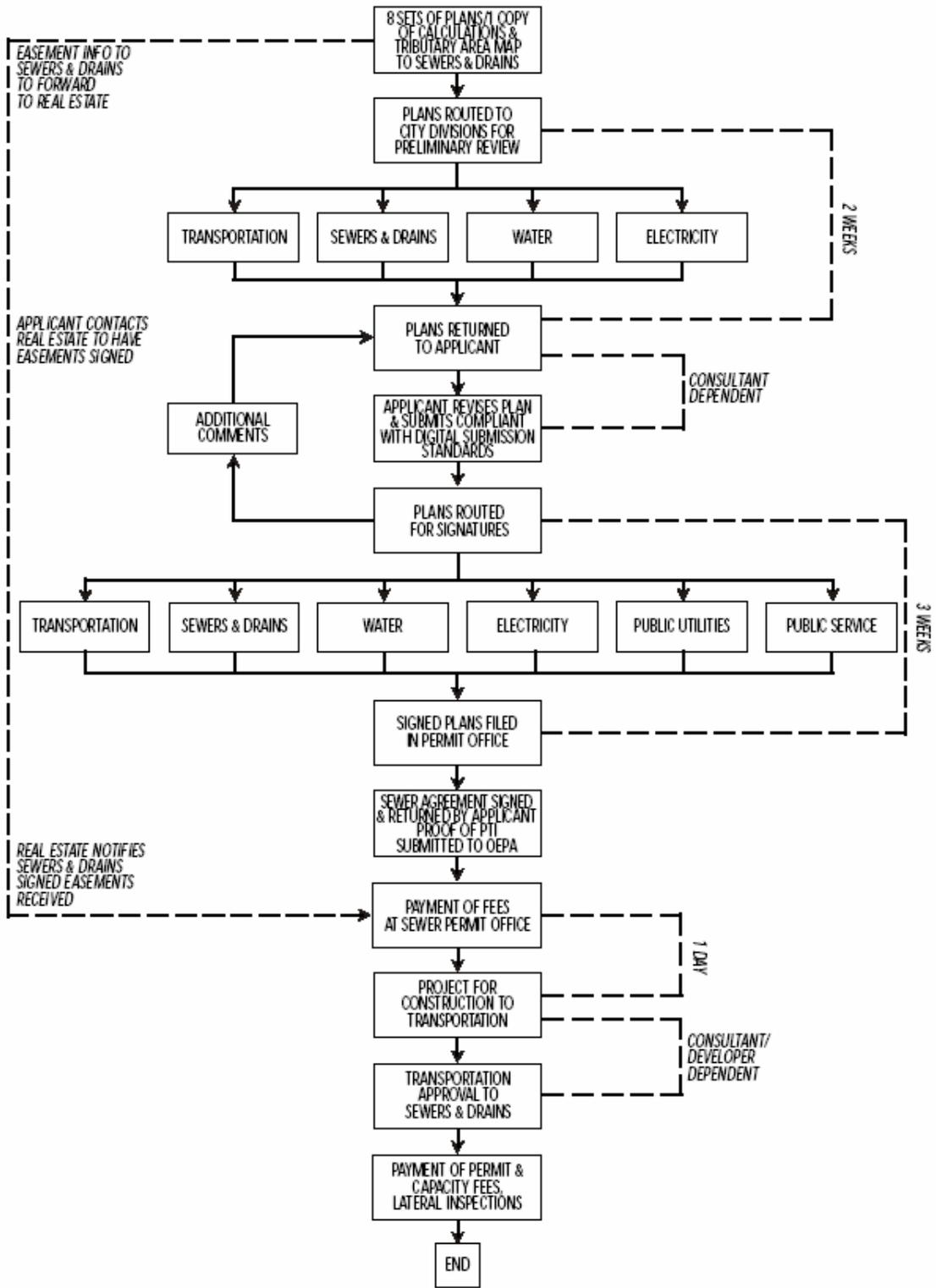
Private and Public Development Review Processes

Any new development, either public or private, proposing to construct stormwater infrastructure within the City, must receive approval from some or all of the following City departments prior to construction, including: Division of Sewerage and Drainage, Division of Water, Division of Electricity, Transportation Division, and the Parks and Recreation Division. Plans for stormwater infrastructure that is to be privately owned are subject to a different review process than facilities that will ultimately be publicly owned and operated. Private stormwater plans, commonly referred to as “CC Drawings” are generally not required to go through a plat approval process as no easements or right-of-way are typically dedicated to the City. Stormwater plans for private infrastructure must be prepared in the format presented in Section 7 and submitted directly to the Division of Sewerage and Drainage, Plan Coordinator at 910 Dublin Road, Columbus, Ohio. Once received by the Plan Coordinator, the draft plans are assigned a CC number and routed to various City departments for review. **Figure 5-1** provides a flow chart illustrating the development review and approval process for CC Drawings.

Stormwater improvements that are to be publicly owned and operated within public right-of-way or in publicly owned easements are incorporated into, and submitted with, the public roadway plans for the development. The public roadway plans are prepared on either “D” or “E” size sheets (referred to as Drawer D or Drawer E plans) in a format specified by the Transportation Division. While the format for Drawer D/E plans is different from the CC Drawing format specified in Section 6, the stormwater improvements that are to be incorporated into Drawer D/E Drawings must be designed in accordance with the standards in the Manual. In addition to meeting different plan format requirements, the Applicant is required to procure approval of a preliminary plat for the development prior to the submission of Drawer D/E plans. **Figure 5-2** provides a flow chart illustrating the public roadway plan review process after the Preliminary Plat is submitted. Both Figures 5-1 and 5-2 are applicable for sanitary and storm sewer drawings and may contain some items not applicable to storm sewer construction. More information on plan review and plat submittal processes is provided in the Columbus Development Guide available on the City’s website.

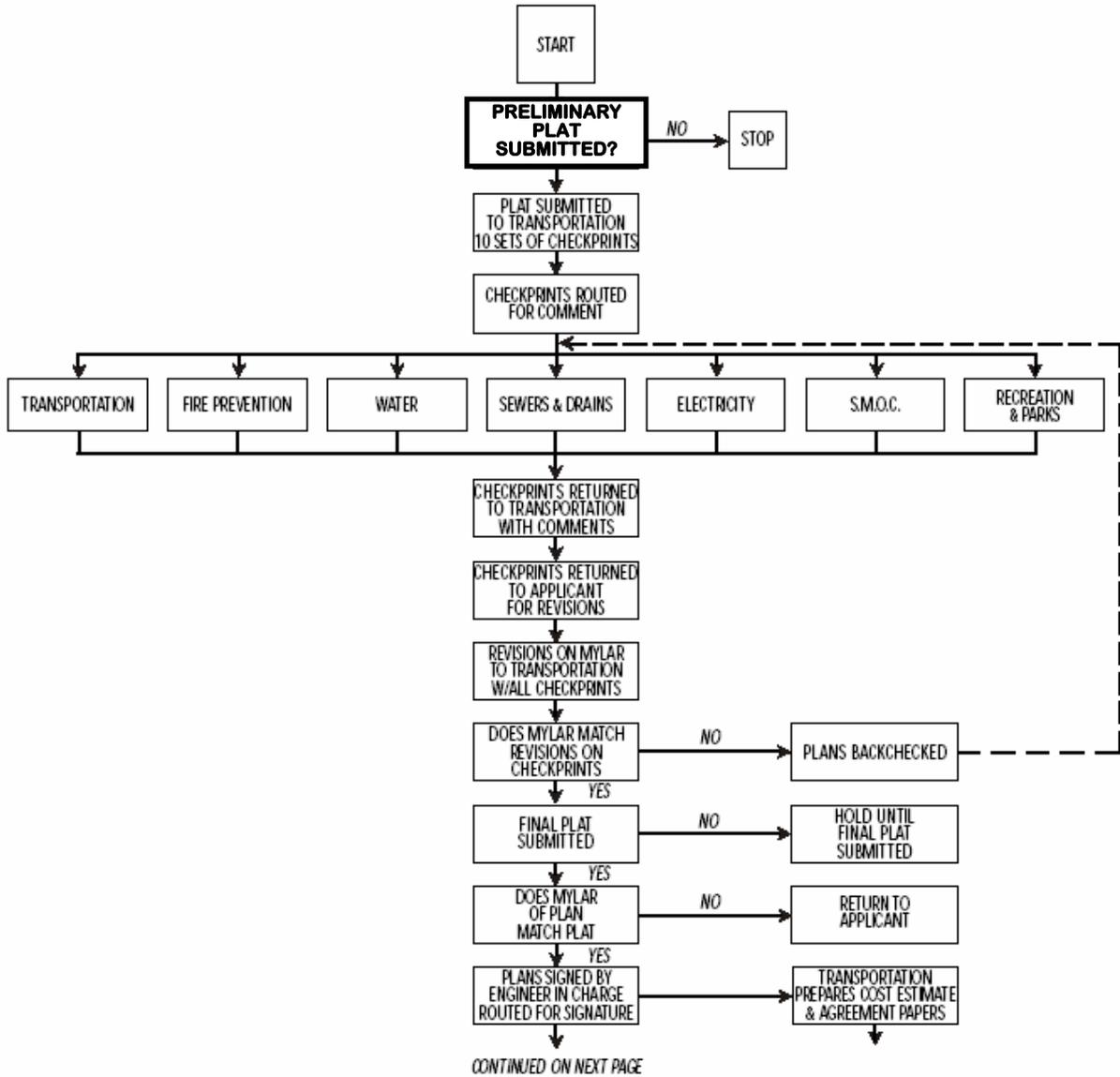
A stormwater management plan is required for review and approval of stormwater systems for both CC Drawings and Drawer D and E drawing submittals. The elements of the stormwater management plan, such as stormwater calculations, maps, permits, etc., are outlined in Section 6. Since the plan format for Drawer D/E plans is not specified by the Division of Sewerage and Drainage, the plan preparation standards presented in the Manual are for CC Drawings only and are shown in normal typeface. Submittal requirements that are specific to only Drawer D/E plans are noted as such.

Figure 5-1
Development Review and Approval Process for CC Drawings¹



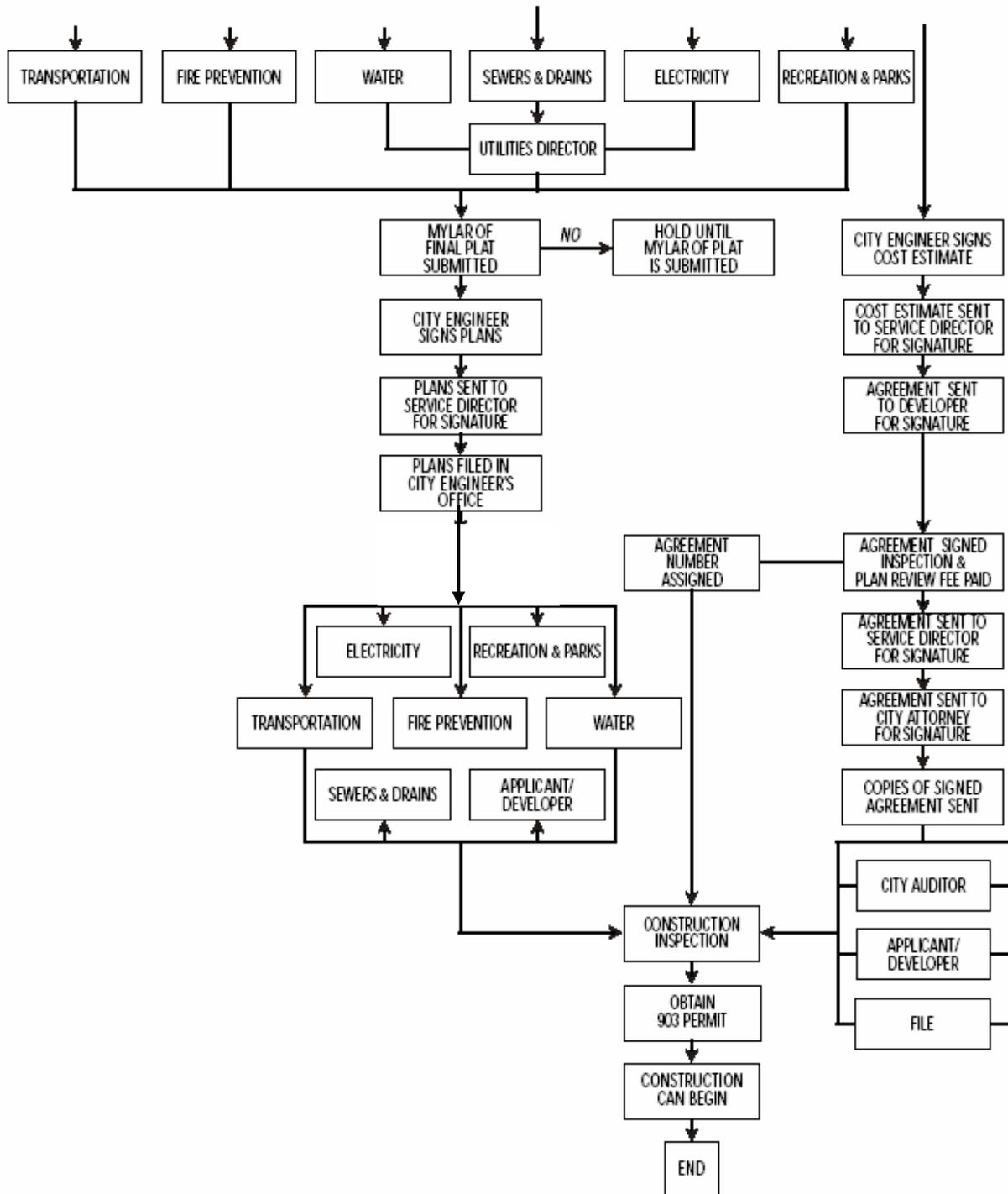
¹ Columbus Development Guide, Chart I.

Figure 5-2
Public Roadway Plan Review Process ²



² Columbus Development Guide, Chart H.

Figure 5-2
(Continued)



Stormwater Drainage Manual



Part II
Section 6

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Section 6

Stormwater Management Report

A stormwater management system shall be designed and incorporated into each development project proposed within the City. The design of proposed stormwater management systems shall be summarized in a bound stormwater management report (Report) and submitted to the City for review and approval. The Report shall contain all pertinent stormwater calculations for detention/retention basins, storm sewers, culverts, open channels, and other stormwater management features, including best management practices (BMPs) as specified in Part I of this document. The following components shall be included in, and considered part of, the Report:

- 1) Master Drainage Plan (if applicable),
- 2) Calculations,
- 3) Stormwater Quality BMP Maintenance Plan(s),
- 4) Easements (if applicable),
- 5) Subsurface investigation reports (if applicable), and
- 6) Non-City Submittals/Permits.

The master drainage plan shall be folded and inserted in a separate sleeved page(s) or pocket(s) of the Report. Construction plans, including Stormwater Pollution Prevention Plans, and the CC Drawing Number Application Form (see Section 7), shall be submitted with the Report, but not attached to it. The Report shall contain divider pages with labeled tabs that clearly identify each component listed above. Each component of the Stormwater Management Report shall be prepared and submitted in accordance with the following requirements.

6.1 Master Drainage Plan Requirements

For developments five (5) acres or greater, or developments that are to be constructed in multiple phases, the general site layout, including the layout of the proposed stormwater system, shall be depicted on a separate master drainage plan. The master drainage plan(s) shall be based on the state plane coordinate system and show all existing and proposed features, including trees. The master drainage plan should show all features indicated in the Manual, including but not limited to:

- 1) Project title,
- 2) North arrow and scale,
- 3) Project boundaries,

- 4) Existing and proposed topography at two-foot contour intervals covering the total development area and any offsite drainage areas tributary to the development site. The total upstream watershed(s) tributary to the development site shall be delineated,
- 5) Pre-development and post-development sub-basins, including onsite and offsite contributory area. The acreages shall be annotated,
- 6) The location and capacity of the immediate downstream receiving waterway or drainage system, if requested by the City,
- 7) Pre-development and post-development major routing flow paths to and from stormwater control facilities,
- 8) Any Tier I and Tier II streams, as defined in Section 1.2, that traverse the property and their respective Stream Corridor Protection Zones, including areas containing slopes 15 percent or greater that are adjacent to Type I and Type II streams, as defined in Section 1.2,
- 9) The location of proposed stormwater quality and quantity control facilities, storm drains, and constructed open watercourses proposed for the site,
- 10) Existing field tile locations,
- 11) Lines designating the phases of multiphase development projects,
- 12) Street layouts and existing and proposed utility lines,
- 13) Flood Hazard limits and classifications,
- 14) The boundary of each wetland on the site (at a minimum the wetland boundaries of the current phase of a multi-phase project shall be shown), defined during a jurisdictional determination under the requirements of a Section 401/404 permit, and the wetland setback boundary established under criteria in Section 1.5 of the Manual, and
- 15) Identify all stormwater outfalls and provide state plane coordinates, size (e.g., diameter), and type (open channel or piped) of each outfall for each.

The master drainage plan(s) is to be prepared on a 22-inch by 34-inch sheet on a scale not to exceed 1 inch = 200 feet. Larger development projects will require multiple sheets with match lines. In the event there is significant offsite tributary area to the proposed project, a second additional master drainage plan showing the entire drainage area is required. Deviations from master drainage plan requirements for unique projects or circumstances may be permitted upon written approval from the Division of Sewerage and Drainage.

6.2 Calculation Requirements

Calculations shall be provided for all of the stormwater conveyance and stormwater control facilities required by the Manual and shall be stamped and sealed by a Professional Engineer registered in the State of Ohio. Calculations shall be organized and presented in a manner that

demonstrates compliance with the City's stormwater management requirements. Specific requirements follow.

6.2.1 Stream Corridor Protection Calculations

Calculations to determine the width of the Stream Corridor Protection Zone for Type I and Type II streams and wetlands shall be presented in the following format:

- 1) ***Stream Corridor Protection Zone Calculations*** – Provide calculations and/or jurisdictional determinations supporting the calculated width of the Stream Corridor Protection Zone based on the requirements of Sections 1.3 and 1.5. A contour map delineating the tributary area used to calculate the Stream Corridor Protection Zone for each stream shall be submitted.
- 2) ***100-year Floodway Limits*** – Provide a FEMA map showing the limits of the 100-year floodway overlain with the calculated Stream Corridor Protection Zone limits determined above. The limits of the Stream Corridor Protection Zone will be the greater of the calculated limits or the 100-year floodway.
- 3) ***Slope Protection*** – Existing slopes 15 percent or greater that are adjacent to Type I and Type II streams are part of the Stream Corridor Protection Zone and shall be identified and annotated on the master drainage plan.
- 4) ***Wetland Protection*** – Delineated wetland boundaries shall be identified and shown on the stormwater management site plan. The limits of the final Stream Corridor Protection Zone shall be extended to include the entire wetland boundary for wetlands that are partially located within the greater of the calculated limits of the preliminary zone or the limits of the 100-year floodway.

6.2.2 Compensatory Floodplain Fill Calculations

Demonstrate that any volume of fill placed in the 100-year floodplain (outside of the Stream Corridor Protection Zone) is compensated with an equal volume of material removed above the ordinary high water table and below the 100-year flood elevation. Show the volume calculations for the fill and the compensating storage.

6.2.3 Impervious Area Calculations

Provide calculations that were used to quantify the amount of impervious area that will be on the site once construction is complete. Impervious area calculations shall be provided in square feet and based on building footprint, paved parking, and private drive and sidewalk not within the public right-of-way.

6.2.4 Storm Sewer Calculations

Storm sewer calculations shall be presented in the following format:

- 1) ***Capacity*** – Demonstrate that the capacity of the storm sewer pipes is sufficient to convey the design storm on Table 2-9 without surcharging. Calculations shall be prepared on the tabulation sheet provided in Appendix C.

- 2) **Hydraulic and Energy Grade Line** – Demonstrate that the sewer system is designed to convey the design storm on Table 2-9 such that the HGL stays below the gutter line of the overlying roadway or the top of castings of the drainage structures outside the roadway. Also indicate the appropriate Manning’s “n” value for the selected pipe material, and indicate the minor loss values at all applicable points in the system, according to criteria in Section 2.3.1. The HGL and EGL shall be shown on the tabulation sheet provided in Appendix C.
- 3) **Tailwater** – List all tailwater assumptions and their source for applicable design storm events.
- 4) **Velocities** – Tabulate the storm sewer flow velocities in each segment, and demonstrate that the sewers are designed to produce velocities within the limits specified in Section 2.3.1.2.
- 5) **Pavement Spread** – Provide calculations that demonstrate that the pavement spread limits do not exceed the criteria presented in Section 2.3.2.

6.2.5 Culvert Calculations

Culvert calculations shall be presented in the following format:

- 1) **100-year HGL** – Demonstrate that the water elevation resulting from the 100-year storm event does not encroach into proposed or existing residential dwellings or places of business. The flood elevation shall be shown on the stormwater management master drainage plan for the project.
- 2) **Bankfull Calculations** – Provide the calculations used to determine the bankfull depth of the stream as required in Section 2.3.3.3.
- 3) **Design Storm** – Provide calculations demonstrating that the headwater elevations for a 10-year event (25-year for arterial streets) are within the limits specified in Section 2.3.3.3. Hand calculations and the use of nomographs per Federal Highway Administration Hydraulic Design Series No. 5 or model output from computer programs such as HY-8 or similar may be used.
- 4) **Velocities** – Tabulate the culvert flow velocities, and demonstrate that the velocities do not exceed the velocity limits specified in Section 2.3.3.3.
- 5) **Tailwater and Energy Loss** – List all tailwater assumptions and their source for applicable design storm events. List the energy loss assumptions at the entrance/exit of the structure.

6.2.6 Constructed Open Watercourse Calculations

For constructed open watercourses, the Applicant shall submit calculations demonstrating that the design criteria in Section 2.3.7 have been satisfied. At a minimum, the following calculations shall be provided:

- 1) **Design Velocity** – Calculations showing that the channel lining can withstand the peak velocity during the 5-year design storm without erosion.
- 2) **Channel Dimensions** – Provide calculations showing the normal water depth, critical flow depth, and water surface width during the 10-year design storm.
- 3) **100-year HGL** – Demonstrate that the hydraulic grade line resulting from the 100-year storm event does not rise to within one foot of the finished grade adjacent to any buildings along the channel.

6.2.7 Flood Routing Calculations

Calculate the water surface profile along the major stormwater routing system using a standard step backwater profile calculation, or using a computer model able to compute backwater curves, such as HEC-RAS or U.S. EPA SWMM. Demonstrate that the water elevation resulting from the 100-year storm event does not encroach into proposed or existing residential dwellings and places of business and meets the depth restrictions presented in Section 2.4. The flood elevation shall be shown on the master drainage plan for the project.

6.2.8 Stormwater Detention Calculations

Calculations for stormwater detention facilities shall be based on methodologies that utilize dynamic hydrograph routing techniques (i.e., methods that allow variable inflows and outflows with respect to time and account for the basin's stage-storage-outflow characteristics). software/models that utilize this methodology and technique that are deemed acceptable to the City include, but are not limited to, SWMM, TR-20, PONDPAK, and HEC-1. The City will not accept methodologies that do not perform dynamic routing of hydrographs. If a model is used to perform stormwater detention calculations, the name and a description of the model must be provided, each model input parameter must be defined, and a complete set of model input data must be included. The calculations for detention facilities shall be presented in the following format:

- 1) **Critical Storm Calculations** – Show the calculations of the total volume of runoff from a one-year, 24-hour storm, before and after development. Show the calculations of percent increase in runoff volume, and reference Table 3-1 in Section 3.2.2 to determine the critical storm.
- 2) **100-year Storm Release Rate Calculations** – Determine the maximum release rate for the 100-year storm event by calculating the 10-year peak pre-developed flow rate.
- 3) **Basin Inflow and Outflow Hydrograph Calculations** – Show the calculations or model input/output that produced the inflow and outflow hydrographs to and from the retention/detention basin. Hydrographs should be shown graphically, with a tabular summary of the peak flow and volume, for all design storms that were considered in the design process. The City will not accept calculations or model input that provide tabular listings of inflow and/or outflow hydrographs.

- 4) *Stage-Storage Calculations* – Show the calculations of the stage-storage relationship for each detention facility.

6.2.9 Water Quality Volume (WQ_v) Calculations for Extended Detention Ponds, Wetlands, and Bioretention Facilities

The Applicant shall prepare a set of water quality volume and facility sizing calculations for control facilities required under Section 3.3 of the Manual. Examples of pertinent calculations are provided in Appendix D of the Manual. At a minimum, the following calculations shall be provided:

- 1) *Water Quality Volume Calculations* – Show the calculations of extended detention, permanent pool, forebay, and sediment storage volumes and depths, as described in Section 3.3.2.
- 2) *Water Quality Drawdown* – Show calculations or model output that demonstrates the release of the WQ_v over the time period(s) specified in Section 3.3.2.
- 3) *Area of Sand Filter and Bioretention Facilities* – Provide calculations used to determine the size of sand filter and bioretention facilities as specified in Section 3.3.5.

6.2.10 Swale and Filter Strip Calculations

The calculations for swales and filter strips shall be presented in the following format:

- 1) *Water Quality Volume Calculations* – Show the calculations of the water quality volume (WQ_v) as described in Section 3.3.2.
- 2) *Intensity-Duration-Frequency Curve* – Use Figure 2-1 to determine the intensity corresponding to the time of concentration.
- 3) *Design Flow Rate* – Show the calculations of the swale/filter strip design flow rate using the Rational Formula. The intensity used in the calculation is obtained from the curve drawn in Step 2 above, at a duration equal to the time of concentration for the tributary area.
- 4) *Geometry* – Show the calculations of the swale/filter strip cross-section geometry using the Manning Equation. Demonstrate that the flow depth is no greater than the maximum flow depth specified in Section 3.3.6 for the design storm calculated above.

6.3 Stormwater Quality BMP Maintenance Plan Requirements

The maintenance plan for the water quality BMPs on single-family residential (with the exception of detention basins and constructed wetlands within single family developments that are to be maintained by the City), commercial, or industrial sites shall define the specific maintenance requirements for each type of control facility designed for the site. Criteria for preparing the maintenance plan are contained in Section 4, and specific maintenance requirements for each type of control are included in **Appendix E**.

6.4 Compensatory Floodplain Restoration Plan Requirements

The stormwater management report shall include a site grading plan with supporting calculations indicating areas where floodplain fill and compensatory floodplain storage are proposed. The amount of compensatory storage and the methods used to provide the necessary compensatory storage shall be determined using the criteria in Section 1.4.

6.5 Easement Preparation Requirements

Dedicated easements to the City of Columbus shall be provided to allow maintenance and access to all stormwater facilities located outside of public right-of-way that are to be publicly owned or operated. Easements shall be designated on the construction plans as platted or deeded, existing or proposed. All existing easements shall be identified by the plat book and page number, or official record number of the deed. Preliminary plats and/or easement descriptions and exhibits shall be included with the stormwater management report submittal and construction drawings.

All descriptions and drawings involving City owned property rights shall apply standard survey techniques. When preparing easement documents for acceptance by DOSD, the following guidelines must be followed:

- 1) **Legal Descriptions** – Shall be the original typed document prepared single spaced on letter size paper and also digitally in WORD form, signed, sealed and dated by a registered surveyor. Metes and bounds descriptions are required; centerline descriptions will not be accepted.
- 2) **Pictorial Exhibit** – Shall be the original document prepared on legal size paper, signed, sealed and dated by a registered surveyor and also digitally in ACROBAT (PDF) form.
- 3) **Format** – Documents are not to be labeled or referenced to as exhibit A, B, or so on.
- 4) **Required Language** – Descriptions and/or pictorial exhibits shall not include caveats such as: subject to covenants, exceptions, or restrictions of record, nor shall they include a purpose such as: installing, replacing, and maintaining a storm sewer, ditch or basin.
- 5) **Contacts** – For private stormwater development plans, the name, mailing address and phone number of the person who will sign or obtain the signatures on the easement document shall be provided.

When approved by the Division of Sewerage and Drainage, easement information will be sent to the Real Estate Division of the City Attorney's Office for Deed of Easement preparation. When the deed is prepared, the Real Estate Division will contact the designated contact person to obtain the signatures and return the signed originals. The Real Estate Division will record the deeds and process them for City Council acceptance. Signed Deeds of Easement must be returned to the Real Estate Division prior to the payment of construction inspection fees.

6.6 Subsurface Investigation Reports

A copy of any subsurface investigation reports and recommendations performed as part of the stormwater design process shall be included in the stormwater management report. Subsurface investigations and recommendations may be warranted in instances where exfiltration of stormwater into sanitary sewers is possible or where underlying soils of a wet detention basin are insufficient to maintain a permanent pool of water. Subsurface reports submitted with the stormwater management report must be prepared and signed by a professional engineer licensed in the State of Ohio and experienced in geotechnical engineering.

6.7 Non-City Submittals/Permits

A copy of the applications for the following permits/approvals that shall be included in the stormwater management report may include, but are not limited to:

- 1) Dam permits as issued by the Ohio Department of Natural Resources (ODNR) for detention pond embankments meeting ODNR dam criteria,
- 2) 401 Water Quality Certification Permits issued by the Ohio Environmental Protection Agency,
- 3) Industrial NPDES Stormwater Permit application to Ohio Environmental Protection Agency,
- 4) 404 Permits for impacts to regulated streams and wetlands issued by the U.S. Army Corps of Engineers, and
- 5) Notice of Intent for coverage under the Ohio Environmental Protection Agency NPDES Construction General Permit, and a copy of the stormwater pollution prevention plan prepared under this permit.

The City may not approve stormwater management reports or plans prior to receipt of copies of approval Federal (404) and State (401) permits if the permits are required.

Stormwater Drainage Manual



Part II
Section 7

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Section 7

Stormwater Management Report Submittal Requirements

All stormwater improvement plans submitted for approval by the City of Columbus shall be prepared, signed, and sealed by a Professional Engineer who is licensed in the State of Ohio. Final plans shall be prepared and submitted on 22" x 34" high quality 4 mil thickness mylar using ink especially adapted to mylar. High quality photographic or Xerox mylar reproductions will be accepted with prior approval. Title blocks shall be in accordance with DOSD standard. Stick on notes, signature block, and/or details will not be accepted. The tracings become the property of the City of Columbus, DOSD, upon approval of the drawings by the Administrator or the Director of the Department of Public Utilities. Copies of approved plans can be obtained from DOSD.

All revisions to the tracings, after they have been signed by the Director of Public Utilities, shall be made in black ink. The original approved alignment, easement limits, manholes, structure numbers, etc., shall be revised as directed by DOSD with a numbered triangle box shown inserted next to the revised work. A numbered triangle box shall then be placed in the revision block of the drawing border with a brief and concise verbal description of the change. Only three (3) relatively small revisions will be permitted on a tracing sheet. Any major revisions, or more than three (3) minor revisions, may require the submission of a new plan.

Appendix F contains standard CC Drawing Forms that shall accompany the submittal. Seven sets of prints (check prints), a completed CC Drawing Number Application (**Exhibit A**), and a completed and signed Plan Review Checklist (**Exhibit D**) shall be submitted to DOSD for review by the various City Divisions. In addition to hard copy plans, DOSD will require the submission of plans and any plan revisions in accordance with the DOSD digital submission standards, current version. The consultant will be notified when all check prints have been returned to DOSD.

7.1 Minimum Plan Format Requirements

The following minimum for requirements apply to all CC Drawings submitted for review to DOSD and are included in the Plan Submittal Checklist as shown in Exhibit D of Appendix F.

7.1.1 Title Sheet

The Title Sheet shall contain the following items:

- 1) **Title** – All private storm sewer plan titles shall be formatted in the title block as follows:

“Private Storm Sewer and Stormwater Facilities for [Insert Project Title]”

The Project Title shall include the street address of the project site.

- 2) **Location Map** – This map shall show the relative location of the project to area streets and well known landmarks so as to determine the location of the project within the City at a quick glance.
- 3) **Benchmarks** – A suitable benchmark shall be provided for every 1,000 lineal feet of sewer shown on the plan, with a minimum of two (2) on each plan. The benchmarks shall be established through a bench circuit with elevations based on the most recent North American Vertical Datum (NAVD) determination.
- 4) **Estimate of Quantities** – An accurate estimate of those items being constructed under the stormwater plan shall be included. The description of the item shall be the same as that under the item description in the CMSC, current edition. The quantities for each phase of a phased project shall be shown separately.
- 5) **Standard Drawings** – All plans shall have a listing of the applicable Standard Construction Drawings which apply to the proposed work.
- 6) **General Notes** – The general notes included in **Exhibit B in Appendix F** of the Manual shall be included on all plans. If space on the title sheet is insufficient, general notes may either be continued on the second sheet or moved in their entirety.
- 7) **Special Notes** – Any notes that the engineer preparing the plan feels may be required due to circumstances of the particular project should be included under these notes. Any special notes should follow the general notes and should be so titled: “Special Notes”. The engineer preparing the plans is responsible for making sure that all notes required to construct the project are provided in the plans.
- 8) **Signature Block** – Along with the necessary signature and date lines, the signature block (**Exhibit C in Appendix F** of the Manual) shall contain the following note:

“Signatures below signify only concurrence with the general purpose and general location of the project. All technical details remain the responsibility of the engineer preparing the plan.”

Whenever a proposed sewer is located on or near (within 100 feet) City Park property, a signature line and date line for the Director of Recreation and Parks shall be provided in the signature block.

7.1.2 Plan View

All plan sheets shall contain the following items:

- 1) **North Arrow** – Plans shall be orientated so that the north arrow is toward the top or left margin of the sheet. Slope of the sewer may be shown from either the left or the right side of the sheet but shall be consistent throughout the plan.
- 2) **Structure Numbering** – All sewer plans shall be submitted with continuous numbering for each stormwater structure included in the project. The lowest structure number shall

be assigned to the most downstream structure on the longest run of sewer. Increasing structure numbers shall be assigned to each structure as the sewer run progresses upstream. Once all structures are assigned a number along the first sewer run, the next number is assigned to the most downstream manhole on the next longest sewer run. The process is repeated until all stormwater structures have been assigned a number.

- 3) **Scale** – Plan views shall be prepared at horizontal scale of sufficient size as to show necessary detail. A horizontal scale of 1"=30' is recommended.
- 4) **Line Weights** – Appropriate line weights are to be used for the various items shown on the plan. All items shown on the plan are to be labeled and clearly distinguishable from each other. For ease of distinction, the proposed sewer should be the heaviest line weight used.
- 5) **Point of Reference** – All plans shall show a distance from some point of the proposed sewer system to an existing reference point outside the project site, accurate to within one foot. (Example: Street Intersection).
- 6) **Property Information** – All properties through which a stormwater management facility passes shall have indicated on the plans the Property Owner's name, parcel acreage, parcel identification number, and the deed book and page number of the title instrument. This includes onsite and offsite properties. All iron pins found during the field survey shall be shown on the plans as "found iron pin".
- 7) **Impervious Surfaces** – All impervious areas on the project site shall be shown. The impervious surfaces shall be prepared digitally using polygons on a separate overlay, or layer, and shall include all building footprints, paved parking, private drives and sidewalks.
- 8) **Streams** – All streams as defined under Section 1.2 of the Manual shall be identified and shown on the plan. The limits and widths of all Stream Corridor Protection Zones and FEMA designated 100-year floodplains shall also be shown. Areas of proposed fills within FEMA designated floodplains as well as areas where compensation for said fills is to be accomplished shall be shown on the plans. The amount of fill volume for which compensation must be made shall be annotated on the drawings.
- 9) **Stormwater Best Management Practices** – The size, location, and maximum ponding limits of all proposed stormwater BMPs shall be provided on the plans. Easements for City access and maintenance (if required) to and around each facility shall also be shown.
- 10) **Agricultural Field Tiles** – All visible agricultural tile outlets and locations shall be field located and shown on the plans. Any plan information for field tile systems received from county agencies shall also be shown.
- 11) **Utilities** – All existing and proposed utilities and sewer lines within, or adjacent to, the project site shall be shown on the plan and clearly identified as to type, size, location, and

ownership. The construction plan number (CC, RP, MM, etc.) of all existing sewers shall be shown. Storm utilities shall include all drainage swales, ditches, creeks, etc.

- 12) **Structure and Pipe Annotation** – All structures shall be labeled as to type and class (if applicable). The state plane coordinates of all proposed structures that are to be publicly owned shall be shown on the plan in tabular format. All pipes shall be delineated and annotated with their respective sizes, materials (if a particular material is specified), and distance measurements. Pipe distances for publicly owned storm sewers shall be determined from center-of-structure to center-of-structure.

7.1.3 Profile View

All profile sheets shall contain the following items:

- 1) **Scale** – The horizontal scale of the sewer profile shall always be the same as the scale of the corresponding plan view unless approved otherwise by DOSD. The vertical scale for profiles shall be of sufficient size to show necessary detail. A vertical scale of 1"=5' is recommended for use with horizontal scales set at 1"=30'.
- 2) **Stationing** – Storm sewer stationing, surface elevations above the centerline of the sewer, and invert elevations shall be provided at the beginning and end of all profiles and at all 100 foot station intervals below all profiles. All sewer plans shall be submitted with continuous stationing along the storm sewer profiles. The first station (0+00) shall begin at the downstream end of the longest sewer run and shall increase in a downstream-to-upstream fashion. The stationing for the next longest continuous length of sewer shall be restarted at 0+00 and shall proceed in the same downstream-to-upstream manner as the first. The process is repeated for each succeeding section of shorter sewer length. Match lines and break lines, in profile views, shall be made at 100 foot stations, or at structures. Station equations or negative stationing in the profile view will not be accepted except by written approval. The centerline station of all right-of-ways crossed by the storm sewer centerline shall be indicated.
- 3) **Utility and Other Crossing** – All utility crossings, whether existing or proposed, shall be shown as accurately as possible (based on existing available records) on the sewer profiles and identified as to their type and size. Other crossings such as streets, alleys, driveways, streams, ditches, etc. shall be shown and identified by name, centerline, edge of pavement, etc.
- 4) **Structure and Pipe Annotation** – All structures shall be labeled as to type, centerline station location, invert and top of casting elevations, and all other pertinent information. Pipes shall be labeled with their respective sizes, slopes, and distances. Pipe distances and slopes shall be determined from center-of-structure to center-of-structure stationing. Existing structures shall be drawn using dashed lines and proposed structures shall be drawn using solid lines.
- 5) **Backfill, Backing, and Encasement** – If the proposed backfill for the proposed sewer line is to be different from that specified under Item 901 in the CMSC, the type of backfill, and

the limits thereof, shall be identified in the profile. Concrete encasement, when used, shall also be shown in the profile with the limits specified.

- 6) **Ground Surfaces** – Existing and proposed ground surfaces shall be shown and clearly marked. Existing surfaces shall be shown as a dashed line. Proposed ground surfaces shall be shown as a solid line.

7.1.4 Details and Cross Sections

All detail and cross-section sheets shall contain the following items:

- 1) **Open channels** – Typical cross sections shall be shown for all proposed open channel systems including, but not limited to, flood routing swales, roadside ditches, and minor storm conveyance channels. Typical cross sections shall show the appropriate dimensions and side slope values for each channel.
- 2) **Culverts** – A profile along each roadway culvert shall be provided showing invert, roadway edge of pavement and/or top of curb, roadway centerline, and design storm and 100 year headwater surface elevations. A table with each profile shall also be provided showing the design and 100-year storm discharge values and their respective outlet velocities.
- 3) **Stormwater Quality BMPs** – Dimensioned cross sections, elevation views and plan views for each water quality BMP shall be shown. A table showing the required WQ_v and drawdown time as well as the designed storage and designed drawdown time of the facility shall be shown. A list of the types and number of any plantings, if required, shall be included on the plans.
- 4) **Detention Basins** – Cross sections of detention basins, wet or dry, shall be provided and dimensioned. Side slopes, basin bottom slope, the elevation of each inlet and outlet structure, and maximum water surface elevations for WQ_v storage, the critical storm, and the 100-year storm shall be annotated. An elevation view and plan view of each outlet riser structure shall be provided and annotated. Cross sections showing side slope, side slope information, bottom width dimensions, overflow weir elevations, bottom lining etc. shall also be shown.

7.1.5 Erosion and Sediment Control Plan

The Applicant shall include a copy of the erosion and sediment control plan for the site, in compliance with City Regulation included in Appendix A of the Manual. Section 3.5 provides guidelines to City criteria for complying with this regulation. In general, a Stormwater Pollution Prevention Plan prepared in compliance with Ohio EPA's NPDES Construction General Permit will satisfy the City's erosion and sediment control regulation.

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Stormwater Drainage Manual



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Stormwater Drainage Manual



Appendix A City of Columbus Erosion and Sediment Pollution Control Regulation



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CITY OF COLUMBUS
DEPARTMENT OF PUBLIC UTILITIES
DIVISION OF SEWERAGE AND DRAINAGE

EROSION AND SEDIMENT POLLUTION
CONTROL REGULATION

ADOPTED REGULATION

JUNE 1, 1994

CITY OF COLUMBUS

Proposed Erosion and Sediment Pollution Control Regulation

**Adopted Regulation
June 1, 1994**

TABLE OF CONTENTS

Article 1	Definitions.....	Page 1
Article 2	General Provisions	Page 8
Article 3	Scope and Intent	Page 8
Article 4	Stormwater Runoff Control Standards	Page 12
Article 5	Soil Erosion and Sediment Control Standards.....	Page 12
Article 6	Soil Erosion and Sediment Control Plan Requirements....	Page 17
Article 7	Administration and Appeals.....	Page 21
Article 8	Compliance Responsibility.....	Page 22

**CITY OF COLUMBUS
EROSION AND SEDIMENT POLLUTION CONTROL REGULATION**

Adopted Regulation June 1, 1994

This regulation has been adopted as a guideline for implementing pollutant reduction programs on construction sites in the City of Columbus. This regulation is applicable to all premises within the City of Columbus and other appropriate premises per the provisions defined in Columbus City Code, Chapter 1145.70.

Earth and land disturbing activities associated with construction contribute to the pollution of public waters through soil erosion and sedimentation. Control programs designed to minimize these problems should incorporate the following planning, inspection, enforcement requirements and best management practices.

ARTICLE 1: DEFINITIONS

For the purposes of this regulation, certain rules of word usage apply to the text as follows:

- a. Words used in the present tense include the future tense; and the singular includes the plural, unless the context clearly indicates the contrary.**
- b. The term “shall” is always mandatory and is not discretionary; the word “may” is permissive.**
- c. The word or term not interpreted or defined by this article or otherwise defined in Columbus City Codes Chapter 101 or 1145, shall be used with a meaning of common or standard utilization, so as to give the regulation its most reasonable application.**

1. **Applicant:** any person submitting an erosion and sediment control plan for approval or requesting the issuance of a permit, when required, authorizing land-disturbing activities to commence.
2. **Approving Agent:** the governing body of the City of Columbus or its duly designated representative being the City of Columbus, Division of Sewerage and Drainage, Department of Public Utilities.
3. **Best Management Practices (BMP's):** means schedules of activities, prohibition of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of waters. BMP's also include treatment requirements, operating procedures, and practices to control construction site runoff, or drainage from material storage.
4. **Channel:** a natural stream that conveys water; a ditch excavated and/or constructed for the flow of water.
5. **Clearing:** the clearing, grubbing, scraping, scalping, removal of trees and stumps, and removing and disposing of vegetation and debris within the site, and shall include the conditions resulting therefrom.
6. **Construction:** the erection, alteration, repair, renovation, demolition or removal of any building or structure; and the clearing, stripping, excavating, filling, grading, and regulation of sites with connection therewith.
7. **Denude:** the act of stripping, scraping, and/or scalping a site of vegetation, thus exposing bare soil.
8. **Detention:** the capture, collection, and subsequent slow release of stormwater runoff; the primary purpose of which is to mitigate increases in stormwater runoff rates, providing protection, whether complete or partial, to down-slope areas, from the adverse effects of increased runoff rates. This can be accomplished through the use of one or more of the following methods:

Dry Detention: a basin or storage area, generally man-made, that is designed to normally drain completely between storm events.

Wet Detention: a basin or storage area , generally man-made, that is designed to drain down to a level that is normally wetted; that is, to a normal pool level, below which there is no outlet other than through infiltration into the ground. These facilities do not normally drain completely dry.

9. **Developer:** any individual, subdivider, firm, association, syndicate, partnership, corporation, trust, or any other legal entity commencing proceedings under these regulations to effect the development of land for himself or for another.
10. **Development:** any man-made change to improved or unimproved real estate, including, but not limited to, buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operations.
11. **Development Area:** any contiguous (abutting) area owned by one person or developed as a single phase or multiple phases (units) and used or being developed or redeveloped, for non-farm commercial, industrial, residential, or other non-farm purposes upon which earth-disturbing/land-disturbance activities are planned or underway.
12. **Ditch:** an open channel with intermittent flow, either man-made or natural, for the purpose of drainage or irrigation. (See also channel and stream)
13. **Dumping:** grading, pushing, piling, throwing, unloading, or placing of fill material, composed of earth, soil, rock, sand, gravel, or demolition material.
14. **Earth-Disturbing Activity:** any grading, excavating, filling, or other alteration of the earth's surface where natural or man-made ground cover is destroyed and which may result in or contribute to erosion and sediment pollution.
15. **Erosion:**
 - a. The wearing away of the land surface by running water, wind, ice or other geological agents, including such processes as gravitational creep.
 - b. Detachment and movement of soil or rock fragments by wind, water, ice, or gravity.
 - c. Erosion includes:
 - (1) **Accelerated Erosion:** erosion much more rapid than normal, natural or geologic erosion, primarily as a result of the influence of the activities of man.
 - (2) **Floodplain Erosion:** abrading and wearing away of the nearly level land situated on either side of a channel due to overflow flooding.
 - (3) **Gully Erosion:** a type of erosion caused by water accumulating in narrow channels and over short periods during and immediately after rainfall or snow or ice melt activity, which removes soil such that channels become considerably deeper than what would otherwise result by normal smoothing or tilling operations.

- (4) **Natural (Geological) Erosion:** the wearing away of the earth's surface by water, ice or other natural agents under natural environmental conditions of climate, vegetation, etc., undisturbed by man.
- (5) **Normal Erosion:** the gradual erosion of land used by man which does not greatly exceed natural erosion.
- (6) **Rill Erosion:** an erosion process in which numerous small channels only several inches deep are formed; occurs mainly recently disturbed soils.
- (7) **Sheet Erosion:** the removal of a fairly uniform layer of soil from the land surface by wind or runoff water.
- (8) **Stream Bank Erosion:** erosion of the stream bank or channel bottom due to the high velocity of flow within the stream.
16. **Exemption:** those activities that are not subject to the erosion and sediment control requirements contained in this regulation.
17. **Final Stabilization:** means that all soil disturbing activities at the site have been completed, and that a uniform perennial vegetative cover with a density of at least 70% of the cover for the disturbed area has been established or equivalent stabilization measures (such as the use of mulches or geotextiles) have been employed.
18. **Finished Grade:** the final grade or elevation of the ground surface conforming to the site-grading plan.
19. **First Order Stream:** means all streams identified on a U.S.G.S. 7.5-minute topographic map by either a dashed or solid blue line.
20. **Grading:** the stripping, cutting, filling, stockpiling, or any combination thereof of earth disturbing activities, including land in its cut or filled conditions.
21. **Grubbing:** any activity, which removes or significantly disturbs the root matter within the ground.
22. **Hazard:** any danger to public health, welfare and safety including exposure to risk or damage to property or liability for personal injury' or risk of harm to land, air or water resulting in environmental degradation. Hazards can include flooding and ponding, compaction and settling, landslides, earthquakes, toxic chemicals, radiation, fire and disease.
23. **Land-Disturbing Activities:** any land change that may result in soil erosion from water or wind and the movement of sediment into waters or onto lands, including

but not limited to, clearing, grading, excavating, transporting and filling of land, except that the term shall not include:

- 1) **Minor land-disturbing activities such as home gardens and individual home landscaping, repairs, and maintenance work;**
 - 2) **Individual service connections.**
 - 3) **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 land-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;**
 - 4) **Septic tank lines or drainage fields unless included in an overall plan for land-disturbing activity relating to the construction of the building to be served by the septic tank system;**
 - 5) **Tilling, planting or harvesting of agricultural, horticultural, or forest crops or livestock feedlot operations; including soil conservation operations related to agriculture as follows: construction of terraces, terrace outlets, check dams, de-silting 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 storm water runoff and does not exacerbate erosion and sedimentation.**
 - 6) **Repair or rebuilding of the tracks within the right-of-way of a railroad company;**
 - 7) **Emergency work to protect life, limb or property and emergency repairs; however, if the land-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.**
24. **Mulching:** the application of suitable materials on the soil surface to conserve moisture, hold soil in place, and aid in establishing plant cover.
25. **Nuisance:** a public nuisance as known by common law or in equity jurisprudence.
26. **One-hundred-year floodplain:** any land area which is susceptible to being inundated by water caused by a flood event having a one (1) percent chance of being equaled or exceeded in any given year.

27. **Owner:** the person in who is vested the fee ownership, dominion, or title of property, i.e. the proprietor. The word “owner”, when applied to property, shall include any part-owner or joint-owner of the whole or any part of such property.
28. **Permittee:** any person to whom approval of an erosion and sediment control plan according and pursuant to this standard is granted, or who is subject to inspection under it.
29. **Plan:** as used in this regulation, “Plan” shall mean the Erosion and Sediment Control Plan.
30. **Pollution:** the man-made or man-induced alteration of the chemical, physical, biological, or radiological integrity of air and water resources.
31. **Public Waters:** those waters within lakes (except private ponds and lakes on single properties), rivers, streams, ditches, and/or waters leaving property on which surface water originates.
32. **Retention:** the collection and storage of stormwater runoff without subsequent discharge other than through infiltration into the ground, or evaporation.
33. **Runoff:** the portion of rainfall, melted snow or irrigation water that flows across the ground surface and eventually is returned to streams, rivers, lakes, and ponds.
 - (1) **Accelerated Runoff:** increased rate and volume of runoff due to less permeable surface or reduced time of concentration primarily caused by urbanization.
 - (2) **Peak Rate of Runoff:** the maximum rate of runoff for any 24 –hour storm of a given frequency.
34. **Sediment:** solid material, both mineral and organic, that is or was in suspension, is being or has been transported, or has been moved from its site of its origin by air, water, gravity, or ice, and has come to rest on the earth’s surface either above or below water.
35. **Sediment Basin:** a facility such as a depression storage area, a pond or trap, barrier, dam, or other suitable detention facility built across an area of water-flow to settle and retain sediment carried by surface drainage runoff water.
36. **Sediment Control plan:** a written description, in graphical and descriptive terms, subject to review and approval by the approving agency, of methods for controlling sediment pollution from accelerated erosion of a development area of two or more contiguous acres.

37. **Site:** any lot or parcel, or a series of lots or parcels of land adjoining or contiguous or joined together under one ownership where clearing, stripping, grading or excavating is performed.
38. **Slip:** any lot or parcel, or a series of lots or parcels of land adjoining or contiguous or joined together under one ownership where clearing, stripping, grading or excavating is performed.
39. **Sloughing:** a slip or downward movement of an extended layer of soil resulting from the undermining action of water or the earth-disturbing activity of man.
40. **Soil Loss:** soil relocated on or removed from a given site by the forces of erosion and the redeposit of the soil at another site on land or in a body of water.
41. **Stabilization:** the prevention of soil movement by any vegetative and/or structural means.
42. **Storm Frequency:** the average period of time within which a storm of a given duration and intensity can be expected to be equaled or exceeded.
43. **Storm water (Stormwater):** water runoff resulting from storm events, including snow melt, surface water runoff and drainage.
44. **Stream:** a body of water running or flowing on the earth's surface or channel in which such flow occurs. Flow may be seasonally intermittent.
45. **Stripping:** any activity, which removes or significantly disturbs the vegetative surface cover.
46. **Subdivision:** (1) The division of any parcel of land shown as a unit or as contiguous units on the last preceding tax roll, into two or more parcels, sites or lots, for the purpose, whether immediate or future, of transfer of ownership; or (2) The improvement of one or more parcels of land for residential, commercial or industrial structures or groups of structures involving the division or allocation of land for the opening, widening or extension of any street or streets, except private streets serving industrial structures; the division or allocation of land as open spaces for the common use by owners, occupants or lease holders or as easements for the extension of any streets, except private streets serving industrial structures; the division or allocation of land as open spaces for the common use by owners, occupants or lease holders or as easements for the extension and maintenance of public sewer, water, storm drainage or other public facilities.
47. **Topsoil:** surface and upper surface soils, which presumably are darker, colored, fertile soil materials, ordinarily rich in organic matter or humus debris.

48. **Waiver:** A permit of **conditional** exemption from the regulation in part or in whole, as specified by the approving agent, in a formal written statement. A waiver from the regulation shall not be assumed to be in effect, without the expressed written statement from the City.
49. **Watercourse:** any natural or artificial waterway (including, but not limited to, streams, rivers, creeks, drainageways, waterways, gullies, ravines, or washes) in which waters flow in a definite direction or course, either continuously or intermittently; and including any area adjacent thereto which is subject to inundation by reason of overflow of flood water.

ARTICLE 2: GENERAL PROVISIONS

2.1 Title:

City of Columbus Erosion and Sediment Pollution Control Regulation

2.2 Statutory Authorization:

This regulation of the Department of Public Utilities, Division of Sewerage and Drainage, is adopted pursuant to Columbus City Code Chapter 1145, as authorized by the Director of Public Utilities.

2.3 Purpose:

This erosion and sediment pollution control regulation is adopted for the purpose of controlling the pollution of public waters by sediment from accelerated soil erosion and stormwater runoff caused by earth –and land-disturbing activities and land use changes associated with construction activities. Control of such pollution will promote and maintain the health, safety and general well being of all life and inhabitants with the City of Columbus.

ARTICLE 3: SCOPE AND INTENT

3.1 Objectives:

This regulation of the City of Columbus, shall apply to earth-disturbing and land-disturbing activities, as defined in Article 1, on areas designated below which are within the jurisdiction of the City of Columbus, unless otherwise excluded within this regulation or unless expressly excluded by state law, including:

Land used or being developed for commercial, industrial, residential, recreational, public service or other non-farm purposes.

3.2 Disclaimer of Liability:

Neither submission of a plan under provisions of this regulation, nor compliance with provisions of this regulation shall relieve any person from responsibility for damage to any person or property otherwise imposed by law, nor impose any liability upon the City of Columbus for damage to any person or property.

3.3 Severability:

If any clause, section, or provision of this regulation is declared invalid or unconstitutional by a court of competent jurisdiction, validity of the remainder shall not be affected thereby.

3.4 Requirements (Regulation applicability)

No person shall cause or allow earth- and/or land- disturbing activities on a development area except in compliance with the standards set out in this regulation and the applicable items below:

- a. An erosion and sediment control plan shall be submitted and approved prior to any land- disturbing activities on development areas involving earth disturbance of two (2) or more acres, including those development areas being a part of a larger common plan of development or sale. The person proposing such land-disturbing activities shall develop and submit for approval a plan containing erosion and sediment pollution control practices so that compliance with other provisions of this regulation will be achieved during and after development. Such a plan shall address specific requirements established by the City of Columbus as set out in Articles 4, 5, and 6 of this regulation.

The person proposing land-disturbing activities shall submit the plan, and supporting information, as outlined in Article 6, to the following office:

Stormwater Program Manager
Division of Sewerage and Drainage
Department of Public Utilities
910 Dublin Road, Utilities Complex
Columbus, Ohio 43215

- b. For proposed development areas involving land-disturbance of less than two acres that is not part of a larger common plan of development or sale, it is not necessary to submit an erosion and sediment control plan; however, the person proposing such land-disturbing activities must comply with all other provisions of this regulation. All land-disturbing activities shall be subject to inspection and site investigation by the City of Columbus to determine compliance with the standards and regulations.

3.5 Exemptions:

Development activities that are exempt from this regulation include the following:

- a. An erosion and sediment control plan shall not be required for public road, highway, or other transportation, or drainage improvement, or maintenance thereof, undertaken by a government agency or entity if such agency or entity plans to follow a statement of erosion and sediment control policy which has been submitted by the sponsoring agency or entity and approved by the City of Columbus.
- b. Clearing and grading activities that disturb less than 2000 square feet AND are situated no closer than 50-feet to a first order stream.
- c. 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.
- d. Emergency work to ensure health, safety and property and emergency repairs. However, if the land 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 this regulation.

3.6 Waivers

- a. 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 Stormwater Program Manager, Division of Sewerage and Drainage, and shall include sufficient detail to support that granting a waiver

will not be detrimental to abutting properties or to watercourses, public waters, or to the sewer system.

- b. Issuance of a waiver shall apply only to the requirement of erosion and sediment control per this regulation, and shall not in any way imply a relaxation of any requirements outlined in the City's Storm Water Drainage Manual, including, but not limited to provisions for adequate on-site drainage, and the ability to accept runoff from land tributary to the development.**
- c. At the discretion of the City, a waiver may be subject to specific conditions, including, but not limited to:**
 - 1) Reasonable control of soil erosion and sediment.**
 - 2) The preparation of plans, maps and/or specified information.**
 - 3) Requirements that any additions, extensions, or modifications of a development for which a waiver has been granted, shall be required to provide erosion and sediment control for the entire site if preceding limitations are exceeded by subsequent additions, extensions, or modifications.**
- d. At the discretion of the City, a waiver may be granted if it is demonstrated the development is not likely to:**
 - 1) Have an adverse impact on a wetland, watercourse or water body;**
 - 2) Contribute to the degradation of water quality; or**
 - 3) Otherwise impair attainment of the objectives of this regulation.**
- e. Examples of the types of development activities which may be considered for waivers include the following:**
 - 1) Single family residential development involving land-disturbance on an individual lot in a previously approved subdivision, which contains active and effective erosion and sediment control measures that, in the opinion of the City, are operating efficiently and are being properly maintained in good working condition.**

ARTICLE 4: STORMWATER RUNOFF CONTROL STANDARDS

4.1 General Requirements:

- a. The requirement for and design of permanent drainage systems for the control of storm water runoff, shall be based upon the general and specific policies and standards and specifications outlined in the latest version of the City of Columbus Storm Water Drainage Manual.**
- b. Temporary stormwater runoff controls shall be designed in accordance with the standards and specifications outlined in the latest edition of the U.S. Department of Agriculture Soil Conservation Service's Manual entitled, "Water Management and Sediment Control for Urbanizing Areas." Other federal, state, or local manuals containing standards and specifications for erosion and sediment control practices may be used, subject to prior approval of these manuals by the Division of Sewerage and Drainage.**

ARTICLE 5: SOIL EROSION AND SEDIMENT CONTROL STANDARDS

5.1 General Requirements:

- a. In order to control sediment pollution of water resources, the owner or person responsible for the development area shall use conservation planning and practices to maintain the level of conservation established by the standards outlined in section 5.2.**
- b. These standards outlined herein are general guidelines and shall not limit the right of the City to impose additional, more stringent requirements, nor shall the standards limit the right of the City to waive individual requirements.**
- c. Erosion and sediment control practices used to satisfy the standards outlined herein shall meet the specifications in the latest edition of SCS's Manual entitled, "Water Management and Sediment Control for Urbanizing Areas", or specifications in other erosion and sediment control manuals, or other accepted practices, receiving prior Division approval. Reasonable modifications will be considered by the City provided that the proposed modification meets the basic requirements of this regulation. Justification shall be provided, upon submission of erosion and sediment control plans for review and approval, for rejecting each practice outlined in Article 5.2, based on site conditions.**

5.2 Standards and Criteria:

- a. **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.
- b. **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.
- c. **Stabilization/Non-structural Practices:** Control practices shall preserve existing vegetation where attainable and disturbed areas shall be re-vegetated as soon as practicable after grading or construction. Such practices may include: temporary seeding, permanent seeding, mulching, matting, sod stabilization, vegetative buffer strips, phasing activities (to minimize denuded areas), and protection of trees. Denuded areas shall have soil stabilization applied within fourteen (14) days of denudation if they are to remain dormant (undisturbed) for more than forty-five days, whether or not final grade has been established. During this 45-day dormant period, the 14-day period shall run concurrent. For areas within fifty (50) feet of any first-order stream (or larger), soil stabilization practices shall be initiated within seven (7) days on all inactive disturbed areas.
- d. **Structural Practices:** Structural practices shall be used to control erosion and trap sediment from all sites remaining disturbed for more than fourteen (14) days. Such structural practices shall store runoff allowing sediments to settle and shall divert flows from exposed soils or otherwise limit runoff from eroding exposed areas of the site. Such practices may include, among others, sediment traps, sediment basins, silt fences, earth diversion dikes, check dams, and storm drain inlet protection:
 - 1) **Settling Ponds:** Concentrated stormwater runoff from denuded areas flowing at rates, which exceed the design capacity of sediment barriers, shall pass through a sediment-settling pond. The pond's storage capacity shall be sixty-seven (67) cubic yards per acre of total drainage area. Settling ponds, by definition, include sediment basins and traps. To the extent

practicable, and without causing adverse effect to adjacent properties, the off-site contributory area to settling ponds should be minimized or eliminated, using diversion berms around the perimeter of the site disturbed area.

- 2) **Sediment Barriers:** Sheet flow runoff from denuded areas shall be intercepted by sediment barriers. Sediment barriers, such as sediment fences or diversions directing runoff to settling ponds, shall protect adjacent properties and water resources from sediment transported by sheet flow.
- 3) **Storm Sewer Inlet Protection:** All storm sewer inlets which accept water runoff from the development area shall be protected so that sediment-laden water will not enter the storm sewer system without first being ponded and filtered or otherwise treated to remove sediment, unless prior approval is granted by the City and/or the storm sewer system drains to a settling pond.

e. **Stream Protection:** Structural practices shall be designed and implemented on site to protect all adjacent streams, from the impacts of sediment runoff. If a stream channel must be disturbed, the environmental impacts of the disturbance shall be minimized. Furthermore, if a stream channel must be disturbed, the site owner shall provide notification to the Division of Sewerage and Drainage, at least 48-hours prior to any such work. In the event work is necessary within or across a stream, the following controls shall be implemented.

- 1) Mitigation measures shall be undertaken to stabilize disturbed areas and repair damages to the stream channel and adjacent bank area immediately after the disturbance is completed.
- 2) Streams including channel-bed and banks shall be re-stabilized immediately after in-channel work is completed, interrupted, or stopped. To the extent practicable, construction vehicles shall be kept out of streams. Where in-channel work is necessary, precautions shall be taken to stabilize the work area during construction to minimize erosion.
- 3) If a wet channel must be crossed by construction vehicles regularly during construction, a temporary stream crossing shall be provided.

f. **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.

g. Sloughing and Dumping:

1) No soil, rock, debris, or any other material shall be dumped or placed into a water resource or into such proximity that it may readily slough, slip, or erode into a water resource, unless such dumping or placing is authorized by the City or its representatives 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.

2) Unstable soils 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.

h. Cut and Fill Slopes: Cut and fill slopes shall be designed and constructed in a manner, which 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.

i. 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, ten-year frequency storm without eroding.

j. Establishment of Permanent Vegetation: A permanent vegetation shall not be considered established until ground cover is achieved which, in the opinion of the City, provides adequate cover and is mature enough to control soil erosion satisfactorily and to survive adverse weather.

k. 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 approving agency. Trapped sediment shall be removed or permanently stabilized to prevent further erosion.

l. 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 to the satisfaction of the City.

- m. To the maximum extent practicable, soil loss shall be minimized through the use of Best Management Practices (BMP's), as referenced within the latest edition of the U. S. Soil Conservation Service's manual entitled "Water Management and Sediment Control for Urbanizing Areas", or referenced within other design manuals, determined to be acceptable by the Division of Sewerage and Drainage.
- n. Underground utility line construction involving dewatering operations: To the extent practicable, sediment-laden effluent from dewatering operations and effluent discharged from dewatering operations to surface-lands and/or surface-waters, shall be controlled by structural practices to filter and trap sediment, such that the erosion and sedimentation resulting from dewatering operations, does not affect flowing streams and lands on or off-site.

5.3 Off-site Drainage Facilities for Sediment Control:

At the City's discretion, the City may allow surface water runoff and associated sedimentation to be discharged into drainage facilities off the site of development only if each of the following conditions are met:

- 1) It is not practicable to completely manage runoff and sedimentation on the site in a manner that meets the performance standards and design standards of this regulation;
- 2) The off-site drainage facilities and channels leading to them are designed, constructed and maintained in accordance with the requirements of this regulation;
- 3) Adverse environmental impacts on the site of development will be minimized.
- 4) A request to use off-site drainage facilities and all information related to these proposed drainage facilities should be made a part of the developer's application.

ARTICLE 6: SOIL EROSION AND SEDIMENT CONTROL PLAN REQUIREMENTS

6.1 Plan Requirements:

- a. **When required by this regulation, a soil erosion and sediment control plan shall be required for the land disturbance activities outlined in Article 3. Furthermore, in accordance with the appropriate requirements of Article 3, the plan shall be prepared, submitted to the City, and approved by the City, prior to any earth- or land-disturbance. The person proposing land-disturbing activities shall submit the plan, and supporting information, as outlined herein, to the following office:**

**Stormwater Program Manager
Division of Sewerage and Drainage
Department of Public Utilities
910 Dublin Road, Utilities Complex
Columbus, Ohio 43215**

- b. **The erosion and sediment control plan shall contain sufficient information, drawings, and notes to describe how soil erosion and off-site sedimentation will be minimized. It is preferred that the erosion and sediment control plan be submitted as part of the Stormwater Drainage Plan, i.e., CC and/or Drawer D drawings. The City shall review the plan to determine compliance with this regulation and the Standards and Specifications prior to approval. The plan shall serve as a basis for all- subsequent grading and stabilization.**

6.2 Erosion and Sediment Control Plan Content:

Any person seeking approval of a land disturbance proposal shall, on a map rendered from a base derived from the site Master Drainage Plan or site grading plan, at a scale not to exceed 1"=100', provide the following information:

- a. **Location of the land disturbance area and its general surroundings including but not limited to:**
 - 1) **Vicinity map indicating north arrow, scale, and other information necessary to easily locate the site;**
 - 2) **Off-site areas susceptible to sediment deposits or to erosion caused by accelerated runoff from the land disturbance area, such as ponds and small streams;**
 - 3) **Off-site areas affecting potential accelerated runoff and**

erosion control.

- b. Existing topography of the land disturbance area and adjacent land within fifty feet of the boundaries. A topographic map should contain an appropriate contour interval to clearly portray the conformation and drainage pattern of the area;**
- c. The location of existing buildings, structures, utilities, water bodies, drainage facilities, vegetative cover, paved areas (streets, roads, driveways, sidewalks, etc.) and other significant natural or man-made features on the land disturbance area and adjacent land within fifty feet of the boundaries.**
- d. A general description of the predominant soil types, their location and their limitations for the proposed use;**
- e. Proposed use of the land disturbance area including present development and ultimate utilization with detail on final soil cover, both vegetative and impervious;**
- f. All proposed earth disturbance including:**
 - 1) Areas of excavation, grading, and filling.**
 - 2) The proposed final elevations and slopes.**
 - 3) Kinds of utilities and proposed areas of installation.**
 - 4) Proposed paved and covered areas in square feet.**
 - 5) Proposed kind of cover on areas not covered by buildings, structures, or pavement. Description shall be in such terms as: lawn, turfgrass, shrubbery, trees, forest cover, rip-rap, mulch, etc;**
- g. Provisions for temporary and permanent erosion and sedimentation control, per the standards of Article 5. Provisions should include the number, types, dimensions, and locations of all runoff; erosion or sediment control devices to be utilized either temporarily or permanently on the area of land disturbance.**
- h. Provisions for management of stormwater, per the requirements of this regulation and the City's Stormwater Drainage Manual. Provisions should be made for both on-site and off-site tributary areas, including control of accelerated on-site runoff to a stable**

receiving outlet, the site conditions around points of all surface water discharge from the site, and velocities of the 10-year flow at outfalls;

- i. Description of measures that will be undertaken to prevent pollution of existing streams during construction activities and after construction is complete.**

 - 1) Description of mitigation measures to repair damage to the stream channels if the stream channel must be disturbed.**
 - 2) Justification for earth disturbance within the stream channel.**
- j. Provisions for maintenance of control facilities including easements to ensure short-term erosion and sediment pollution control;**
- k. Proposed construction sequence describing the relationship between the implementation and maintenance of controls, including permanent and temporary stabilization and the various stages or phases of earth disturbance and construction. The sequence of construction shall, as a minimum, include a schedule and time frame for the following activities:**

 - 1) Clearing and grubbing for those areas necessary for installation of perimeter controls;**
 - 2) Construction of perimeter controls;**
 - 3) Remaining clearing and grubbing;**
 - 4) Road grading;**
 - 5) Grading for the remainder of the site;**
 - 6) Utility installation and whether storm drains will be used, protected or abandoned after construction;**
 - 7) Final grading, landscaping or stabilization; and;**
 - 8) Removal of controls.**
- l. Seeding mixtures and rates, lime and fertilizer application rates, and kind and quantity of mulching for both temporary and permanent vegetative control measures. Details on proposed methods and schedules of providing temporary and permanent stabilization, pertaining to seeding and/or mulching shall be included;**
- m. Map reference data including title, scale, direction, legend, and date on all plan maps; additionally, the plan, as part of the overall stormwater drainage plan, shall provide space for signatures of City of Columbus officials;**
- n. 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;

- o. A statement indicating that the owner will notify the City forty-eight (48) hours before commencing any land disturbing activity. At the time this notice is given, the owner shall identify the site manager.
- p. Appearing on the Erosion and Sediment Control Plan, as part of the overall Stormwater Drainage Plan, shall be a certification (signature and seal) by a Professional Engineer, registered in the State of Ohio, that the plan has been prepared in accordance with the requirements of this regulation, and in accordance with good engineering practices and principles.

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

6.4 Any person seeking approval of an Erosion and Sediment Control Plan 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 be provided for surface water outlets.

ARTICLE 7: ADMINISTRATION AND APPEALS

7.1 General Intent:

Prior to the development or re-development of any land in the City, the responsible person shall meet the requirements outlined in Article 3.4 of this regulation:

- a. For projects involving earth- or land-disturbance of 2 or more acres, an erosion and sediment control plan shall be developed and submitted for review and approval to the City, to ensure that compliance with the provisions of this regulation will be achieved during and after development. This plan shall be approved prior to commencement of work.
- b. For projects involving earth- or land-disturbance of less than 2-acres, when not a part of a larger common plan of development, it is not necessary to submit an erosion and sediment control plan; however, the person responsible for such land- disturbing activities must comply with all other provisions of this regulation. These sites will be

subject to spot-inspection and site investigation by the City to ensure compliance with this regulation.

7.2 Plan Review:

The City shall upon receipt of the plan initiate review and make a good faith effort to indicate its approval or disapproval (status of compliance or non-compliance) within 21-days, to the person who filed the plan. Indication of disapproval (non-compliance) shall include the plan deficiencies and the procedures for filing a revised plan. In the event an approved plan necessitates a revision, pending preparation and approval (determination of compliance) of the revised plan, earth-disturbing activities shall proceed only in accordance with conditions outlined by the approving agent. Failure to act within the above-described plan review time, shall not imply or represent plan approval.

Plan approval does not constitute assurance that the proposed facilities will perform in the manner indicated by the design. The responsibility of the proper functioning operation and maintenance of the facilities remains with the owner. The owner shall be responsible for providing any additional means or methods necessary to meet the intent of these regulations.

7.3 Appeal Process:

Regarding this regulation, any person aggrieved by any written order or written requirement, final determination (whether approval or disapproval), and action or inaction (including failure to respond or review plans per the requirements of this regulation) may appeal to the Director of Public Utilities, pursuant to City of Columbus Code Chapter 1145.82.

ARTICLE 8: COMPLIANCE RESPONSIBILITY

8.1 Performance Liability:

No provision of this standard shall limit, increase or otherwise affect the liabilities of the developer nor impose any liability upon the City not otherwise imposed by law.

8.2 Ownership and Maintenance:

The person(s) or entity responsible for the continued maintenance of temporary and permanent erosion control measure shall, prior to any earth- or land-disturbance, be identified to the satisfaction of the City. Erosion and sediment control facilities, which are to be privately owned and maintained by an individual or group of property owner(s) shall be:

- a. **Designed and constructed by the developer with easements sufficient to allow adequate access for inspections, maintenance and corrective actions, if necessary, by the City.**
- b. **Inspected as needed by the City to ensure privately owned installations are being properly maintained and, if not, the City may compel the owners to make the necessary repairs at the expense of the owner.**
- c. **Maintained as installed by the developer according to the approved design and not be altered unless approved by the City.**
- d. **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.**

8.3 Operations and Management:

Prior to any earth- or land-disturbance on a development area, the person(s) or entity responsible for continued operation and management of temporary and permanent erosion and sediment control measures, shall be identified to the satisfaction of the City.

Both during and after site development the responsible person(s) or entity, as identified above, is responsible for:

- a. **Carrying out all provisions as approved on the erosion and sediment control plan and required by this standard.**
- b. **Promptly removing all soil, miscellaneous debris or other materials that may become spilled, dumped or otherwise deposited on any public thoroughfares during transport to and from the development site, and**
- c. **Taking precautions to inhibit the deposition of sediment into any sewer system or natural watercourse.**
- d. **The developer shall assume responsibility and all cost for removing any sedimentation deposited in downstream drainage ways or facilities deemed objectionable by the City to the proper functioning of these downstream areas.**

8.4 Inspection and Enforcement:

- a. **Development Sites involving land-disturbance of less than 2-acres, when not a part of a larger plan of common development:** These sites, while not requiring submission of an erosion and sediment control plan, are subject to spot-inspection and site investigation by the City to determine that requirements of this regulation are being met.

- b. **Development Sites involving land-disturbance of 2 or more acres, including those development areas being a part of a larger common plan of development or sale:** It shall be the responsibility of the site owner to provide notification to the City 48-hours prior to commencement of initial site land-disturbance. In addition, the site owner shall provide notification to the City, at least 48-hours prior to any work within or across a stream-channel. Furthermore, within 45-days after Site Final Stabilization has been achieved, it shall be the responsibility of the site owner to file a Notice that site activities are complete. All notifications shall be made to the following City office:

**Stormwater Program Manager
Division of Sewerage and Drainage
Department of Public Utilities
910 Dublin Road, Utilities Complex
Columbus, Ohio 43215**

Phone: (614) 645-6311

Inspection and enforcement actions shall include the following:

1) General Inspection Requirements:

- i) **The City or its representative, may inspect all site development activities, including erosion and sediment control devices and facilities while a development site, when subject to this regulation, is under construction. When facilities are not constructed according to approved plans, the City has the explicit authority to compel compliance with the approved plan and the objectives and standards of this regulation.**

- ii) **Final Inspection: Prior to final inspection, the developer's engineer shall provide the site grading plan documenting the intended site final grades.**

2) General Inspection Procedures:

- i) **A copy of the approved erosion and sediment control plan shall be maintained on site, or in a location easily accessible by the contractor and the City's inspector.**

- ii) **On developing areas with disturbed areas in excess of 2 acres, the permittee may request that the inspection agency inspect work completed at the stages of construction specified below to ensure accordance with the approved erosion and sediment control plan, the grading or building permit, and this regulation:**
 - (a) **Upon completion of installation of perimeter erosion and sediment controls, prior to proceeding with any other earth disturbance or grading. Other building or grading inspection approvals may not be authorized until initial approval by the inspection agency is made; and**
 - (b) **Upon final stabilization before removal of sediment controls.**
- iii) **Every active site having a designed erosion and sediment control plan may be inspected for compliance with the plan at a frequency to be determined by the City.**
- iv) **Inspectors shall prepare written reports after every inspection. The inspection report shall describe:**
 - (a) **The date and location of the site inspection;**
 - (b) **Whether or not the approved plan has been properly implemented and maintained;**
 - (c) **Any practice deficiencies or erosion and sediment control plan deficiencies; and the agreed upon type(s) of corrective action necessary to rectify any identified deficiencies.**
 - (d) **If a violation exists, the type of enforcement action taken.**
 - (e) **The site manager shall sign and receive a copy of the report before the inspector leaves the site.**
- v) **The inspection agency shall notify the on-site personnel or the owner /developer when deficiencies are observed, describing the nature of the deficiency, the agreed upon corrective action, and the time period in which to have the deficiency corrected. If after a reasonable amount of time for voluntary compliance,**

the corrective actions are not undertaken to the satisfaction of the City, the City may issue a Notice of Violation pursuant to Columbus City Codes Section 1145.80 and proceed with other enforcement remedies as provided by Columbus City Codes Chapter 1145 and other applicable provisions of the Columbus City Codes. Where the violations and/or deficiencies represent an immediate and substantial threat to the public health, safety or welfare, the City may immediately proceed with enforcement remedies as provided by Columbus City Codes Chapter 1145 and other applicable provisions of the Columbus City Codes.

Stormwater Drainage Manual



Appendix B

Native Plant Species for
Stormwater Quality
Best Management Practices



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Appendix B Native Plant Species For Stormwater Quality Best Management Practices

Selection of Native Plant Species

We are fortunate in Ohio to have a great diversity of plants to choose from, including many that thrive under adverse conditions. Native plants can be found to suit a variety of sites: wet or dry, sun or shade, high or low fertility, and acidic or calcareous soils¹. When used correctly, native plants may:

- **Promote Biodiversity:** Contributes to the ecological balance of flora and fauna that have evolved in the geographic area. Natives perpetuate the relationships that exist between native plants, the soils, and the many organisms that depend upon them for survival. Biodiversity is degraded through the destruction of natural landscapes and their invasion by exotic species. Because biodiversity has evolved over thousand of years, this loss is irreversible.
- **Save Time, Money, and Energy:** Native plants generally require less maintenance making the use of natives less expensive. Because they are adapted to a local region, they tend to resist damage from freezing, drought, common diseases, or herbivores.
- **Conserve Natural Resources:** Because they are adapted to the soils, temperatures and rainfall patterns, native plants typically require less irrigation and fertilization than traditional plantings. Many native species thrive in poor soils. Native plants, used wisely, can protect water quality by controlling soil erosion and moderating floods and droughts.
- **Attract Wildlife:** Native plants are the best choice for attracting and nourishing native wildlife. Birds, mammals, butterflies and other wildlife depend on the many characteristics that native plants provide. These species have evolved with the local bird, mammal, butterfly and insect populations and are therefore their best source of food and habitat.
- **Genetic Resource.** Native plants serve as an important genetic resource for future food crops. However, in the long run, natives will, in most cases, form self-sustaining plant communities that provide the keystone elements for ecosystem restoration. They are a vital component of any native ecosystem.

What are invasive plants?

Invasive species are aggressive non-native plants introduced into environments where they did not evolve. These species are also referred to as exotics, aliens, weeds, and non-indigenous species.

Invasive species spread rapidly because they often have no natural pests to limit their spread, displacing native species and disrupting natural ecosystems by changing the composition, structure and function of natural plant communities. Table B-1 lists common invasive plant species found in Franklin County that should be avoided.

¹ The Ohio State University Extension Bulletin 865

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-1 Common Invasive Plants Found in Franklin County	
Botanical Name	Common Name
<i>Ailanthus altissima</i>	Tree of Heaven
<i>Alliaria petiolata</i>	Garlic mustard
<i>Berberis thunbergii</i>	Japanese barberry
<i>Coronilla varia</i>	Crown vetch
<i>Euonymous alatus</i>	Burning bush
<i>Euonymous fortunei</i>	Wintercreeper vine
<i>Hemerocallis fulva</i>	Day lily
<i>Ligustrum vulgare</i>	Common privet
<i>Lonicera maackii</i> , <i>L. morrowii</i> , <i>L. tatarica</i>	Bush honeysuckle
<i>Lonicera japonica</i>	Japanese honeysuckle
<i>Lythrum salicaria</i>	Purple loosestrife
<i>Ranunculus ficaria</i>	Lesser celandine
<i>Rosa multiflora</i>	Multiflora rose
<i>Polygonum cuspidatum</i>	Japanese knotweed
<i>Vinca minor</i>	Periwinkle, Myrtle

Table B-2 lists native plant species that are approved for use in stormwater best management practices in the City of Columbus. The plants listed are generally available in nursery stock specializing in native plants. If no specific designation for use is shown, the designer must determine the survivability of the selected species based on site conditions.

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Acorus americanus</i>	Sweet flag	Wet				x	x	x	
<i>Agastache nepetoides</i>	Yellow giant hyssop	Dry							
<i>Agastache scrophulariaefolia</i>	Purple giant hyssop	Dry							
<i>Alisma subcordatum</i>	Common water plantain	Wet		x	x	x	x	x	
<i>Allium canadense</i>	Wild onion	Dry							
<i>Allium cernuum</i>	Nodding wild onion	Medium	x						
<i>Amorpha fruticosa</i>	Indigo bush	Wet							x
<i>Andropogon gerardii</i> ⁴	Big bluestem grass	Medium	x					x	
<i>Andropogon virginicus</i>	Broom sedge	Medium							x
<i>Anemone canadensis</i>	Meadow anemone	Wet							
<i>Anemone cylindrica</i>	Thimbleweed	Dry	x						

² See attached citations and reference list for source information.

³ Information provided by The Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois

⁴ Ohio native grass

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Anemone virginiana</i>	Tall anemone	Dry	x						
<i>Anemonella thalictroides</i>	Rue anemone	Dry							
<i>Angelica atropurpurea</i>	Great angelica	Wet		x					
<i>Apocynum androsaemifolium</i>	Spreading dogbane	Dry							
<i>Aquilegia canadensis</i>	Wild columbine	Medium	x						x
<i>Asclepias incarnata</i>	Swamp milkweed	Wet		x		x			
<i>Asclepias purpurascens</i>	Purple milkweed	Dry							
<i>Asclepias sullivantii</i>	Prairie milkweed	Dry							
<i>Asclepias syriaca</i>	Common milkweed	Dry	x						
<i>Asclepias tuberosa</i>	Butterfly weed	Dry	x						x
<i>Asclepias verticillata</i>	Whorled milkweed	Dry	x						
<i>Aster cordifolius</i>	Heart-leaved aster	Dry							
<i>Aster divaricatus</i>									

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Native Plant Species
For Stormwater Quality Best Management Practices**

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Aster ericoides</i>	Heath aster	Dry							x
<i>Aster firmus</i>	Shining aster	Wet							
<i>Aster laevis</i>	Smooth blue aster	Dry						x	x
<i>Aster lanceolatus</i>								x	
<i>Aster lateriflorus</i>	Side-flowering aster	Medium							
<i>Aster macrophyllus</i>	Big-leaved aster	Dry							
<i>Aster novae-angliae</i>	New England aster	Wet		x				x	
<i>Aster oolentangiensis</i>	Sky-blue aster	Dry	x						x
<i>Aster praealtus</i>	Willow aster	Wet							
<i>Aster puniceus</i>	Bristly aster	Wet		x					x
<i>Aster sagittifolius</i>	Arrow-leaved aster	Dry							
<i>Aster shortii</i>	Short's aster	Dry							
<i>Aster umbellatus</i>	Flat-top aster	Wet		x	x				
<i>Astragalus canadensis</i>	Canadian milk vetch	Dry							
<i>Baptisia australis</i>	Blue wild indigo	Dry	x						x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Baptisia lactea</i>	White wild indigo	Medium	x						
<i>Baptisia tinctora</i>	Yellow wild indigo	Dry							
<i>Bidens cernua</i>	Nodding beggars tick	Wet		x	x			x	x
<i>Bidens coronata</i>	Tall swamp marigold	Wet							
<i>Bidens frondosa</i>	Common beggars tick	Wet						x	
<i>Blephilia hirsuta</i>	Wood mint	Dry							
<i>Boltonia asteroides</i>	False aster	Wet							
<i>Bouteloua curtipendula</i>	Side-oats grama	Dry	x					x	x
<i>Brasenia schreberi</i>	Water shield	Wet							
<i>Bromus ciliatus</i>	Fringed brome	Wet							
<i>Bromus pubescens</i>	Woodland brome	Medium							
<i>Cacalia atriplicifolia</i>	Pale indian plantain	Dry	x						
<i>Cacalia muhlenbergii</i>	Great indian plantain	Dry							
<i>Cacalia plantaginea</i>	Prairie indian	Medium							

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Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
	plantain								
<i>Cacalia suaveolens</i>	Sweet indian plantain	Wet							
<i>Calamagrostis canadensis</i> ³	Blue joint grass	Wet		x	x			x	
<i>Caltha palustris</i>	Marsh marigold	Wet			x	x			
<i>Campanula americana</i>	Tall bellflower	Medium							
<i>Carex annectens</i>	Large yellow fox sedge	Wet							
<i>Carex aquatilis</i>	Long-bracted tussock sedge	Wet							
<i>Carex atherodes</i>	Hairy-leaved lake sedge	Wet							
<i>Carex bebbii</i>	Bebb's oval sedge	Wet							
<i>Carex bicknellii</i>	Copper-shouldered oval sedge	Dry							
<i>Carex brevior</i>	Plains oval sedge	Dry							

**Appendix B
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For Stormwater Quality Best Management Practices**

Table B-2

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Carex cephaloidea</i>	Rough-clustered sedge	Medium							
<i>Carex comosa</i>	Bristly sedge	Wet		x			x	x	
<i>Carex crinita</i>	Fringed sedge	Wet			x		x		
<i>Carex cristatella</i>	Crested oval sedge	Wet						x	
<i>Carex crus-corvi</i>	Crowfoot fox sedge	Wet							
<i>Carex davisii</i>	Awned graceful sedge	Medium							
<i>Carex emoryi</i>	Riverbank sedge	Wet							
<i>Carex frankii</i>	Bristly cattail sedge	Wet							
<i>Carex granularis</i>	Pale sedge	Wet						x	
<i>Carex grayi</i>	Common bur sedge	Wet							
<i>Carex haydenii</i>	Long-scaled tussock sedge	Wet							
<i>Carex hystericina</i>	Porcupine sedge	Wet			x				
<i>Carex interior</i>	Prairie star sedge	Wet							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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				Saturated	Shallow	Shallow	Deep	Tested ³	
Carex lacustris	Common lake sedge	Wet					x		
Carex lupulina	Common hop sedge	Wet			x		x		
Carex lurida	Bottlebrush sedge	Wet				x	x		
Carex muhlenbergii	Sand bracted sedge	Dry							
Carex muskingumensis	Swamp oval sedge	Wet			x				
Carex normalis	Spreading oval sedge	Medium							
Carex pensylvanica	Common oak sedge	Dry							
Carex plantaginea	Plantain-leaved wood sedge	Dry							
Carex prairea	Fen paniced sedge	Wet							
Carex projecta	Loose-headed oval sedge	Wet							
Carex rosea	Curly-styled wood sedge	Dry							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Carex scoparia</i>	Lance-fruited oval sedge	Wet							
<i>Carex shortiana</i>									
<i>Carex squarrosa</i>	Narrow-leaved cattail sedge	Wet			x				
<i>Carex stipata</i>	Common fox sedge	Wet						x	
<i>Carex straminea</i>	Awned oval sedge	Wet							
<i>Carex stricta</i>	Common tussock sedge	Wet		x					
<i>Carex tribuloides</i>	Awl-fruited oval sedge	Wet							
<i>Carex typhina</i>	Common cattail sedge	Wet			x				
<i>Carex utriculata</i>	Common yellow lake sedge	Wet							
<i>Carex vesicaria</i>	Tufted lake sedge	Wet							
<i>Carex viridula</i>	Green yellow sedge	Wet							
<i>Carex vulpinoidea</i>	Brown fox sedge	Wet			x	x	x	x	

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Chamaecrista fasciculata</i>	Partridge pea	Dry	x						
<i>Chelone glabra</i>	Turtlehead	Wet			x				
<i>Cinna arundinacea</i>	Common wood reed	Wet			x				
<i>Clematis virginiana</i>	Virgin's bower	Medium							
<i>Coreopsis palmata</i>	Prairie coreopsis	Dry	x						
<i>Coreopsis tripteris</i>	Tall coreopsis	Medium		x				x	
<i>Crotalaria sagittalis</i>	Rattlebox	Dry							
<i>Cyperus esculentus</i>	Field nut sedge	Medium					x	x	
<i>Danthonia spicata</i>									
<i>Decodon verticillatus</i>	Swamp loosestrife	Wet					x		
<i>Deschampsia caespitosa glauca</i>	Tufted hair grass	Wet							x
<i>Desmanthus illinoensis</i>	Illinois sensitive plant	Dry	x						
<i>Desmodium canadense</i>	Showy tick trefoil	Medium							

**Appendix B
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For Stormwater Quality Best Management Practices**

Table B-2

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Desmodium canescens</i>	Hoary tick trefoil	Dry							
<i>Desmodium illinoense</i>	Illinois tick trefoil	Dry	x						
<i>Desmodium sessilifolium</i>	Sessile-leaved tick trefoil	Dry							
<i>Diarrhena americana</i>	Beak grass	Dry							
<i>Dodecatheon meadia</i>	Shooting star	Medium	x						
<i>Dulichium arundinaceum</i>	Three-way sedge	Wet							
<i>Echinacea pallida</i>	Purple coneflower	Dry							
<i>Echinacea purpurea</i>	Broad-leaved purple coneflower	Dry	x						x
<i>Echinochloa crus-galli</i>	Barnyard grass	Wet		x	x				x
<i>Eleocharis acicularis</i>	Needle spike rush	Wet					x		
<i>Eleocharis obtusa</i>	Blunt spike rush	Wet				x	x	x	

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

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Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Eleocharis palustris</i> major	Great spike rush	Wet					x		x
<i>Eleocharis smallii</i>	Creeping spike rush	Medium						x	
<i>Elymus canadensis</i>	Canada wild rye	Medium	x	x	x			x	
<i>Elymus riparius</i> ³	Riverbank wild rye	Medium							
<i>Elymus villosus</i>	Silky wild rye	Dry							
<i>Elymus virginicus</i> ³	Virginia wild rye	Medium			x	x		x	
<i>Epilobium coloratum</i>	Cinnamon willow herb	Wet							
<i>Equisetum hyemale</i>	Tall scouring rush	Medium		x					
<i>Eryngium yuccifolium</i>	Rattlesnake master	Medium							
<i>Eupatorium coelestinum</i>	Blue mistflower	Medium	x						
<i>Eupatorium fistulosum</i>	Hollow joe-pye weed	Wet							
<i>Eupatorium maculatum</i>	Spotted joe-pye weed	Wet		x				x	

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Eupatorium perfoliatum</i>	Common boneset	Wet		x		x		x	x
<i>Eupatorium purpureum</i>	Purple joe-pye weed	Dry	x						
<i>Eupatorium rugosum</i>	White snakeroot	Dry							
<i>Eupatorium serotinum</i>	Late boneset	Medium	x						
<i>Euphorbia corollata</i>	Flowering spurge	Dry	x						
<i>Filipendula rubra</i>	Queen of the prairie	Wet		x					
<i>Gentiana andrewsii</i>	Bottle gentian	Wet		x					
<i>Gentiana flavida</i>	Cream gentian	Medium							
<i>Geranium maculatum</i>	Wild geranium	Dry							
<i>Geum triflorum</i>	Prairie smoke	Dry							
<i>Glyceria canadensis</i>	Rattlesnake grass	Wet							
<i>Glyceria grandis</i>	Reed manna grass	Wet							
<i>Glyceria pallida</i>	Pale manna grass	Wet							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Glyceria striata</i>	Fowl manna grass	Wet		x	x	x		x	
<i>Helenium autumnale</i>	Sneezeweed	Wet		x	x	x		x	x
<i>Helianthus giganteus</i>	Tall sunflower	Wet							
<i>Helianthus grosseserratus</i>	Sawtooth sunflower	Medium	x					x	
<i>Helianthus mollis</i>	Downy sunflower	Dry	x						
<i>Helianthus occidentalis</i>	Western sunflower	Dry	x						
<i>Helianthus rigidus</i>	Prairie sunflower	Dry							
<i>Helianthus strumosus</i>	Pale-leaved sunflower	Dry							
<i>Helianthus tuberosus</i>	Jerusalem artichoke	Medium	x						
<i>Heliopsis helianthoides</i>	False sunflower	Dry							
<i>Heracleum maximum</i>	Cow parsnip	Dry							
<i>Heuchera richardsonii</i>	Prairie alum root	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Hibiscus laevis</i>	Halberd-leaved rose mallow	Wet					x		
<i>Hibiscus moscheutos</i>	March hibiscus	Wet							
<i>Hibiscus palustris</i>	Swamp rose mallow	Wet					x		x
<i>Hierochloe odorata</i>	Sweet grass	Wet							x
<i>Hypericum pyramidatum</i>	Great St. John's wort	Medium							x
<i>Hypericum virginicum</i>	Marsh St. John's wort	Wet							x
<i>Hypericum prolificum</i>	Shrubby St. John's wort	Dry	x						
<i>Hystris patula</i>	Bottlebrush grass	Dry							
<i>Ilex verticillata</i>	Winterberry	Wet							x
<i>Iris virginica shrevei</i>	Blue flag iris	Wet		x		x	x	x	
<i>Iris versicolor</i>									
<i>Juncus canadensis</i>	Canadian rush	Wet							x
<i>Juncus dudleyi</i>	Dudley's rush	Medium							
<i>Juncus effusus</i>	Common rush	Wet		x		x	x	x	
<i>Juncus tenuis</i>	Path rush	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Juncus torreyi</i>	Torrey's rush	Wet						x	x
<i>Justicia americana</i>	Water willow	Wet					x		
<i>Koeleria cristata</i>	June grass	Dry							
<i>Kuhnia eupatoroides corymbulosa</i>	False boneset	Dry							
<i>Lathyrus palustris</i>	Marsh vetchling	Wet							x
<i>Leersia oryzoides</i>	Rice cut grass	Wet		x	x	x	x	x	
<i>Lemna minor</i>	Duckweed, floating								
<i>Lespedeza capitata</i>	Round-headed bush clover	Dry	x						
<i>Liatris aspera</i>	Rough blazing star	Dry	x						x
<i>Liatris cylindracea</i>	Cylindrical blazing star	Dry	x						
<i>Liatris pycnostachya</i>	Prairie blazing star	Medium	x						
<i>Liatris scariosa nieuwlandii</i>	Savanna blazing star	Dry							
<i>Liatris spicata</i>	Marsh blazing star	Medium	x						
<i>Lobelia cardinalis</i>	Cardinal flower	Wet		x		x			

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Lobelia inflata</i>	Indian tobacco	Dry	x						
<i>Lobelia siphilitica</i>	Great blue lobelia	Wet		x	x	x			
<i>Lobelia spicata</i>	Pale spiked lobelia	Medium	x						
<i>Ludwigia alternifolia</i>	Seedbox	Wet		x		x			
<i>Lupinus perennis occidentalis</i>	Wild lupine	Dry	x						
<i>Lycopus americanus</i>	Common water horehound	Wet							
<i>Lythrum alatum</i>	Winged loosestrife	Wet							
<i>Matteuccia struthiopteris</i>									
<i>Mentha arvensis villosa</i>	Wild mint	Wet							
<i>Mertensia virginica</i>	Virginia bluebells	Wet							
<i>Mimulus ringens</i>	Monkey flower	Wet			x	x			
<i>Monarda fistulosa</i>	Wild bergamot	Dry	x					x	
<i>Monarda punctata</i>	Horse mint	Dry							
<i>Napaea dioica</i>	Glade mallow	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Nelumbo lutea</i>	Lotus (clay ball)	Wet							
<i>Nuphar advena</i>	Yellow pond lily	Wet					x		x
<i>Nymphaea tuberosa</i>	White water lily (rooted buds)	Wet					x		
<i>Nymphaea odorata</i>									
<i>Oenothera biennis</i>	Common evening primrose	Dry							
<i>Onoclea sensibilis</i>									
<i>Opuntia humifusa</i>	Eastern prickly pear	Dry							
<i>Osmorhiza claytonii</i>	Hairy sweet cicely	Dry							
<i>Osmunda cinnomomea</i>									
<i>Osmunda regalis</i>									
<i>Oxypolis rigidior</i>	Cowbane	Wet							
<i>Panicum clandestinum</i>	Deer-tongue grass	Wet							
<i>Panicum rigidulum</i>	Munro grass	Wet							
<i>Panicum virgatum</i> ³	Switch grass	Medium	x	x	x			x	x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Parthenium integrifolium</i>	Wild quinine	Dry	x						
<i>Parthenocissus quinquefolia</i>	Virginia creeper	Medium							x
<i>Pedicularis lanceolata</i>	Fen betony	Wet							
<i>Peltandra virginica</i>	Arrow arum	Wet		x			x		
<i>Penstemon calycosus</i>	Smooth beard tongue	Dry	x						
<i>Penstemon digitalis</i>	Foxglove beard tongue	Medium	x						
<i>Penstemon hirsutus</i>	Hairy beard tongue	Dry	x						
<i>Penthorum sedoides</i>	Ditch stonecrop	Wet							
<i>Petalostemum candidum</i>	White prairie clover	Dry							
<i>Petalostemum purpureum</i>	Purple prairie clover	Dry	x					x	x
<i>Phlox divaricata</i>	Woodland phlox	Dry							
<i>Phlox pilosa</i>	Sand prairie phlox	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Physostegia virginiana</i>	Obedient plant	Wet							x
<i>Physostegia virginiana arenaria</i>	Prairie obedient plant	Dry	x						
<i>Polygonatum canaliculatum</i>	Smooth Solomon's seal	Dry							
<i>Polygonum amphibium stipulaceum</i>	Water knotweed	Wet					x	x	
<i>Polygonum pensylvanicum</i>	Pinkweed	Wet							x
<i>Pontederia cordata</i>	Pickerel weed	Wet				x	x		
<i>Potamogeton natans</i>	Common pondweed	Wet					x		
<i>Potamogeton pectinatus</i>	Sago pondweed	Wet					x		x
<i>Potentilla arguta</i>	Prairie cinquefoil	Dry							
<i>Prenanthes altissima</i>	Tall white lettuce	Dry							
<i>Pycnanthemum muticum</i>	Broad-leaved mountain mint	Wet							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Pycnanthemum tenuifolium</i>	Slender mountain mint	Medium							
<i>Pycnanthemum virginianum</i>	Common mountain mint	Wet		x				x	
<i>Ranunculus fascicularis</i>	Early buttercup	Dry							
<i>Ratibida pinnata</i>	Yellow coneflower	Dry						x	
<i>Rhynchospora macrostachya</i>	Horned beak rush	Wet							x
<i>Rosa carolina</i>	Pasture rose	Dry							
<i>Rosa palustris</i>	Swamp rose	Wet				x			
<i>Rudbeckia hirta</i>	Black-eyed susan	Dry	x					x	x
<i>Rudbeckia laciniata</i>	Wild golden glow	Wet			x	x			
<i>Rudbeckia speciosa sullivantii</i>	Showy black-eyed susan	Wet							
<i>Rudbeckia subtomentosa</i>	Sweet black-eyed susan	Medium	x						
<i>Rudbeckia triloba</i>	Brown-eyed susan	Medium							
<i>Rumex altissimus</i>	Pale dock	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
Rumex orbiculatus	Great water dock	Wet							x
Rumex verticillatus	Swamp dock	Wet							
Sabatia angularis	Rose gentian	Medium							
Sagittaria latifolia	Common arrowhead	Wet		x		x	x	x	
Saururus cernuus	Lizard's tail	Wet				x			
Schizachyrium scoparium ³	Little bluestem	Dry						x	
Scirpus acutus	Hard-stemmed bulrush	Wet				x	x	x	x
Scirpus americanus	Chairmaker's rush						x	x	
Scirpus atrovirens	Dark green rush	Wet		x	x	x	x		
Scirpus cyperinus	Wool grass	Wet					x		x
Scirpus fluviatilis	River bulrush	Wet					x	x	
Scirpus pendulus	Red bulrush	Wet							
Scirpus pungens	Chairmaker's rush	Wet				x			x
Scirpus tabernaemontani	Soft-stem bulrush						x	x	
Scirpus validus creber	Great bulrush	Wet		x		x	x		x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Scrophularia marilandica</i>	Late figwort	Dry							
<i>Senecio aureus</i>	Golden ragwort	Wet							
<i>Senna hebecarpa</i>	Wild senna	Wet		x		x			
<i>Silene regia</i>	Royal catchfly	Dry							
<i>Silene stellata</i>	Starry campion	Dry							
<i>Silene virginica</i>	Fire pink	Dry							
<i>Silphium integrifolium</i>	Rosin weed	Dry							
<i>Silphium laciniatum</i>	Compass plant	Dry	x					x	
<i>Silphium perfoliatum</i>	Cup plant	Medium		x					
<i>Silphium terebinthinaceum</i>	Prairie dock	Dry						x	
<i>Sisyrinchium angustifolium</i>	Stout blue-eyed grass	Medium							
<i>Sisyrinchium atlanticum</i>	Eastern blue-eyed grass	Wet							
<i>Sium suave</i>	Tall water parsnip	Wet							x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Smilacina racemosa</i>	Feathery false Solomon's seal	Dry							
<i>Solidago altissima</i>	Tall goldenrod	Dry							
<i>Solidago caesia</i>	Blue-stemmed goldenrod	Dry							
<i>Solidago canadensis</i>	Canadian goldenrod	Dry							
<i>Solidago flexicaulis</i>	Broad-leaved goldenrod	Dry							
<i>Solidago gigantea</i>	Late goldenrod	Medium						x	
<i>Solidago graminifolia</i>	Common grass-leaved goldenrod	Medium							
<i>Solidago juncea</i>	Early goldenrod	Dry							
<i>Solidago nemoralis</i>	Old-field goldenrod	Dry							
<i>Solidago ohioensis</i>	Ohio goldenrod	Wet							
<i>Solidago patula</i>	Swamp goldenrod	Wet							
<i>Solidago riddellii</i>	Riddell's goldenrod	Wet							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Solidago rigida</i>	Stiff goldenrod	Dry	x					x	x
<i>Solidago rugosa</i>	Rough goldenrod	Medium							
<i>Solidago speciosa</i>	Showy goldenrod	Dry							x
<i>Sorghastrum nutans</i> ³	Indian grass	Medium						x	
<i>Sparganium americanum</i>	American bur reed	Wet					x		
<i>Sparganium eurycarpum</i>	Common bur reed	Wet				x	x	x	
<i>Spartina pectinata</i> ³	Prairie cord grass	Wet		x	x			x	x
<i>Sporobolus heterolepis</i>	Prairie dropseed	Dry							x
<i>Stipa spartea</i>	Porcupine grass	Dry							
<i>Styloforum diphyllum</i>	Calendine poppy	Dry							
<i>Tephrosia virginiana</i>	Goat's rue	Dry							
<i>Teucrium canadense</i>	Germander	Wet							x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Thalictrum dasycarpum</i>	Purple meadow rue	Medium	x						
<i>Thalictrum dioicum</i>	Early meadow rue	Medium	x						
<i>Tradescantia ohiensis</i>	Common spiderwort	Medium	xx					x	
<i>Triglochin maritima</i>	Common bog arrow grass	Wet							
<i>Triosteum aurantiacum</i>	Early horse gentian	Dry							
<i>Typha latifolia</i>									
<i>Uniola latifolia</i>	Spike grass	Wet							
<i>Vallisneria american</i>							x		
<i>Verbena hastata</i>	Blue vervain	Wet		x		x	x	x	
<i>Verbena stricta</i>	Hoary vervain	Dry							x
<i>Verbesina alternifolia</i>	Wingstem	Wet			x	x			
<i>Vernonia altissima</i>	Smooth tall ironweed	Medium							
<i>Vernonia altissima taeniotricha</i>	Hairy tall ironweed	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Vernonia fasciculata</i>	Common ironweed	Wet				x		x	
<i>Vernonia missurica</i>	Missouri ironweed	Medium							
<i>Vernonia novaboracensis</i>									
<i>Veronicastrum virginicum</i>	Culver's root	Medium	x						
<i>Viola lanceolata</i>	Lance-leaved violet	Wet							
<i>Viola pedata lineariloba</i>	Bird's foot violet	Dry							
<i>Zizania aquatica</i>	Wild rice	Wet					x		x
<i>Zizia aptera</i>	Heart-leaved meadow parsnip	Dry							
<i>Zizia aurea</i>	Golden alexanders	Medium	x						x
WOODY MATERIAL - Native Ohio Trees									

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
and Shrubs									
<i>Acer negundo</i>	Box elder	Medium							
<i>Acer rubrum</i>	Red maple	Medium						x	
<i>Acer saccharinum</i>	Silver maple	Medium							
<i>Acer saccharum</i>	Sugar maple	Dry							
<i>Aesculus flava</i>	Yellow Buckeye	Dry							
<i>Aesculus glabra</i>	Ohio Buckeye	Dry							
<i>Alnus incana</i>	Black Alder								
<i>Alnus serrulata</i>	Smooth Alder	Wet							
<i>Amelanchier arborea</i>	Serviceberry	Medium							
<i>Amelanchier laevis</i>	Smooth Serviceberry								
<i>Aronia arbutifolia</i>	Red Chokeberry								
<i>Aronia melanocarpa</i>	Black chokeberry	Medium							
<i>Asimina triloba</i>	Pawpaw	Wet							
<i>Betula alleghaniensis</i>	Yellow Birch	Medium							
<i>Betula lenta</i>	Sweet birch	Medium							
<i>Betula nigra</i>	River birch	Wet							x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Betula populifolia</i>	Gray birch	Medium							
<i>Carpinus caroliniana</i>	Blue beech	Medium							
<i>Carya glabra</i>	Pignut hickory	Dry							
<i>Carya laciniosa</i>	Kingnut hickory	Wet							
<i>Carya ovata</i>	Shagbark hickory	Medium							x
<i>Ceanothus americanus</i>	New Jersey tea	Dry							
<i>Celtis occidentalis</i>	Hackberry	Medium						x	
<i>Cephalanthus occidentalis</i>	Buttonbush	Wet						x	
<i>Cercis canadensis</i>	Redbud	Dry							
<i>Chionanthus virginicus</i>	Fringe tree	Medium							
<i>Clethra alnifolia</i>									
<i>Cornus alternifolia</i>	Alternate lf dogwood	Dry							
<i>Cornus amomum</i>	Silky dogwood	Wet							
<i>Cornus florida</i>	Flowering dogwood	Dry							
<i>Cornus racemosa</i>	Grey dogwood	Medium						x	

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Cornus sericea</i>	Red-osier dogwood	Wet						x	
<i>Crataegus crus-galli</i>	Cockspur	Medium							
<i>Diospyros virginiana</i>	Persimmon	Medium							
<i>Fagus grandifolia</i>	American beech	Medium							
<i>Fraxinus americana</i>	White ash	Medium							
<i>Fraxinus pennsylvanica</i>	Green ash	Medium						x	x
<i>Fraxinus quadrangulata</i>	Blue ash								
<i>Gymnocladus dioica</i>	KY coffee tree								
<i>Hamamelis virginiana</i>	Witchhazel	Dry							
<i>Ilex verticillata</i>	Winterberry	Medium							
<i>Juglans nigra</i>	Black Walnut	Medium							
<i>Juniperus virginiana</i>	Eastern red cedar								
<i>Lindera benzoin</i>	Spicebush	Medium							
<i>Liquidambar styraciflua</i>	Sweet gum	Dry							x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

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				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Liriodendron tulipifera</i>	Tulip tree	Medium							
<i>Nyssa sylvatica</i>	Black gum	Medium							x
<i>Parthenocissus quinquefolia</i>	Virginia creeper	Medium							
<i>Physocarpus opulifolius</i>	Ninebark	Medium							
<i>Platanus occidentalis</i>	Sycamore	Wet							x
<i>Populus deltoides</i>	Eastern cottonwood	Wet							
<i>Populus tremuloides</i>	Quaking aspen	Medium							
<i>Prunus serotina</i>	Black cherry	Medium							
<i>Prunus virginiana</i>	Choke cherry	Medium							
<i>Quercus alba</i>	White oak	Medium							x
<i>Quercus bicolor</i>	Swamp white oak	Wet						x	x
<i>Quercus coccinea</i>	Scarlet oak	Dry							
<i>Quercus imbricaria</i>	Shingle Oak	Dry							
<i>Quercus macrocarpa</i>	Bur oak	Medium						x	x

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Quercus muhlenbergii</i>	Chinquapin oak	Dry							
<i>Quercus palustris</i>	Pin oak	Wet						x	x
<i>Quercus rubra</i>	Red oak	Dry							x
<i>Quercus shumardii</i>	Shumard oak	Medium							
<i>Quercus velutina</i>	Black oak	Dry							
<i>Rhus aromatica</i>	Fragrant sumac	Dry							
<i>Rhus copallina</i>	Winged sumac	Medium							
<i>Rhus typhina</i>	Staghorn sumac	Dry							
<i>Salix amygdaloides</i>	Peachleaf willow	Medium						x	
<i>Salix discolor</i>	Pussy willow	Medium							
<i>Salix nigra</i>	Black willow	Medium						x	
<i>Salix sericea</i>	Silky willow	Wet							
<i>Sambucus canadensis</i>	Elderberry	Medium							x
<i>Sassafras albidum</i>	Sassafras	Medium							
<i>Spiraea alba</i>	Meadowsweet	Wet							x
<i>Spiraea tomentosa</i>	Steeple bush	Wet							x
<i>Staphylea trifolia</i>	Bladdernut	Medium							

**Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices**

Table B-2

Approved Native Plant Species²

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested ³	
<i>Taxodium distichum</i>	Bald cypress	Wet							x
<i>Thuja occidentalis</i>	Arborvitae	Medium							
<i>Tilia americana</i>	American basswood	Medium							
<i>Viburnum cassinoides</i>	With-rod	Medium							
<i>Viburnum dentatum</i>	Arrow wood	Medium						x	
<i>Viburnum lentago</i>	Nannyberry	Medium						x	x
<i>Viburnum prunifolium</i>	Black haw	Medium							x
<i>Viburnum recognitum</i>	Northern arrow-wood	Medium							
<i>Viburnum trilobum</i>	American highbush cranberry	Wet							x

Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices

Citations and References for Native Plant Species:

Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois.

1997. Prepared by USDA Natural Resources Conservation Service's Chicago Metro Urban and Community Assistance Office

In cooperation with

US Environmental Protection Agency, Region 5

US Fish and Wildlife Service, Chicago Field Office

US Army Corps of Engineers, Chicago District

Native Ohio Tree Species Suitable for Planting within 1,000 feet of State Wild, Scenic and Recreational Rivers.

2005. Ohio Department of Natural Resources, Division of Natural Areas and Preserves.

Mack, John J. 2004. Integrated Wetland Assessment Program. Part 4: Vegetation Index of Biotic Integrity (VIBI) and Tiered Aquatic Life Uses (TALUs) for Ohio wetlands. Ohio EPA Technical Report WET/2004-4. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water,

Columbus http://www.epa.state.oh.us/dsw/wetlands/wetland_bioassess.html

Andreas, Barbara K.; Mack, John J.; and McCormac, James S. 2004 Floristic Quality Assessment Index (FQAI) for Vascular Plants and Mosses for the State of Ohio. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group. Columbus Ohio. http://www.epa.state.oh.us/dsw/wetlands/wetland_bioassess.html

Thunhorst, Gwendolyn A. 1993. Wetland Planting Guide for the Northeastern United States; Plants for Wetland Creation, Restoration, and Enhancement. Environmental Concern, Inc.; St Michaels MD 21663.

Czarapata, Elizabeth. 2005. Invasive Plants of the Upper Midwest. University of Wisconsin Press.

Ohio DNR, Division of Natural Areas and Preserves; and The Nature Conservancy. 2000. Ohio's Invasive Plant Species. ODNR DNAP (614) 265-6453 or ODNR Div of Wildlife (614) 265-6309. TNC (6114) 717-2770

City of Portland Bureau of Environmental Services. 2004. Stormwater Management Manual. Chapter 2.7 and Appendix F. available at www.portlandonline.com/bes

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Stormwater Drainage Manual



Appendix C Calculation Worksheets



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Stormwater Drainage Manual

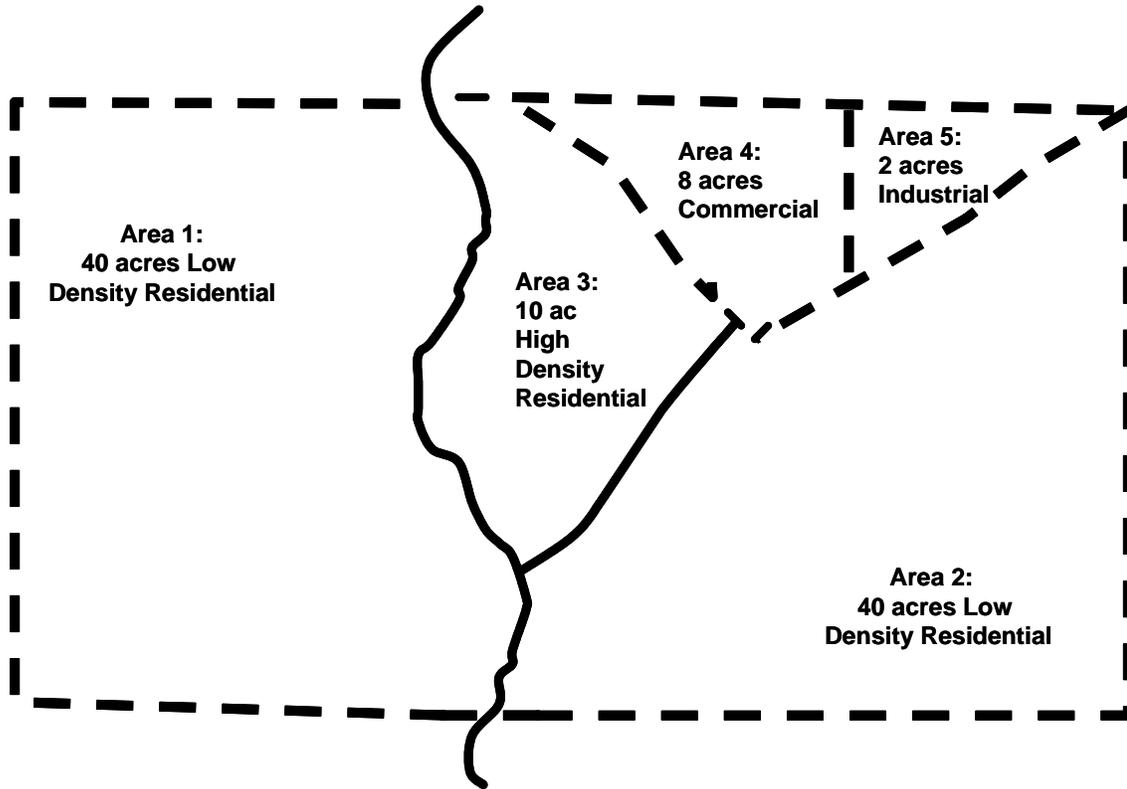


Appendix D

Example Calculations for Stream
Corridor Protection Zone
and Stormwater Quality Controls

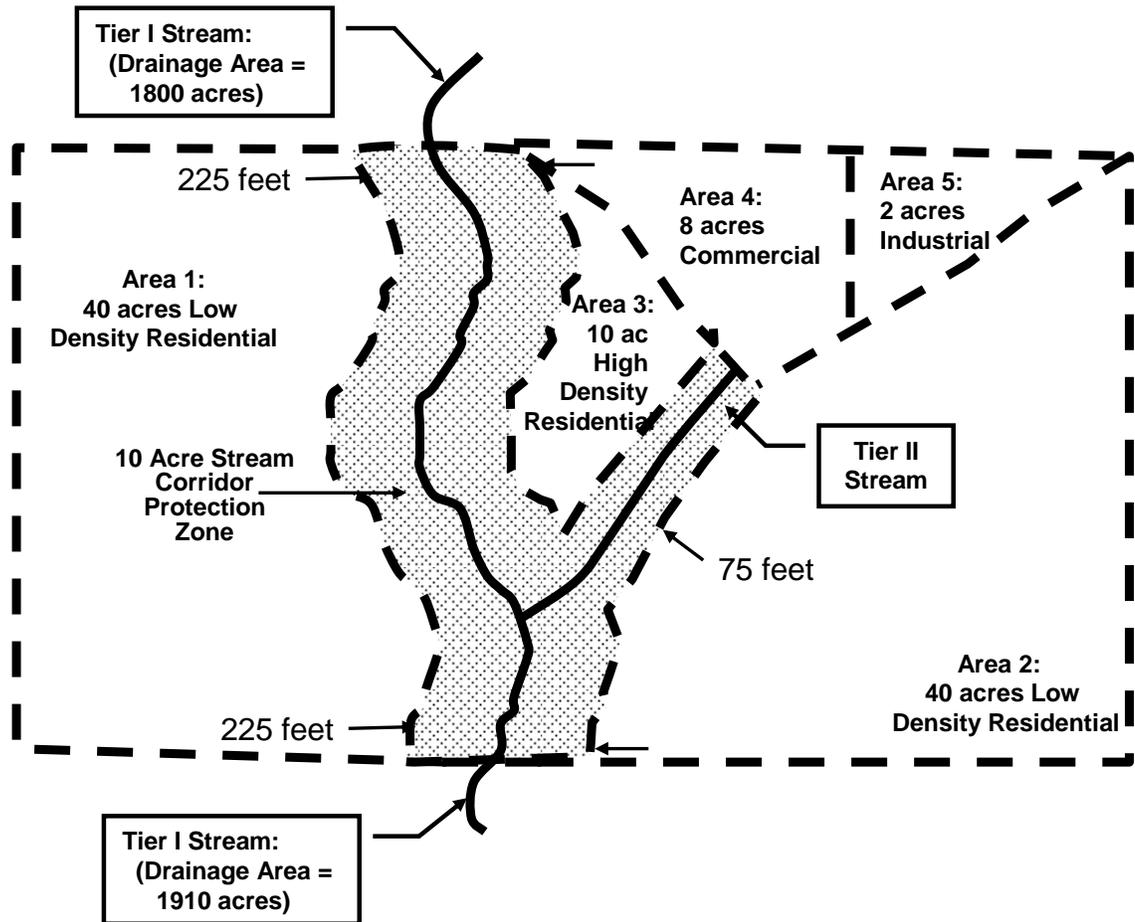
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Example 110 Acre Development Site: Area Details



Area Identifier	Size (ac)	Equivalent Land Use (Table 3-5: Runoff Coefficients for Determining WQv)	Runoff Coefficient for WQv
Area 1: Low Density Residential	40	½ acre lots	0.3
Area 2: Low Density Residential	40	½ acre lots	0.3
Area 3: High Density Residential	10	1/8 acre lots (TND-NE)	0.5
Area 4: Commercial	8	Commercial/Business (TND-TC) and Industrial	0.8
Area 5: Industrial	2	Commercial/Business (TND-TC) and Industrial	0.8

Example 110 Acre Development Site: Stream Corridor Protection Zone Delineation



Stream Corridor Protection Zone Delineation Calculations (Section 1.3.1)

Stream Corridor Protection Zone Widths shall be determined by the contributing drainage area in acres as shown in **Table 1-1**.

Tier I Stream at Upstream Project Limit:

Stream Corridor Protection Zone Width for 1800 acre contributing drainage area is 225 feet as determined by **Table 1-1**.

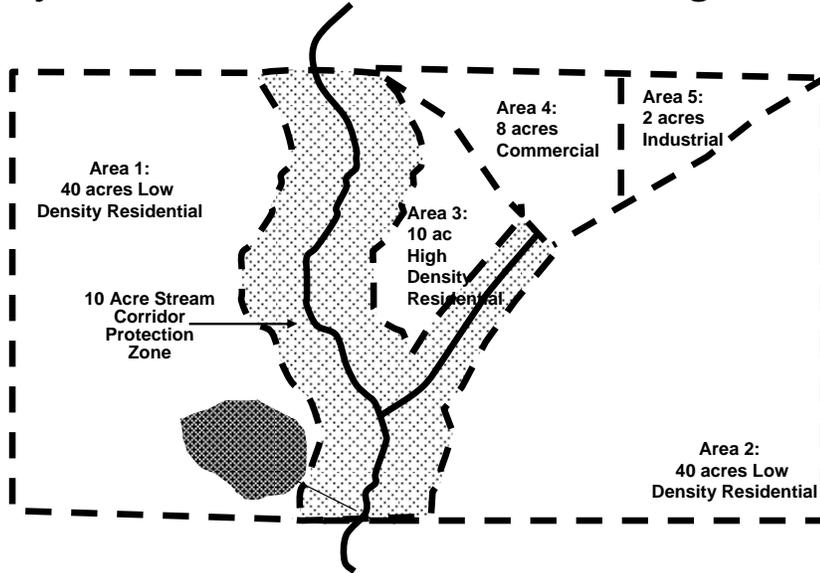
Tier I Stream at Downstream Project Limit:

Stream Corridor Protection Zone Width for 1910 acre contributing drainage area is 225 feet as determined by **Table 1-1**.

Tier II Stream:

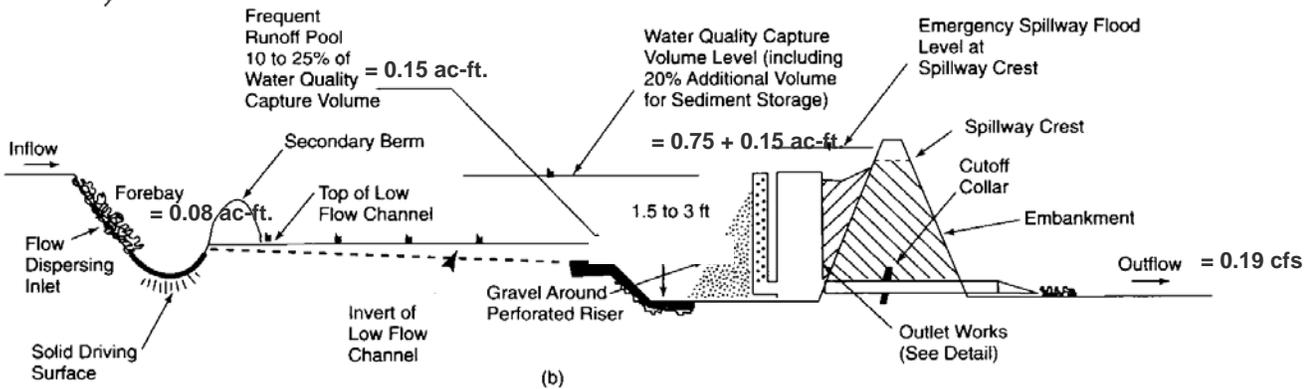
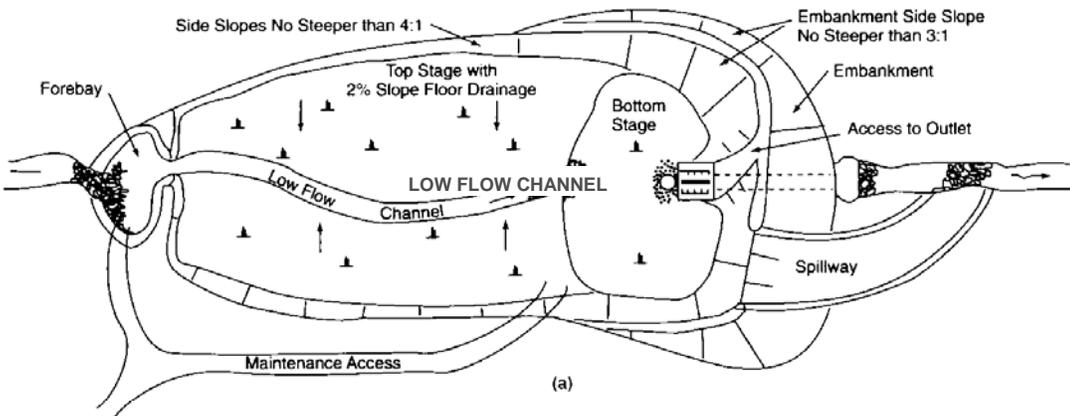
Stream Corridor Protection Zone Width for 10 to 20 acre contributing drainage area is 75 feet minimum as determined by **Table 1-1**.

Example 110 Acre Development Site: Dry Extended Detention Basin Sizing for Area 1



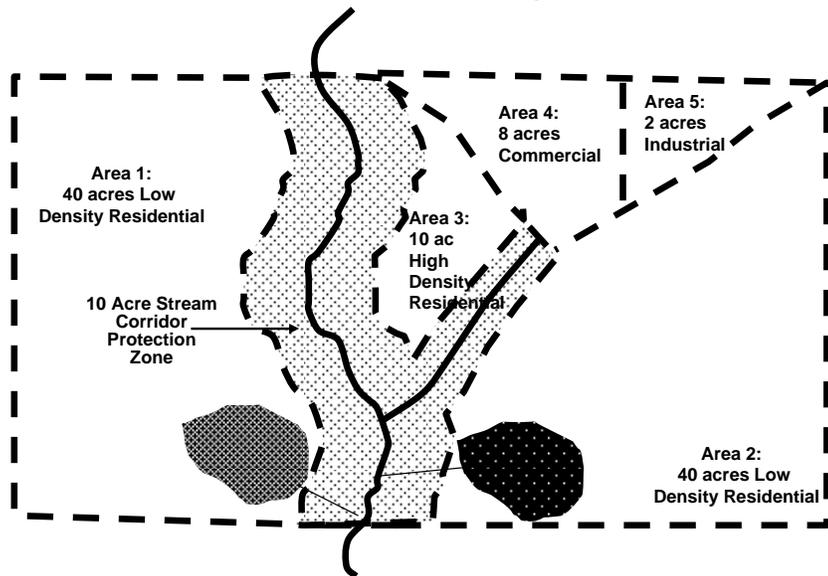
Area 1:
Extended Dry Detention Pond
 $WQV = P * C * A / 12$ (Sec. 3.3.2)
 $WQV = (0.75" * 0.3 * 40 \text{ ac}) / 12$
 $= .75 \text{ ac-ft}$
 Extended Detention = WQV (Sec. 3.3.4)
 $= .75 \text{ ac-ft}$
 Sediment Storage = $0.2 * WQV$ (Sec. 3.3.4)
 $= .15 \text{ ac-ft}$
 Forebay = $0.1 * WQV$ (Sec. 3.3.4.1)
 $= 0.08 \text{ ac-ft}$
 Micropool = $0.2 * WQV$ (Sec. 3.3.4.1)
 $= 0.15 \text{ ac-ft}$
 Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.4)
 $= (.75 \text{ ac-ft} / 48 \text{ hrs}) *$
 $(43560\text{sf/ac})(1\text{h}/3600\text{s})$
 $= .19 \text{ cfs}$
 Assume max depth = 5 ft
 4 inch diameter perforated riser with 1/4 inch perforations
 Area of perforation = 0.049 in^2
 Flow through perforation (Sec. 3.3.4.1)
 $= AC(64.4 H)^{1/2}$
 $= (0.049/144)*0.8(64.4*5)^{1/2}$
 $= 0.005 \text{ cfs}$
 Number of perforations (Sec. 3.3.4.1)
 $= 0.19 \text{ cfs} / 0.005 \text{ cfs}$
 $= 38$ (Use 5 rows with 8 perforations per row with each row 4 inches apart)

Extended Dry Detention Basin Site



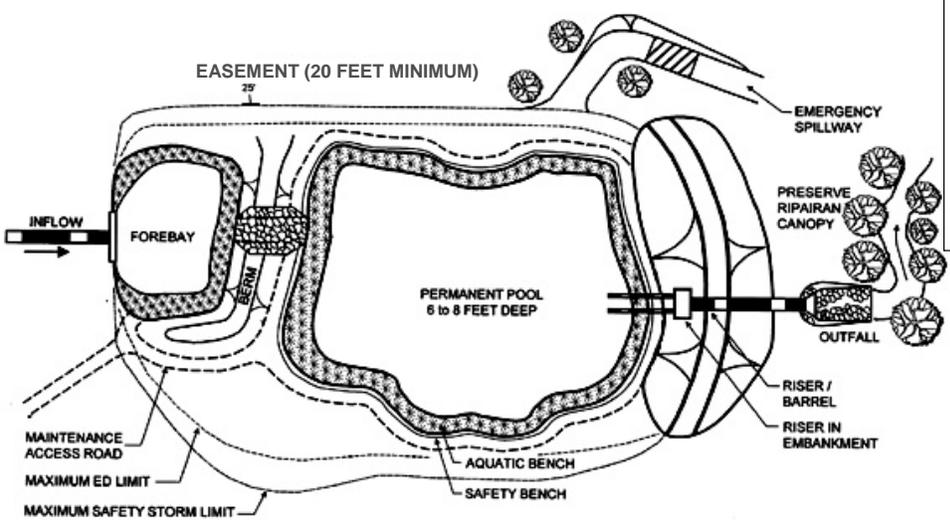
Note: The water quality capture volume plus sediment storage volume includes the forebay volume and micropool volume.

Example 110 Acre Development Site: Wet Detention Basin Sizing for Area 2

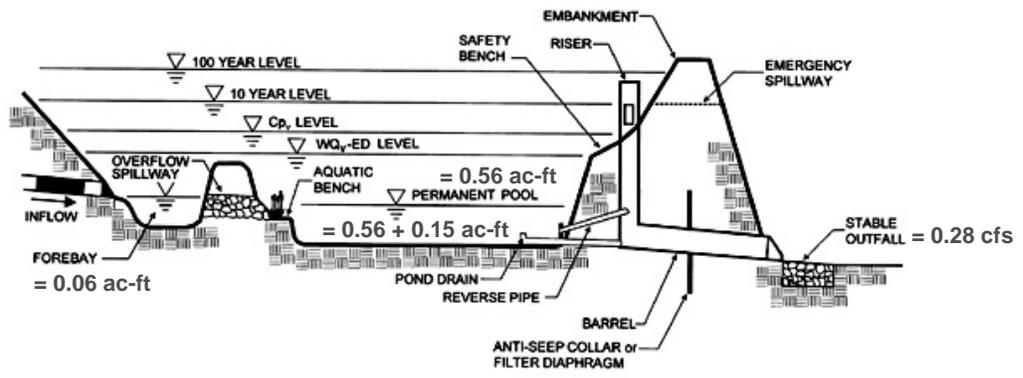


Area 2:
Wet Detention Pond
 $WQV = P * C * A / 12$ (Sec. 3.3.2)
 $WQV = (0.75 * 0.3 * 40 \text{ ac}) / 12$
 = .75 ac-ft
 Extended Detention = $0.75 * WQV$ (Sec. 3.3.4)
 = .56 ac-ft
 Permanent Pool = $0.75 * WQV$ (Sec. 3.3.4)
 = .56 ac-ft
 Sediment Storage = $0.2 * WQV$ (Sec. 3.3.4)
 = .15 ac-ft
 Forebay = $0.1 * WQV$ (Sec. 3.3.4.1)
 = 0.08 ac-ft
 Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.4)
 = (.56 ac-ft / 24 hrs) * (43560sf/ac) * (1h/3600s)
 = .28 cfs
 Assume Max depth = 5 ft
 Outlet orifice size: (Sec. 3.3.4.1)
 $Q = AC(64.4 H)^{1/2}$
 $0.28 = A * 0.66(64.4 * 5)^{1/2}$
 $A = 0.024 \text{ ft}^2$
 $= \pi * D^2 / 4$
 $D = (4 * 0.024 \text{ ft}^2 / \pi)^{1/2} * 12$
 = 2 inches

Extended Dry Detention Basin Site
 Wet Detention Basin Site

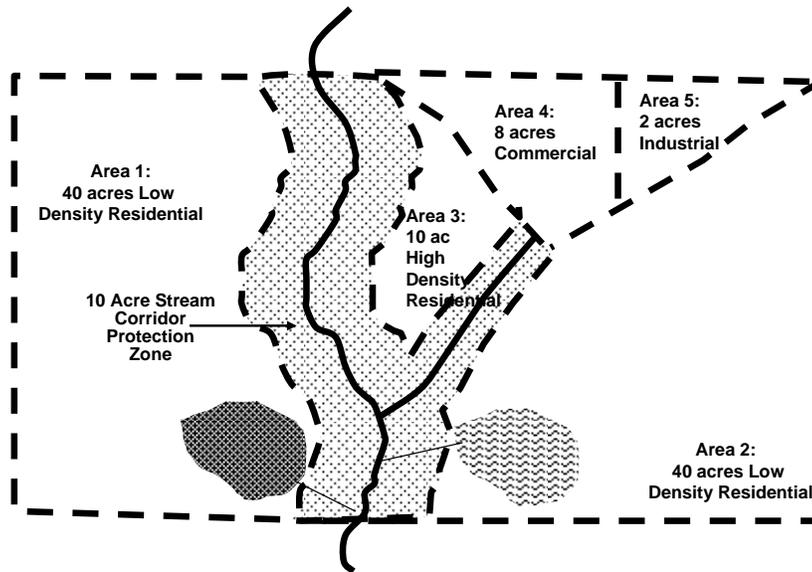


PLAN VIEW



PROFILE

Example 110 Acre Development Site: Wetlands Sizing for Area 2 (Alternative to Wet Detention Basin)



**Area 2 (Alternative):
Wetland**

$WQV = P * C * A / 12$ (Sec. 3.3.2)
 $WQV = (0.75 * 0.3 * 40) / 12$
 = .75 ac-ft

Extended Detention = WQV (Sec. 3.3.4)
 = .75 ac-ft

Sediment Storage = $0.2 * WQV$ (Sec. 3.3.4)
 = .15 ac-ft

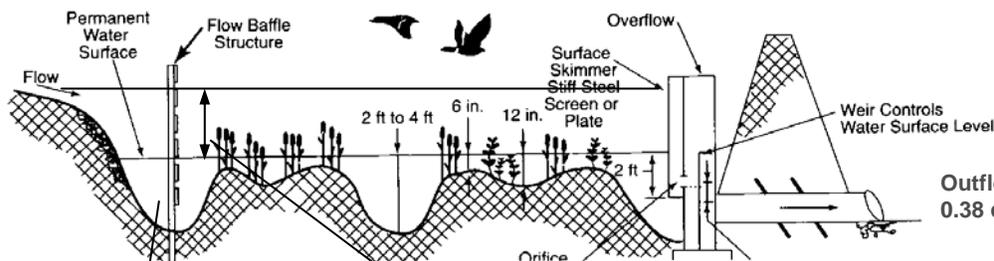
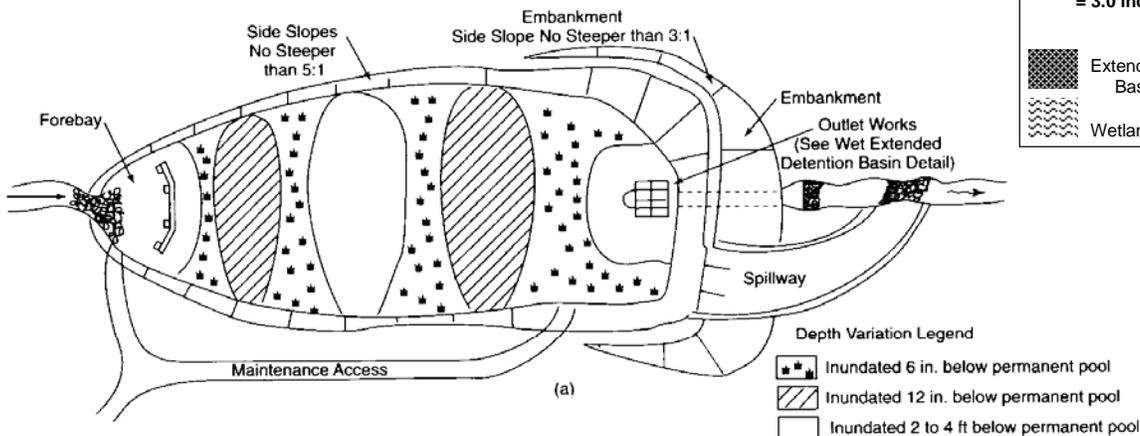
Forebay = $0.1 * WQV$ (Sec. 3.3.4.1)
 = 0.08 ac-ft

Max depth = 2 ft
 Surface Area = $.75 \text{ ac-ft} / 2 \text{ ft}$
 = .38 ac

Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.4)
 = $(.75 \text{ ac-ft} / 24 \text{ hrs}) * (43560 \text{ sq ft/ac}) / (1 \text{ h} / 3600 \text{ s})$
 = .38 cfs

Outlet orifice size (Sec. 3.3.4.1):
 $Q = AC(64.4 H)^{1/2}$
 $0.38 = A * 0.66(64.4 * 2)^{1/2}$
 $A = 0.05 \text{ ft}^2$
 $= \pi * D^2 / 4$
 $D = (4 * 0.05 \text{ ft}^2 / \pi)^{1/2} * 12$
 = 3.0 inches

Extended Dry Detention Basin Site
 Wetland Site



Outflow =
0.38 cfs

Forebay =
0.08 ac-ft

Extended Detention Pool = 0.75 + 0.15 ac-ft @ 2 ft (max)

Example 110 Acre Development Site: Wetland Water Balance for Area 2

The following *water balance calculation* shall be performed to demonstrate that any proposed stormwater wetland is sufficient to maintain normal pool elevation(s) during a thirty day drought at summer evaporation rates. The City requires that the permanent pool of any proposed stormwater wetland shall be at least two times the volume of evapotranspiration during a thirty day drought at summer evaporation rates or 0.75WQ_v, whichever is greater.

The change in water storage is given by:

$$\Delta V = \text{Inflows} - \text{Outflows}$$

Potential inflow sources include rainfall-runoff and baseflow, and potential outflows include basin discharges, evaporation and evapotranspiration. During a drought, assume that there is no rainfall-runoff, baseflow, or basin discharges.

Therefore:

$$\Delta V = - (E_t) * A * T$$

where:

ΔV = change in volume of the permanent pool (ac-ft/month)

E_t = Evapotranspiration rate (inches/day)

= 75 percent of the summertime pan evaporation rate¹

A = surface area of permanent pool (acres)

T = Duration of drought = 30 days

The pan evaporation rate reported by NOAA for the region including the City of Columbus is 0.2 inches/day for all of the summer months of June, July and August.

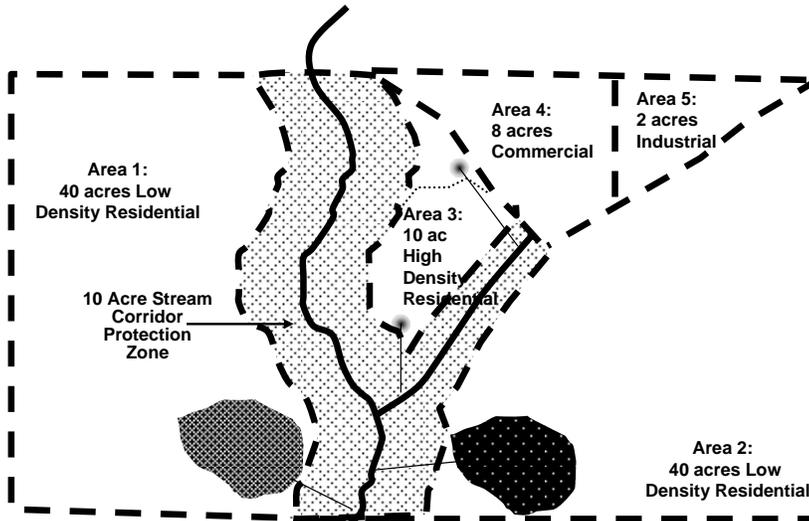
Therefore:

$$\begin{aligned} \Delta V &= - (0.75 * 0.2 \text{ inches / day}) * A * 30 \text{ days} * 1 \text{ foot} / 12 \text{ inches} \\ &= -0.375 * A \text{ ac-ft} \end{aligned}$$

In other words, the volume of water lost to evapotranspiration in the wetlands will be 0.375 times the area of the wetland, and the permanent pool depth will decrease approximately 0.375 ft (4 inches) during a one-month drought where no rainfall occurs. The permanent pool volume must be twice the evapotranspiration volume, i.e., 0.75 times the area of the wetland, or 0.75 times the WQ_v, whichever is greater. Vegetation selected for constructed wetlands must be able to tolerate a drawdown of this depth.

¹ *Treatment Wetlands*, pg. 192.

Example 110 Acre Development Site: Bioretention Facility Sizing for Area 3



Area 3:
Bioretention

$WQV = P * C * A / 12$ (Sec. 3.3.2)
 $WQV = (0.75'' * 0.5 * 10 \text{ ac}) / 12$
 = .31 ac-ft = 13,612 cu. ft.

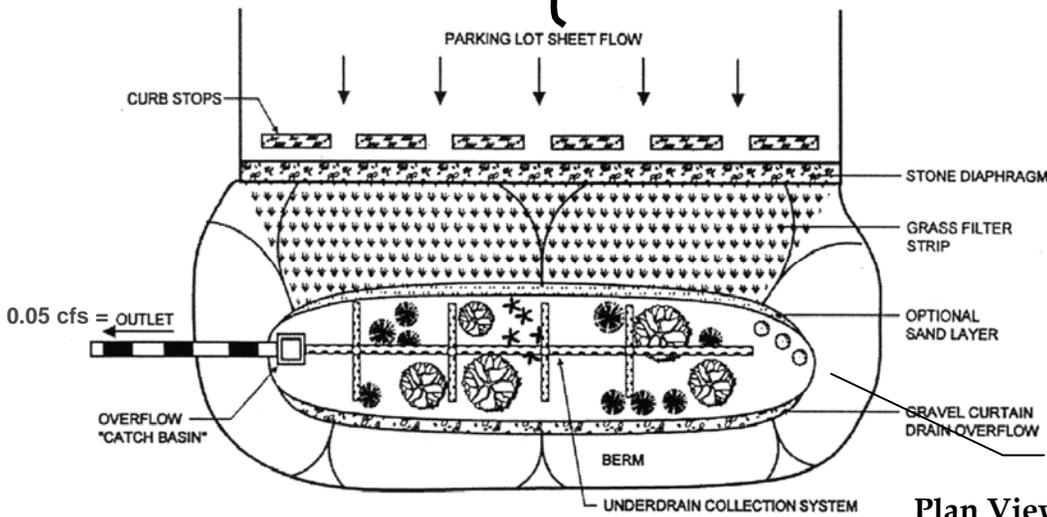
Maximum Drainage Area = 5 ac.
 → 10 ac / 5 ac per filter = 2 units
 Volume per Unit = $WQV / 2$
 = 6,806 cu. ft.

Sediment Storage = $0.2 * \text{vol}$ (Sec. 3.3.4)
 = 1,361 cu. ft.

Discharge = Volume / Drawdown
 (Sec. 3.3.5.1)
 = 6,806 cu. ft. / 40 hrs
 = .05 cfs

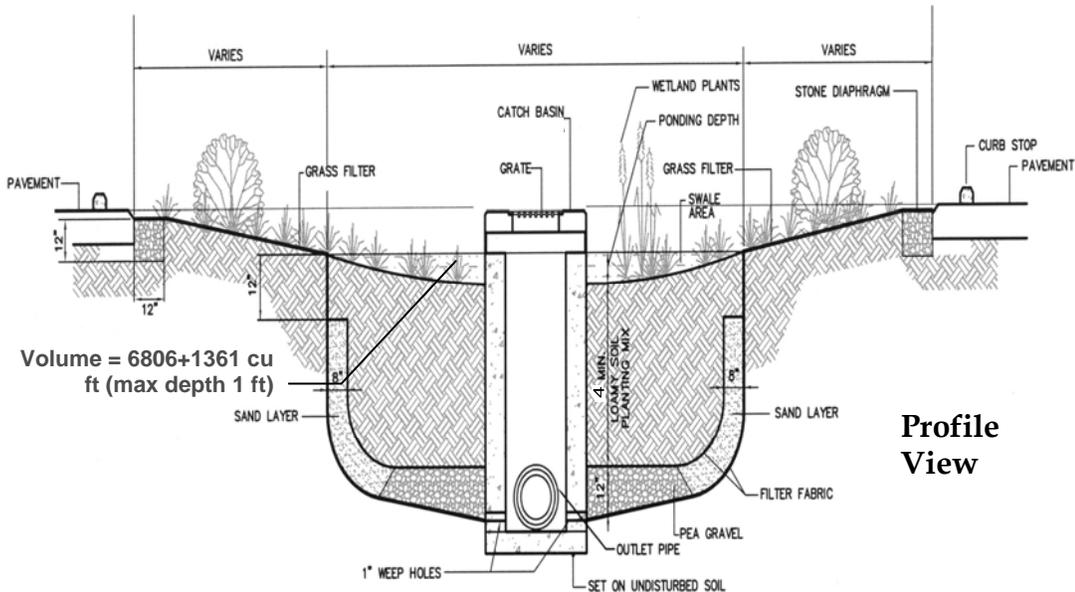
Surface Area of each Facility
 $d = \text{planting media depth} = 4 \text{ ft}$
 $h = \text{max depth water} = 1 \text{ ft}$
 $K = \text{planting media permeability} = 1.2 \times 10^{-5} \text{ ft/sec}$
 $A = WQv * d / (3600 * k * T * (h+d))$
 (Sec. 3.3.5.1)
 = $.16 \text{ ac-ft} * 4 \text{ ft} / (3600 * 1.2 \times 10^{-5} \text{ ft/s} * 40 \text{ hr} * (1 \text{ ft} + 4 \text{ ft}))$
 = .074 ac = 3227 ft²

Extended Dry Detention Basin Site
 Wet Detention Basin Site
 Bioretention Facility Site



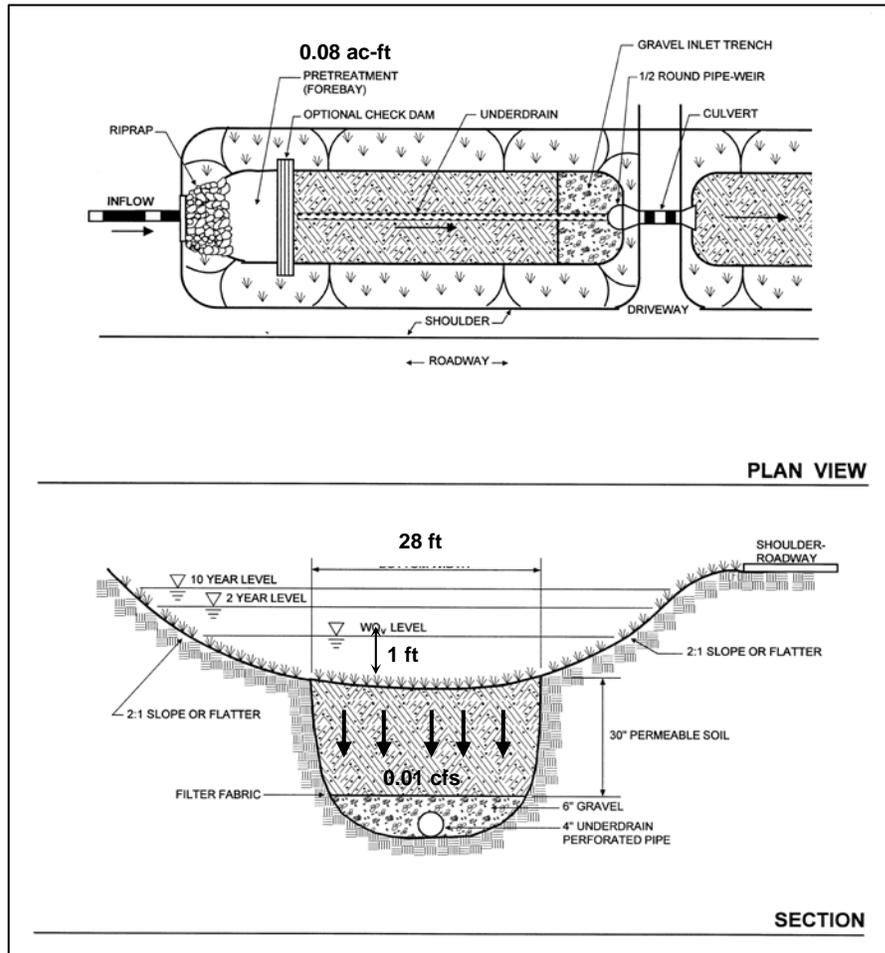
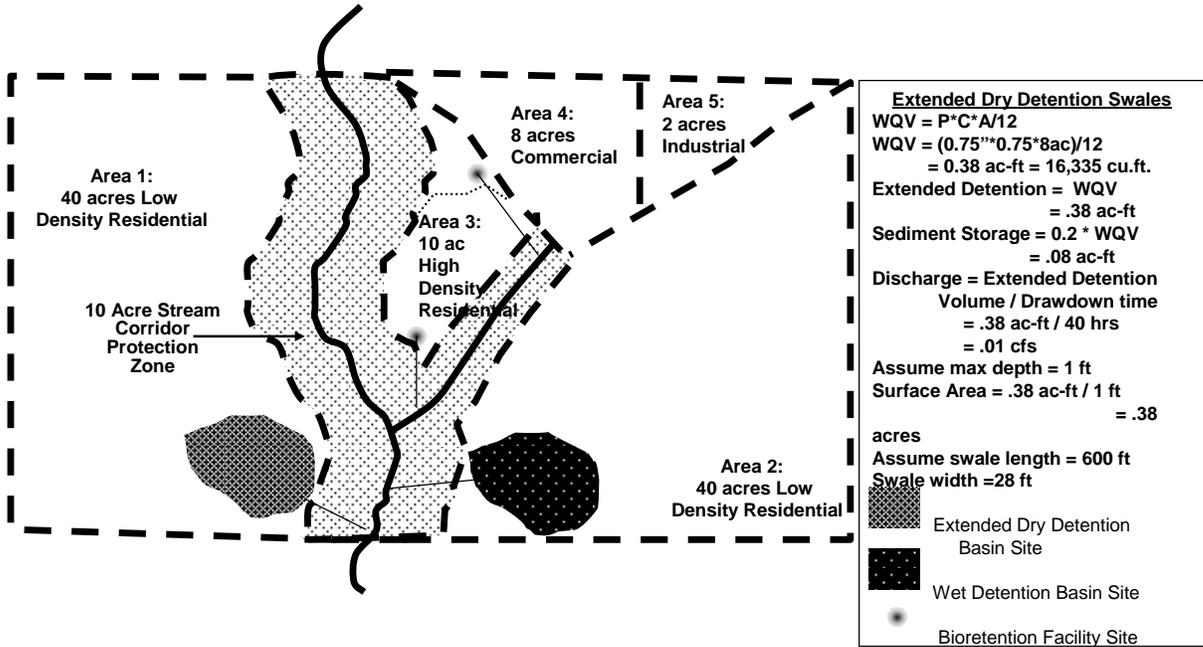
Area = 3,227 sq ft

Plan View

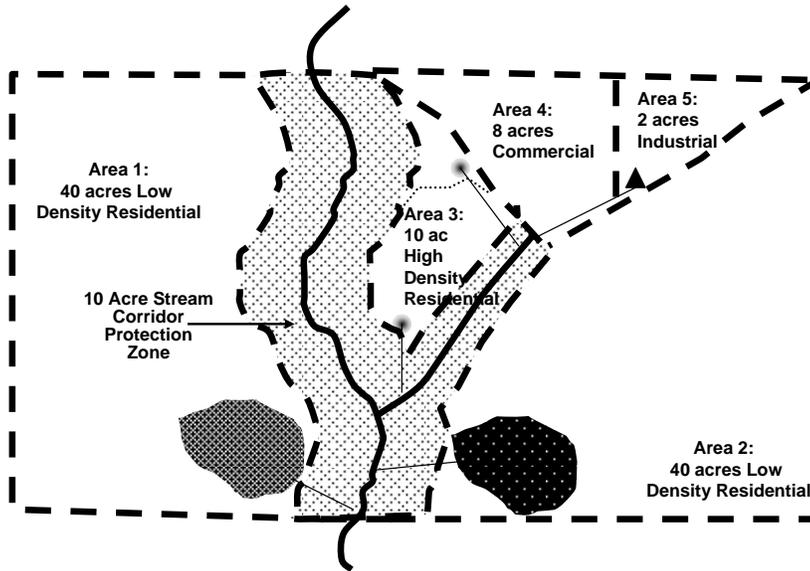


Profile View

Example 110 Acre Development Site: Extended Dry Detention Swale for Area 4



Example 110 Acre Development Site: Sand Filter Water Quality Treatment for Area 5



**Area 5:
Sand Filter**

$$WQV = P * C * A / 12 \text{ (Sec. 3.3.2)}$$

$$WQV = (0.75'' * 0.8 * 2 \text{ ac}) / 12$$

$$= .1 \text{ ac-ft (43560sf/ac)}$$

$$= 4,356 \text{ cu ft}$$

Sedimentation Basin = WQV
(Sec. 3.3.5.2)

$$= 4,356 \text{ cu ft}$$

Sediment Storage = 0.2 * WQV
(Sec. 3.3.4)

$$= 871 \text{ cu ft}$$

**Discharge = Extended Detention
Volume / Drawdown time**
(Sec. 3.3.5.2)

$$= 4,356 \text{ cu ft} / 40 \text{ hrs}$$

$$= .03 \text{ cfs}$$

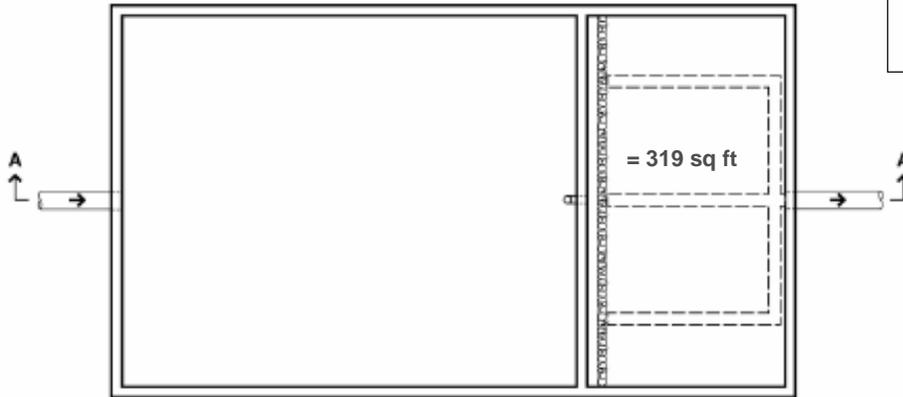
Assume depth on filter = 4 ft
(Sec. 3.3.5.2, L&G#2)

Surface area, sand filter
 $A_f = WQV * d / (k * t * (h + d))$ (Sec. 3.3.5.2)

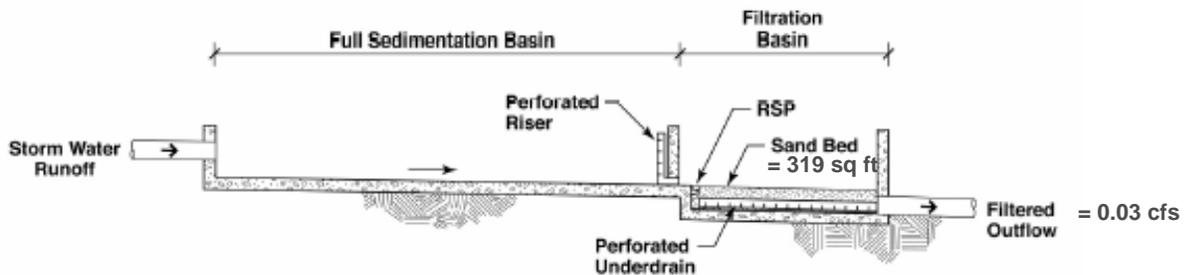
$$= \frac{4,356 \text{ cu ft} * 1.5 \text{ ft}}{(3.5 \text{ ft/day} * 1.67 \text{ day} * (2 \text{ ft} + 1.5 \text{ ft}))}$$

$$= 319 \text{ sq ft}$$

- Extended Dry Detention Basin Site
- Wet Detention Basin Site
- Bioretention Facility Site
- Sand Filter Site



PLAN



SECTION A-A

Example < 5 Acre Development Site: Vegetated Swale for 4 acre Development Site

Vegetated Swales

$$WQV = P \cdot C \cdot A / 12$$

$$WQV = (0.75'' \cdot 0.75 \cdot 4ac) / 12$$

$$= 0.19 \text{ ac-ft} = 8,168 \text{ cu.ft.}$$

$$t_o = 1.8(1.1-C)L^{1/2} / s^{1/3}$$

$$t_o = 1.8(1.1-0.75)100^{1/2} / 0.03^{1/3}$$

$$t_o = 20 \text{ minutes}$$

Using Figure 2-1, intensity = 1.1 in/hr

$$Q_p = C \cdot I \cdot A = 0.75 \cdot 1.1'' / \text{hr} \cdot 4 \text{ ac}$$

$$= 3.3 \text{ cfs (Peak flow)}$$

Since $Q_p > 1$ cfs, 4 swales should serve the 4 ac site, with $Q_p = 0.82$ cfs

$$Q = (1.49/n) A R^{2/3} S^{1/2}$$

$$0.82 \text{ cfs} = (1.49/0.25) A R^{2/3} 0.03^{1/2}$$

$$0.79 = A R^{2/3}$$

Max depth, d , is 2 in (0.17ft)

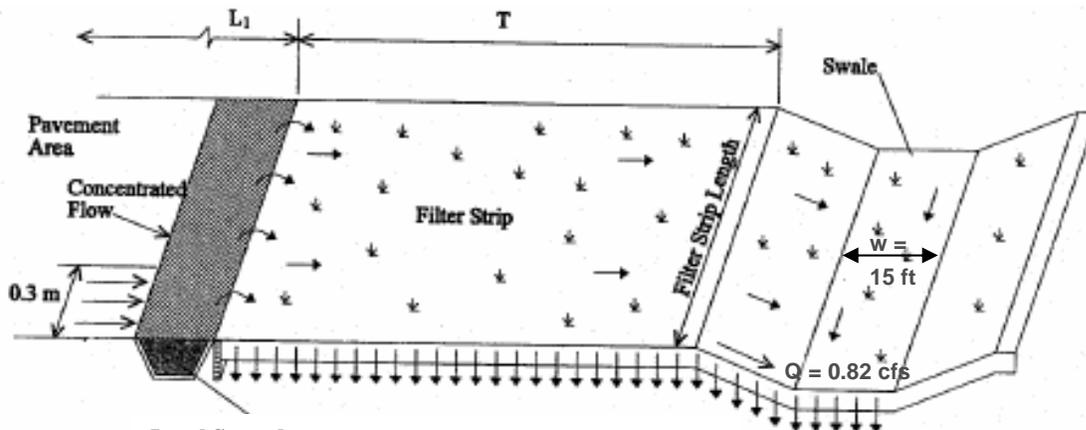
With wide channel assumption:

$$A = wd$$

$$R = d$$

$$0.79 = w \cdot (0.17)^{5/3}$$

$$w = 15 \text{ ft}$$



Level Spreader

Designs include gravel trenches, sills, embedded curbs, modular porous pavement, stabilized turf strip)

Note: Not to Scale

Stormwater Drainage Manual



Appendix E Operation and Maintenance Inspection Report Checklists



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Operation and Maintenance Inspection Report for Stormwater Basins and Wetlands ^(*)

Project Location (inc. SP coordinates) _____

Inspector Name _____

Inspection Date/Time _____

Stormwater Pond _____

Watershed _____

Normal Pool _____

Owner Name _____

Normal Dry _____

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
Pond Components				
1. Embankment and Emergency Spillway				
a. Adequate vegetation and ground cover			A	
b. Embankment erosion			SA	
c. Animal burrows			A	
d. Unauthorized plantings			A	
e. Cracking, bulging, or sliding of dam				
i. Upstream face			A	
ii. Downstream face			A	
iii. At or beyond toe				
Upstream			A	
Downstream			A	
iv. Emergency spillway			A	
f. Pond, toe & chimney drains clear and functioning			A	
g. Leaks on downstream face			A	
h. Abutment protection or riprap failures			A	
i. Visual settlement or horizontal misalignment of top of dam				
j. Emergency spillway clear of debris			A	
k. Other (specify)			A	
2. Riser and principal spillway				
Type: Reinforced concrete _____ Corrugated pipe _____ Masonry _____				
a. Low flow orifice obstructed			A	
b. Low flow trash rack				
i. Debris removal necessary			A	
ii. Corrosion control			A	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
c. Weir trash rack i. Debris removal necessary			A	
ii. Corrosion control			A	
d. Excessive sediment accumulation inside riser			A	
e. Concrete/Masonry condition Riser and barrels				
i. Cracks or displacement			A	
ii. Minor spalling (<1")			A	
iii. Major spalling (rebars exposed)			A	
iv. Joint failures			A	
v. Water tightness			A	
f. Metal pipe condition			A	
g. Control valve				
i. Operational/exercised			A	
ii. Chained and locked			A	
h. Pond drain valve			A	
i. Operational/exercised			A	
ii. Chained and locked			A	
i. Outfall channels flowing			A	
j. Other (specify)			A	
3. Permanent pool (wet ponds)				
a. Undesirable vegetative growth			M	
b. Floating or floatable debris removal required			M	
c. Visible pollution			M	
d. High water marks			M	
e. Shoreline problems			M	
f. Sediment accumulation			M	
g. Other (specify)			M	
4. Sediment forebays				
a. Sedimentation noted			M	
b. Sediment removal when depth <20% design depth			M	
5. Dry pond areas				
a. Vegetation adequate			M	
b. Undesirable vegetative growth			M	
c. Undesirable woody vegetation			M	
d. Low flow channels clear of obstructions			M	
e. Standing water or wet spots			M, S	
f. Sediment and/or trash accumulation			M	
g. Other (specify)			M	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
6. Condition of outfalls into pond				
a. Riprap failures			A,S	
b. Slope erosion			A,S	
c. Storm drain pipes			A,S	
d. Endwalls/headwalls			A,S	
e. Other (specify)			A,S	
7. Other				
a. Encroachments on ponds or easement area			M	
b. Complaints from residents (describe on back)			M	
c. Aesthetics				
i. Grass height			M	
ii. Graffiti removal necessary			M	
iii. Other (specify)			M	
d. Any public hazards (specify)			M	
e. Maintenance access			M	
f. Monitor mosquito larvae presence (seasonal)			M	
8. Constructed wetland areas				
a. Vegetation healthy and growing (50% surface area coverage)			M	
b. Evidence of invasive species			M	
c. Excessive sedimentation in wetland area			M	

Inspection Frequency Key A = Annual, SA = Semi-annual, M = Monthly, S = After major storm

(*) Source: Georgia Stormwater Management Manual – Adapted from Watershed Management Institute, Inc. (1997)

Summary

1. Inspectors Remarks: _____

Overall condition of Facility (Check one)

- Acceptable
 Unacceptable

2. Dates any maintenance must be completed by: _____

CERTIFICATION STATEMENT

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION ON THIS FORM AND BELIEVE THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

Authorized Representative Signature

Title

Date

Operation and Maintenance Inspection Report for Media Filters ^(*)

Project Location (inc. SP coordinates) _____

Inspector Name _____

Inspection Date/Time _____

Site Status/Owner Name _____

Watershed _____

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
<i>Bioretention and Sand Filter (if applicable) Facilities</i>				
1. Debris removal				
a. Bioretention and contributing areas clean of debris			M	
b. No dumping of yard wastes into practice			M	
c. Any dumping of yard wastes into facility			M	
d. Litter (branches, etc.) been removed			M	
2. Vegetation (if applicable)				
a. Plant height not less than design water depth			M	
b. Fertilized per specification			M	
c. Plant composition according to approved plans			M	
d. No placement of inappropriate plants			M	
e. Grass height not greater than 6 inches			M	
f. No evidence of erosion			M	
3. Check dams/energy dissipators/sumps				
a. No evidence of sediment buildup			A,S	
b. Sumps should not be more than 50% full of sediment			A,S	
c. No evidence of erosion at downstream toe of drop structures			A,S	
4. Dewatering				
a. Dewaterers between storms			M	
b. No evidence of standing water			M	
5. Sediment deposition				
a. Swale clean of sediments			A	
b. Sediments should not be > than 20% of swale design depth			A	
6. Outlets/overflow spillway				
a. Good condition (no need for repair)			A,S	
b. No evidence of erosion			A,S	
c. No evidence of blockages			A,S	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
7. Integrity of facility				
a. Filter bed has not been blocked or filled inappropriately			A	
b. Vandalism			A	
<i>Sand Filter Facilities</i>				
1. Media / Filtration Chamber				
a. Media removal/disposal if drain time > 72 hours			M	
b. Media replacement if < 90% of design depth			SA	
c. Check for cracks/ leakage			SA	
2. Sedimentation Chamber				
a. Clear of sediment buildup (7 to 10-year cleanout recommended)			A	
b. Check for cracks/leakage			SA	

Inspection Frequency Key A = Annual, SA = Semi-annual, M = Monthly, S = After major storm
 (*) Source: New York State Stormwater Management Design Manual; ETA & Biohabitats (1993); Watershed Management Institute, Inc. (1997); California Stormwater BMP Handbook – TC-40 (2003).

Summary

1. Inspectors Remarks: _____

Overall condition of Facility (Check one)

_____ Acceptable
 _____ Unacceptable

2. Dates any maintenance must be completed by: _____

CERTIFICATION STATEMENT

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION ON THIS FORM AND BELIEVE THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

 Authorized Representative Signature

 Title

 Date

Operation and Maintenance Inspection Report for Vegetated Swales, Filter Strips and Level Spreaders ^(*)

Project Location (inc. SP coordinates) _____

Inspector Name _____

Inspection Date/Time _____

Watershed _____

Owner Name _____

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
<i>Vegetated Swales and Filter Strips (Vegetated Swales, as applicable)</i>				
1. Debris removal				
a. Facility and adjacent area clear of debris			M	
b. Inlets and outlets clear of debris			M	
c. Any dumping of yard wastes into facility			M	
d. Has litter (branches, etc) been removed			M	
2. Vegetation				
a. Adjacent area stabilized			M	
b. Grass mowed to height of 3 inches			M	
c. Plant height not less than design water depth			M	
d. Fertilized per specification			M	
e. Any evidence of erosion			M	
f. Is plant composition according to approved plans			M	
g. Any unauthorized or inappropriate plantings			M	
h. Any dead or diseased plants			M	
i. Any evidence of plant stress from inadequate watering			M	
j. Any evidence of deficient stakes or wires			M	
3. Oil and grease				
a. Any evidence of filter clogging			M	
4. Dewatering				
a. Facility dewateres between storms			M	
5. Check dams/energy dissipators/sumps				
a. Any evidence of sedimentation buildup			A,S	
b. Are sumps greater than 50% full of sediment			A,S	
c. Any evidence of erosion at downstream toe of drop structures			A,S	

6. Sediment deposition				
a. Swale clean of sediments			A	
b. Sediments should not be > than 20% of swale design depth			A	
7. Outlets/overflow spillway				
a. Good condition (no need for repair)			A,S	
b. Any evidence of erosion			A,S	
c. Any evidence of blockages			A,S	
8. Integrity of facility				
a. Has facility been blocked or filled inappropriately			A	
b. Check for evidence of erosion/washout of inlet/outlet filter media			A	
9. Bioretention planting soil				
a. Any evidence of planting soil erosion			A	
10. Organic layer				
a. Mulch covers entire area (NO voids) and to specified thickness			A	
b. Mulch is in good condition			A	
<i>Level Spreaders</i>				
a. Vegetated area has vigorous stand of grass			SA, S	
b. Spreaders uniformly distributes flow over level lip.			SA, S	
c. Check for evidence of erosion/washout of inlet/outlet filter media			A	

Inspection Frequency Key: A=Annual, SA = Semi-Annual, M=Monthly, S=After major storm

(*) Source: Georgia Stormwater Management Manual – Adapted from Watershed Management Institute, Inc. (1997)

Summary

1. Inspectors Remarks: _____

Overall condition of Facility (Check one)

- Acceptable
 Unacceptable

2. Dates any maintenance must be completed by: _____

CERTIFICATION STATEMENT

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION ON THIS FORM AND BELIEVE THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

Authorized Representative Signature

Title

Date

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Stormwater Drainage Manual



Appendix F

CC Drawing Submittal Forms



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EXHIBIT A - DOSD DRAWING NUMBER APPLICATION FORM

**CITY OF COLUMBUS DIVISION OF SEWERAGE AND DRAINAGE
DRAWING NUMBER APPLICATION
FOR SEWER CONSTRUCTION PLANS**

Drawing Number (assigned by DOSD): _____

Drawing Type: ___Sanitary ___Storm ___Combined ___Other (_____)

Project Title: _____

Project Zoning Code Class: Res. _____ Apt. _____ Comm. _____ Other _____

Acreage: Project On-site _____ Above _____ Below _____

Easements: Number Required _____ On-site _____ Off-site _____ Platted _____

Contact Information:

Property Owner Name: _____

Address: _____

Phone: _____ Email Address: _____

Contact (if other than property owner): _____

Address: _____

Phone: _____ Email Address: _____

Project Developer (organization name): _____

Primary Developer Contact Person: _____

Address: _____

Phone: _____ Email Address: _____

Plan Prepared by (organization name): _____

Primary Contact Person: _____

Address: _____

Phone: _____ Email Address: _____

Design Date: _____

Enclosed: Design Area Map _____ Calculations _____ Prelim. Easement Description _____

Other _____ (Describe: _____)

Digital File Name(s) Submitted:

EXHIBIT B
General Notes
To Be Included Within the CC-Plans

- The City of Columbus Construction and Material Specifications, (current version) including all supplements thereto, shall govern all construction items that are a part of this plan unless otherwise noted.
- The Contractor shall notify the following Divisions at least 24-hours in advance of anticipated start of construction:

Division of Sewerage and Drainage (614) 645-7102
Transportation Division, Inspection Services Section (614) 645-3182

- The Contractor is responsible for the investigation, location, support, protection, and restoration of all existing utilities and appurtenances whether shown on these plans or not. The Contractor shall expose all utilities or structures prior to construction to verify the vertical and horizontal effect on the proposed construction. The Contractor shall call, toll free, the Ohio Utilities Protection Service (1-800-362-2764) 72-hours prior to construction and shall notify all utility companies at least 48-hours prior to work in the vicinity of their underground lines.
- Construction of this project may not begin until the easements indicated have been recorded by the City.
- The Developer/Owner shall, prior to any construction operation, deposit with the City the total estimated costs for inspection and where required a repaving guarantee.
- Any modification to the work as shown on these drawings must have prior written approval by the Administrator, Division of Sewerage and Drainage.
- All plastic sewer lines shall be deflection tested after installation in conformance with the requirements of item 901 of the City of Columbus, Construction and Material Specifications, current version.
- All concrete pipe, storm and sanitary sewer structures will be stamped or have such identification noting that said pipe, storm and sanitary structures have been inspected by the City of Columbus and meets their specifications. Pipe and structures without proper identification will not be permitted for installation.
- Erosion and sediment control measures are required as part of this project. Erosion and Sediment Control measures specific to this site may be found on Sheet No. __ of this plan. Land-disturbing activities must comply with all provisions of the Division of Sewerage and Drainage EROSION AND SEDIMENT CONTROL REGULATION. All land-disturbing activities shall be subject to inspection and site investigation by the City of Columbus and/or the Ohio EPA.

- It is the responsibility of the site owner to notify the City of Columbus two working days prior to commencement of initial site land disturbance on any site of one or more acres. This includes site clearing, grubbing and any earth moving. Primary erosion and sediment control practices are mandated by regulation to be in place from the beginning of the construction activity. Please contact The Stormwater Management Office @ (614) 645-6700 or fax @ (614) 645-1506. Details of this requirement may be found in the EROSION AND SEDIMENT POLLUTION CONTROL REGULATION (adopted June 1, 1994). Failure to comply may result in enforcement action as detailed in the Columbus City Codes Section 1145.80.

THIS NOTE SHALL BE ADDED TO ANY PLAN WHERE CITY OF COLUMBUS PARK PROPERTY MAY BE INVOLVED IN THE LIMITS OF CONSTRUCTION:

“The Contractor is hereby notified to contact the City Forester of the Recreation and Parks Department (Phone: (614) 645-3350) 24-hours prior to any construction in or near the park property.”

- The Contractor shall ensure there is a surveyor’s level and rod on the project for use in performing grade checks whenever sewer line structures or pipe are being installed. The Contractor shall make this equipment available for use and assist the City inspector in performing grade checks when requested by the inspector. The inspector will make all reasonable attempts to confine requests for assistance in performing grade checks to times convenient to the Contractor.

These checks will be performed to ensure the following:

1. Proper placement of each structure.
2. Proper installation of initial runs of pipe from a structure.
3. Grade, after an overnight or longer shutdown.
4. Grade, at any other time the inspector has reason to question grade of installation.

Grade checks performed by the City inspector in no way relieve the Contractor of the ultimate responsibility to ensure construction to the plan grade.

- The amount of fill within designated FEMA floodplain areas onsite is ____ C.Y. The amount of fill compensated within designated FEMA floodplain areas onsite is ____ C.Y.
- The ponding or detention areas shown on the plans are a part of the storm sewer facilities. The Developer/Owner will assume the responsibility to maintain the ponding or detention areas so as not to reduce the water storage areas. If the Owner does not maintain the ponding and detention areas, the plan will become void and the City will plug the sewer at the outlet.

As a condition of final acceptance, the property owner shall be responsible for providing as-built surveys to verify the final grades and elevations of stormwater detention basins and wetlands that are to be owned and operated by the City. At the completion of home construction, the Owner/Developer shall field survey the stormwater detention facility to verify that the facilities are constructed according to approved plans. Should a discrepancy between the plans and constructed grades exist, the design storage of the detention facility shall be restored by the Owner/Developer as directed by the City of Columbus.

Exhibit C
Sample Signature Block
To Be Included on the Cover Sheet of the CC Plans

APPROVALS: SIGNATURES BELOW SIGNIFY ONLY CONCURRENCE WITH THE GENERAL PURPOSES AND GENERAL LOCATION OF THE PROJECT. ALL TECHNICAL DETAILS REMAIN THE RESPONSIBILITY OF THE ENGINEER PREPARING THE PLANS.

PRIVATE DEVELOPMENT SECTION MANAGER, DIVISION OF SEWERAGE AND DRAINAGE	DATE	ADMINISTRATOR, DIVISION OF SEWERAGE AND DRAINAGE	DATE
---	------	---	------

ADMINISTRATOR, DIVISION OF ELECTRICITY	DATE	CITY ENGINEER, TRANSPORTATION DIVISION	DATE
---	------	---	------

ADMINISTRATOR, DIVISION OF WATER	DATE	DIRECTOR, DEPARTMENT OF PUBLIC SERVICE	DATE
-------------------------------------	------	---	------

DESIGN AND PLAN SERVICES ENGINEER, TRANSPORTATION DIVISION	DATE	DIRECTOR, DEPARTMENT OF PUBLIC UTILITIES	DATE
---	------	---	------

- FOR PROJECTS NEAR
PARK PROPERTY

DIRECTOR, DEPARTMENT OF RECREATION AND PARKS	DATE
--	------

Note: Refer to DOSD digital submittal standards for current title block format.

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Exhibit D – SWMS Plan Review Checklist for CC Drawings

Plans

- _____ Registered Engineer signature and seal
- _____ 22" x 34" paper size
- _____ 22" x 34" mylar (final plans only)
- _____ Digital submittal on disk/CD
- _____ Completed CC-drawing application form
- _____ Easement Descriptions and Exhibits
- _____ Seven (7) sets of check prints

Master Drainage Plan

- _____ Project Title
- _____ North arrow and scale
- _____ Project boundaries
- _____ Existing and proposed topography at two-foot contour intervals
- _____ Pre-development and post-development sub-basins
- _____ Location and capacity of the immediate downstream receiving waterway or drainage system
- _____ Pre-development and post-development major routing flow paths
- _____ Soil type by sub-basin
- _____ Tier I and Tier II streams and Stream Corridor Protection Zones
- _____ Proposed stormwater facilities
- _____ Existing field tile locations
- _____ Lines designating the phases of multiphase development projects
- _____ Lot lines, streets, right-of-ways, setbacks, and easements
- _____ Flood Hazard limits and classifications
- _____ Regulated wetlands
- _____ All outfalls identified with major outfalls clearly labeled

Calculations

- _____ Stream Corridor Protection Zone and Floodplain Compensation
 - _____ Stream Corridor Protection Zone sizing calculations
 - _____ Floodplain fill volume calculations
 - _____ Compensatory floodplain fill volume calculations
- _____ Impervious Area

- ___ **Storm sewers**
 - ___ **Pipe sizing calculations**
 - ___ **Hydraulic grade line check calculations**
 - ___ **Pavement spread calculations**
 - ___ **Inlet spacing/capacity calculations**
 - ___ **Inlet tributary area map(s)**

- ___ **Culverts**
 - ___ **Hydrologic calculations**
 - ___ **Hydraulic calculations/overtopping analysis**
 - ___ **Tributary area map**

- ___ **Constructed Open Watercourses**
 - ___ **Ditch sizing calculations**
 - ___ **Tributary area map**
 - ___ **HEC-2 analysis, if required**

- ___ **Flood routing**
 - ___ **Hydrologic calculations**
 - ___ **Hydraulic calculations**

- ___ **Detention**
 - ___ **Predeveloped flow calculations**
 - ___ **Post developed flow calculations**
 - ___ **Critical Storm determination calculations**
 - ___ **Stage-discharge curve**
 - ___ **Stage-storage curve**
 - ___ **Routing calculations**
 - ___ **Storage Volume Table (shown on plans)**

- ___ **Stormwater Quality BMPs**
 - ___ **Water quality volume (WQv) calculations**
 - ___ **Drawdown calculations**
 - ___ **Required areas for media filters (Group 2)**
 - ___ **Design and design flow rate for swale and filters strips (Group 3)**
 - ___ **BMP Maintenance plan**
 - ___ **Commercial Activity Areas**
 - ___ **Location shown and area clearly delineated**
 - ___ **Standard Industrial Classification (SIC) identified**
 - ___ **Materials handling areas clearly delineated**
 - ___ **High-risk and low-risk pollutant source identified**
 - ___ **On-site storm and sanitary sewer systems including discharges and outfalls shown**

- _____ **If applicable, oil/water separator, spill containment (110% of volume stored) and treatment systems shown**
- _____ **Area covered from rainfall with cover or roof of required dimensions**
- _____ **Area graded to minimize runoff**
- _____ **Appropriate methods for material disposal shown including sanitary sewer or other**

Easement Descriptions

- _____ **Legal Descriptions**
 - _____ **Legal size paper**
 - _____ **Registered surveyor signature and seal**
- _____ **Exhibits**
 - _____ **Legal size paper**
 - _____ **Registered surveyor signature and seal**
- _____ **Owner Name**
- _____ **Mailing address**
- _____ **Phone number**

Title Sheet

- _____ **Correct project title**
- _____ **Location map**
- _____ **Bench marks**
- _____ **Estimated quantities**
- _____ **Standard drawings**
- _____ **General notes**
- _____ **Signature block**

Plan View

- _____ **North Arrow orientation**
- _____ **Proper structure numbering**
- _____ **Scale**
- _____ **Reference point**
- _____ **Property information**
- _____ **Stream identification**
 - _____ **100 year flood plain limits (if different from SCPZ limits)**
 - _____ **SCPZ limits**
 - _____ **Floodplain fill and compensatory volume location and limits**

- ___ **Stormwater facilities size, types, and location**
 - ___ **Water quality BMPs**
 - ___ **Detention facilities (include maximum ponding limits)**
 - ___ **Storm sewers**
 - ___ **Open channels**
 - ___ **Flood routing**
 - ___ **Culverts**

- ___ **Proposed and existing easements**
- ___ **Agricultural field tiles**
- ___ **Existing and proposed utilities**
- ___ **Proper structure and pipe annotation**
- ___ **Stormwater Pollution Prevention Plan (SWP3)**

Profile View

- ___ **Scale**
- ___ **Stationing**
- ___ **Utility, street, driveway, and stream crossings**
- ___ **Proper structure and pipe annotation**
- ___ **Granular backfill and encasement limits**
- ___ **Proper ground surface line types**

Details and Cross Sections

- ___ **Open channel and flood routing swale cross-sections**
- ___ **Culvert profiles**
 - ___ **Elevation information**
 - ___ **Flow and velocity data**
- ___ **Stormwater BMP details**
 - ___ **Plan view**
 - ___ **Elevation view**
 - ___ **Volume and drawdown data**
 - ___ **Planting list**
- ___ **Detention Ponds**
 - ___ **Cross section(s)**
 - ___ **Elevation information**
 - ___ **Forebay details**
 - ___ **Outlet structure details**

Exhibit E – Erosion and Sediment Control Land Disturbance Note

EROSION AND SEDIMENT CONTROL. Land Disturbance areas less than one* acre and not part of a larger common plan of development are not required to submit to the City of Columbus a full scale erosion and sediment control plan for approval. However, the proposed land disturbing activities must comply with all of the provisions of the Division of Sewerage and Drainage Erosion and Sediment Control regulation. All land disturbing activities shall be subject to inspection and site investigation by the City of Columbus to determine compliance with City standards and regulations. Failure to comply with these regulations may subject the site to enforcement action by the City. Questions regarding Erosion and Sediment Control may be referred to the Stormwater Management Office at 645-6311.

Onsite Contact:
Phone:
FAX:
E-mail:

***As of March 10, 2003 – NPDES Permit Phase II**

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Stormwater Drainage Manual



Appendix G As-Built Location Forms

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**City of Columbus
Division of Sewerage and Drainage
Stormwater Outfall As-built Location Form**

This form must be filled out and submitted for each constructed outfall that discharges directly to an open watercourse. Please submit completed forms to:

**City of Columbus
Division of Sewerage and Drainage
Stormwater and Regulatory Compliance Section
1250 Fairwood Avenue
Columbus, Ohio 43206**

Stormwater Outfall As-built Location

Date of field location: _____
Drawing No. (CC, Drawer D, etc.) _____

State Plane Coordinate of outfall location
Northing _____,
Easting _____,
Elevation _____,

Check all that apply:

Pipe Shape: **Circular** **Other**
 Pipe arch
 Elliptical
 Box section

Pipe Material:

Concrete
 Corrugated Metal (CMP)
 Ductile Iron (DI)
 Vitrified Clay
 High-Density Polyethylene (HDPE)
 Polyvinyl Chloride (PVC)
 Other Describe: _____

Pipe Size: **inches inside diameter, or**
 inches (rise) x **inches (span)**

Name of receiving stream, if known _____

For office use only: City asset no. assigned _____
Maintenance responsibility: **City of Columbus** or **Private property owner/Home Owners Association**

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**City of Columbus
Division of Sewerage and Drainage
Stormwater Control Facility As-built Location Form**

This form must be filled out and submitted for the location of each outlet structure of a stormwater control facility. Please submit completed forms to:

**City of Columbus
Division of Sewerage and Drainage
Stormwater and Regulatory Compliance Section
1250 Fairwood Avenue
Columbus, Ohio 43206**

Stormwater Control Structure As-built Location

Date of field location: _____

Drawing no. (CC, Drawer D, etc.) _____

State Plane Coordinate of (check those that apply):

_____ **principle spillway location for dry detention basins, wet detention basins, and constructed stormwater wetlands**

_____ **overflow catch basin or standpipe for bioretention facilities**

_____ **outlet end of sand filters**

_____ **outlet end of vegetated swales or filter strips that are designed to serve as a water quality BMP only**

_____ **overflow catch basin or standpipe for dry extended detention swales**

Northing _____

Easting _____

Is facility intended to provide (check those that apply):

_____ **water quality control only**

_____ **water quantity control only, or**

_____ **water quality control and water quantity control**

For office use only: City asset no. assigned _____

Maintenance responsibility: _____ **City of Columbus or** _____ **Private property owner/Home Owners Association**

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