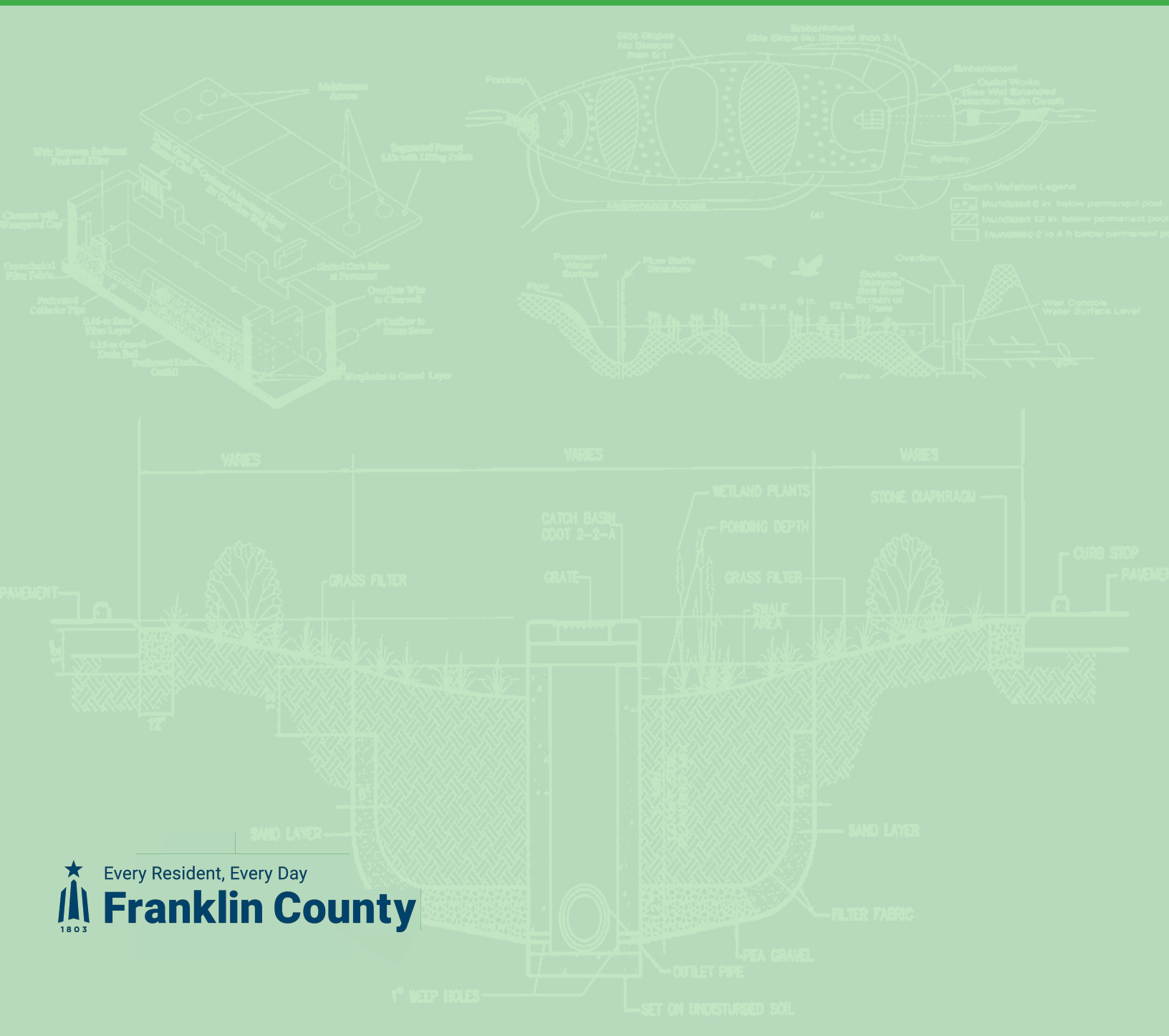
Franklin County
Stormwater Drainage Manual



Every Resident, Every Day
Franklin County
1803

The Franklin County

Stormwater Drainage Manual

For unincorporated areas of Franklin County, Ohio

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1803

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In appreciation and recognition, the following is a partial list of those involved in the drafting and application of the Franklin County Stormwater Drainage Manual:

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Stormwater Drainage Manual

Introduction

Introduction

Franklin County is one of Ohio's 88 counties and is centrally located in Ohio at the intersection of north/south Interstate 71 and east/west Interstate 70. Franklin County is home to the most populous city and capital of the state, Columbus. Franklin County is diverse in its development ranging from the densely populated urban core to the rural sections on the western and southern sections of the county. Franklin County estimated 2024 population is over 1,330,000 people.

Due to the dispersed nature of incorporated areas in Franklin County (the County) and the fact that watersheds, streams, and storm sewers connect the incorporated and unincorporated lands, in 2012, the County adopted the Franklin County Stormwater Drainage Manual (the Manual). The Manual sets forth standards applicable to new development or redevelopment. Generally speaking, the Manual requires all public and private development to control stormwater leaving the site after construction for both water quality and water quantity.

This Manual is intended to serve both the incorporated and unincorporated area of Franklin County as a technical guidance document in support of subdivision regulations and zoning regulations. In incorporated areas, the city's regulations will supersede this Manual.

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 Franklin County, Ohio, are to prevent flooding, streambank erosion, and water quality degradation that may result from stormwater runoff from development and redevelopment projects. 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 County's stormwater policies and design practices, as well as assist developers, engineers, and County 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 County 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 County also recognizes that there may be instances where alternative stormwater standards may apply to protect sensitive ecological areas (e.g., Hellbranch Run and the Darby Creek watersheds) or to meet the goals established by the Ohio Environmental Protection Agency (OEPA). Where alternative standards conflict with the requirements of the Manual, the more stringent criteria shall apply.

Major Changes from the 2012 Manual

As noted above, the 2012 Manual was revised. Some of the more significant changes to the manual include the following:

- Section and sub-section numbers have changed throughout the manual.
- Definitions for ephemeral, intermittent and perennial watercourses have been added to the Definitions section.
- Stormwater Best Management Practices are now referred to as Stormwater Control Practices throughout the document.
- Ditch Petition has been replaced with Drainage Improvement Petition throughout the document.
- **Section 1 –** Section 1 has been updated to include language regarding stream identification, wetland identification, watershed considerations and floodplain preservation and development. Sections 1.1 - 1.5 from the 2012 Manual are included in this 2025 Manual as sections 1.5 – 1.9.
- **Section 2.1.5 –** A section has been added to the manual regarding combined sewer systems.
- **Section 2.3.6.1 –** This section has been removed from the manual.
- **Section 2.3.6.2 –** This section has been removed from the manual.
- **Section 2.3.6.3 –** This section has been removed from the manual.
- **Section 3.1 –** A new detail has been added to the manual narrative for a typical outlet structure configuration.
- **Section 3.4 –** This section has been added to the manual. In the 2012 Manual, the acceptable methods and criteria were included in Section 3.3. This addition shifts subsequent section numbers.
- **Section 3.4.1.1 –** A new detail has been added to the manual for a typical concrete forebay.
- **Section 3.4.1.1** - The general requirements for detention basins and specific criteria for the design of both wet and dry basins have been updated to current OEPA standards.
- **Section 3.4.1.3** - The submerged bench detail (**Figure 3-4**) has been updated to include a protective layer of stone atop filter fabric.
- **Section 3.4.3** - Underground Detention System requirements have been updated to current OEPA standards.
- **Section 4 –** This section has been added to the manual - Construction Verification, Operation, Maintenance, and Monitoring of Stormwater Control Practices
- **Section 4 –** As-built survey information is included in Section 4 of this manual; was previously included in 2012 manual as Section 3.4.
- **Section 5 –** Language was added that requires written approval of mitigation of isolated wetlands and/or isolated streams.

- **Section 6 –** Additional requirements for the Stormwater Management Report have been included throughout Section 6.
- **Section 6.2.7 –** Additional calculations are not required for Water Quality Flow, Design Flow, and SCP geometry.
- **Section 6.6 –** This section was added to the manual and outlines the requirement for Wetland/Stream Delineation Reports to be included as part of the overall Stormwater Management Report.
- **Section 7** - Stormwater Construction Plan submittal requirements have been updated per the current FCEO design standards.
- **Section 7.1** - Stormwater Construction Plan requirements for the title sheet have been updated.
- **Section 7.2 –** Stormwater Construction Plan requirements for the plan views have been updated.
- **Section 7.3** - Stormwater Construction Plan requirements for the profile views have been updated.
- **Section 7.4** - Stormwater Construction Plan requirements for the cross section views and details have been updated.
- **Section 7**.5 – This section has been added to the manual and requires the preparation and submittal of a complete stand-alone Stormwater Pollution Prevention Plan (SWP3) in accordance with OEPA's Construction General Permit.
- **Appendix A** - The inspection forms included in **Appendix A** have been updated.
- **Appendix I** - **Appendix I** was added to the document and includes example legal descriptions and sample plans for right-of-way and easements.

Applicability

Unless otherwise exempted, the Manual shall be used for all public and private projects that change land use, existing stormwater flow or patterns, conveyance system, or stormwater pollutant discharges from applicable premises within the unincorporated area of Franklin County.

Unless otherwise exempt, any new development or redevelopment disturbing more than one acre or involving the following shall be subject to the Manual:

1) Construction or expansion of commercial, industrial, or institutional facilities,
2) Redevelopment of commercial, industrial, or institutional facilities if the renovation will substantially affect stormwater drainage,
3) Construction of multi-family residential facilities,
4) Redevelopment of multi-family residential facilities if the renovation will substantially affect stormwater drainage,
5) Construction or expansion of residential subdivisions, as defined in the Franklin County Subdivision Regulations,
6) Redevelopment of residential subdivisions, as defined in the Franklin County Subdivision Regulations, if the renovation will substantially affect stormwater drainage,
7) Construction, reconstruction, improvement, and/or modification of all private and public transportation and transit facilities, by private enterprise or due to private development,

which add impervious surface or alter existing drainage patterns. 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, when the entire disturbance for the proposed construction activities is less than one (1) acre.

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. It discusses ecosystem and water quality problems related to stormwater runoff from developed sites and methods of conceptual planning and design that minimize the impacts of development.
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 County'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 unincorporated area of Franklin County.
2) Stormwater Management Report Submittal Requirements (Section 6) are summarized in this section. The design for proposed stormwater systems shall be submitted to the County for review and approval in accordance with this section.
3) Stormwater Construction Plan 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 County will utilize ODOT's Construction and Materials Specifications (CMS), current edition, and the applicable Standard Construction Drawings. If ODOT's specifications and/or standard drawings do not address project elements, the default requirement will be City of

Columbus Construction and Materials Specifications (CMSC), current edition, and the Standard Construction Drawings maintained by the City of Columbus. All construction activity within the Unincorporated County must also comply with the requirements stipulated by OEPA and Section 3.5 of this Manual, whichever is more restrictive. Current ODOT CMS and Standard Construction Drawings can be found online at ODOT's Publications gateway. Current City of Columbus CMSC and Standard Construction Drawings are available online at their document library web page.

Variances

The County recognizes that there may be individual projects involving special or unusual design challenges that must be resolved prior to development approval. Regulatory or zoning authorities that reference the Franklin County Stormwater Drainage Manual may grant variances in cases where the applicant demonstrates that the application of the Manual is impracticable because of specific site conditions. The variance application must demonstrate either:

1) that the proposed alternative will provide the same level of flood and water quality protection as those provided for in the Manual, or
2) 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.

County and Township regulatory agencies do not have the authority to grant variances to state or federal regulations. The Franklin County Planning Commission and County and Township Boards of Zoning Appeals may grant variances as provided above with input from the Franklin County Drainage Engineer. Contact the applicable subdivision or zoning authority for more information about variance requests and approval processes.

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 words used in the plural shall include the singular. Words used in the present tense shall include the future tense. The word SHALL is mandatory and not discretionary.

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 County, federal, or state regulatory approval to proceed with a project.

As-Built Survey — A survey shown on a plan or drawing prepared under the direction of a registered Professional Surveyor indicating the actual dimensions, elevations, and locations of any structures and topography of stormwater control facilities after construction has been completed.

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.

Bridge — Any structure of ten feet or more clear span or ten feet or more in diameter on, above, or below a highway, including structures upon which railroad locomotives or cars may travel.

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.

Commercial Activity Areas — Outdoor areas where the following activities are conducted and are exposed to stormwater:

1) Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas, and
2) Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed, and
3) Areas where high-risk materials 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.

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.

County — Franklin County, Ohio.

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 stormwater system; 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.

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

Ephemeral Watercourse — A watercourse that has flowing water only during and for a short duration after precipitation events in a typical year. The stream bed of an ephemeral watercourse is located above the water table year-round. Groundwater is not a source of water for the watercourse. Runoff from rainfall is the primary source of water for watercourse flow.

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 County 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 OEPA. This definition shall be consistent with the County'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, gravel parking lots, artificial turf surfaces, and other similar surfaces.

Intermittent Watercourse — An intermittent watercourse has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.

Larger Common Plan of Development or Sale — As defined in the OEPA Construction General Permit.

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 system within the urban environment including things such as catch basins, detention basins, and storm sewer pipes. The portion of the stormwater 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.

ODOT L&D Manual — ODOT Location & Design Manual, current version.

Offsite — Taking place or located away from the site.

OEPA Construction General Permit — Current version of the General Permit Authorization for Storm Water Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System issued by OEPA and any revisions and amendments thereto.

Onsite — Taking place or located within the site.

O&M Manual – A document that serves as a specialized comprehensive guidance reference for protocols, and instruction for the effective management, operation, and maintenance of Stormwater Control Practices. See **Appendix H**.

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.

Perennial Watercourse — A perennial watercourse has flowing water year-round during a typical year. The water table is located above the stream bed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.

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.

Post-construction Stormwater Control Practice (SCP) — A permanent, structural practice intended to capture or treat stormwater runoff; reduce stormwater runoff rate or volume; or minimize contact between pollutant sources and precipitation or runoff.

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 a public entity, including County, State, municipality, etc.

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 a public entity, including County, State, municipality, etc.

Reasonably Close Conformity — Shall be as defined under Item 101.03 of the State of Ohio Construction and Material Specifications (CMS), current edition.

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. For flood control determinations, the hydrologic and hydraulic condition of the project site prior to redevelopment shall be the condition of the project site immediately before plan submittal and shall remain applicable to the project site for a period of five years.

Riparian — Area immediately adjacent to 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.

Roadway Widening Project — Roadway widening projects include any roadway project that widens an existing street or road to add contiguous travel lanes, including but not limited to contiguous lanes for vehicle or bicycle travel.

OEPA Routine Maintenance Exclusion — The conditions and activities defined in OEPA's current Routine Maintenance Exclusion — Construction Activity Permitting and any revisions and amendments thereto.

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. For purposes of calculating runoff, the site shall be considered to be the limits of the disturbed area.

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 system required for all construction.

Stormwater 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 natural well-defined bed and bank which confines and conducts continuous or periodical flowing water in such a way that terrestrial vegetation cannot establish roots within the channel. Man-made ditches and grass swale waterways are not to be mistaken for streams.

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.

Subdivision — 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, any one of which is less than five acres, for the immediate or future purpose of transfer of ownership; the improvement of land for residential, commercial, or industrial structures or groups of structures, involving the division or allocation of land for street opening, widening, or extension or as open space or common area for use by owners, occupants, or lease holders, or as easements for extension and maintenance of sewer, water, drainage, or public facilities.

Substantially Affect Stormwater Drainage — Any change to the site drainage characteristics including, but not limited to, removal of existing or installation of new collection and conveyance feature such as inlets, curb and gutter, underdrains, or the alteration of existing site grading that changes drainage direction or volume.

Swale — A man-made 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 County's Approved Native Plant Species for Stormwater Quality Control Practices, found in **Appendix B**.

Transportation Facilities — Systems used for the safe and efficient movement of people and goods on streets, highways, sidewalks, shared-use paths, and transit systems.

Watercourse — See definitions for Ephemeral, Intermittent, and Perennial Watercourse.

Watershed — An area of land that drains all the streams and rainfall to a single point such as the outflow of a reservoir, mouth of a bay, or any point along a stream channel.

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

Wetlands — Areas where water covers the soil, or is present either at or near the surface of the soil, all year or for varying periods of time during the year, including during the growing season. Water saturation (hydrology) largely determines how the soil develops and the types of plant and animal communities living in and on the soil. Wetlands may support both aquatic and terrestrial species. The prolonged presence of water creates conditions that favor the growth of specially adapted plants (hydrophytes) and promote the development of characteristic wetland (hydric) soils.

Acronyms

BDF	Basin Development Factor
BMP	Best Management Practice
COC	City of Columbus
CMS	ODOT'S Construction and Material Specifications
CMSC	City of Columbus Construction and Material Specifications
CN	Curve Number
DOSD	City of Columbus Division of Sewerage and Drainage
ESC	Erosion and Sediment Control
FCDE	Franklin County Drainage Engineer
FCEO	Franklin County Engineer's Office
FCEDP	Franklin County Economic Development and Planning Department
FCPH	Franklin County Public Health Department
FCSE	Franklin County Sanitary Engineer
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
FSWCD	Franklin Soil and Water Conservation District
GI	Green Infrastructure
HEL	Highly Erodible Lands
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
NFIP	National Flood Insurance Program
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
O&M Manual	Operation and Maintenance Manual
ORC	Ohio Revised Code
RLDM	Rainwater and Land Development Manual
TND	Traditional Neighborhood Development
WQv	Water Quality Volume
SCP	Stormwater Control Practice
SCS	United States Department of Agriculture Soil Conservation Service (which is now the NRCS)
SWDM	Stormwater Drainage Manual
SWPPP/SWP3	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USGS	United States Geologic Survey

Stormwater Drainage Manual

Part I

Stormwater Policy and Facility Design Criteria

Part I – Stormwater Policy and Facility Design Criteria

Part I of the Manual supports the layout and design of stormwater management facilities. The County has determined that the stormwater management guidelines 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 County's guidelines for successfully designing the stormwater management facilities and the layout requirements that must accompany acceptable projects altering land use. These requirements are organized in four sections containing subsections for each pertinent element of the stormwater management system.

Stormwater Drainage Manual

Part I

Section 1
Preservation and Protection

Section 1: Preservation and Protection

Urbanization of natural areas has a profound impact on the natural drainage system and water resources in our communities. It not only changes the physical aspects of our streams, but the biological and chemical aspects as well. Depending on the magnitude of development and changes to the land surface, the resulting impact on the drainage system can be seen in several areas.

1.1 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 and drainageways within the project site and/or streams receiving stormwater discharges from the project site on the master drainage plan (Section 7) submitted as part of the Stormwater Management Report. The Applicant shall provide information that supports the classification of streams with the Stormwater Management Report. Such information is typically provided in a stream/wetland delineation report prepared by a qualified environmental consultant.

The County may require input from other sources including, but not limited to, the U.S. Army Corps of Engineers (USACE), Ohio Environmental Protection Agency (OEPA), Ohio Department of Natural Resources (ODNR), or Franklin Soil and Water Conservation District (FSWCD). The USACE will have final determination regarding whether the watercourse or channel meets the classification of a stream for the purposes of the Manual.

1.2 Wetland Identification

The County 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, and rare, threatened, or endangered wildlife species.

Jurisdictional and isolated wetlands shall be delineated and categorized by a qualified professional as required by USACE and OEPA. The Applicant shall provide information that supports the identification of wetlands with the Stormwater Management Report. Such information is typically provided in a stream/wetland delineation report prepared by a qualified environmental consultant. The Applicant shall identify and label all wetlands within the project site on the master drainage plan (Section 7) submitted as part of the Stormwater Management Report.

1.3 Watershed Considerations

In 2000, there was a development restriction placed on land in the Big Darby Watershed. At that time, the Big Darby Accord was formed through participation of watershed communities. The resulting product was the Big Darby Accord Watershed Master Plan developed in 2006 and was adopted by all of Franklin County's communities in 2008. The plan provides a framework for managing development, and protecting the unique natural resources and water quality in the Big Darby Creek watershed. The Big Darby Creek is a state and national scenic river. Requirements for Post Construction Design, Groundwater Recharge, and Stream Setback distances are covered in the Construction General Permit for the Big Darby Watershed.

1.4 Floodplain Preservation and Development within Special Flood Hazard Areas

All development within the FEMA designated Special Flood Hazard Areas is subject to the Special Resolution National Flood Insurance Program (NFIP) Regulation, Unincorporated Franklin County, Ohio, Community Number 390167, as revised September 19, 2007.The Special Resolution grants the Franklin County Floodplain Administrator the authority to administer the NFIP requirements as outlined in the Special Resolution.

1.5 Stream Flow Impacts

The introduction of impervious surfaces in a watershed alters the flow characteristics of streams in several ways:

Increased Runoff Volumes - More water running off the land into the streams than originally would and less being absorbed.

Increased Peak Runoff Discharges - The stormwater runoff flows reach a higher peak and more quickly than before.

Greater Runoff Velocities - Increased speed at which the storm water runs off.

Increase in Frequency of Bankfull Events - The three items identified above contribute to stream channel morphology where changes in the channel shape through erosion, scour, and sedimentation can cause property damage, loss of habitat, and a degradation of the ecosystem. All of which diminishes the quality of life in the watershed.

Increased Flooding - The increase in the volume of water, the higher peak discharges, and the greater velocities also increase the severity of flooding.

Lower Dry Weather Flows - With increases in runoff volumes and velocities comes reduced dry period base flows in streams. A lessened base flow is visible evidence there has been a reduction in the amount of water permitted to recharge the ground water aquifers.

1.6 Stream Geometry Impacts

The increase in stream flows due to increased impervious surfaces can have a variety of negative impacts on the geometric characteristics of streams:

Stream Widening and Bank Erosion - More frequent peak flows and higher stream velocities associated with smaller and more frequent storm events cause channels to erode and widen to convey the increased water volumes. This causes scour and undercutting of the steeper stream banks causing them to slump and collapse during the larger storm events, which can trigger more erosion and damage.

Stream Down Cutting - Another way streams change in order to carry higher flows is by down cutting of the stream bed. This is another cause for erosion and bank instability.

Loss of Riparian Tree Canopy - As stream banks undercut and erode away, the roots of the trees that have been protecting the bank become exposed and eventually fall into the stream and die causing further bank instability, erosion, and log jams.

Changes in Channel Bed Due to Sedimentation - As stream banks erode more quickly under the increased water velocities, more sediment is carried and deposited as the streams change course. These deposits can create sand bars and cover the stream bed and substrates which will negatively impact the environment.

Increase in Flood Elevations - Increased peak flows cause flood levels to rise. The filling of the floodplain causes these flood elevations to rise even higher.

1.7 Ecosystem Impacts

The changes in stream geometry due to increases in flow can directly impact the aquatic habitat of the stream:

Degradation of Habitat Structure - Higher and faster stream flows due to development can wash away entire biological communities. Stream bank erosion and the loss of riparian vegetation reduce the habitat for many fish species and other aquatic life. Sediment deposits can smother bottom dwelling organisms. All of these changes impact the overall ecosystem of the stream corridor.

Loss of Pool and Riffle Structure - Natural streams in undeveloped areas often contain pools of deep, slower moving water separated by shallow, faster moving water called riffles. This combination of pools and riffles provides valuable habitat for fish and other aquatic species especially during dry periods. Increased flows and sediment load from developed areas tend to replace these pools and riffle zones with more uniform and often shallower conditions that are detrimental to this habitat and the species living there.

Reduced Base Flows - The increase in impervious surfaces and lessened infiltration for ground water recharge adversely affects the ground water levels, thus decreasing the base flows in the streams during dry periods. Again, this will have a detrimental impact on aquatic species.

Increased Stream Temperature - Runoff from warm impervious surfaces, storage in detention/retention basins, and the loss of the riparian vegetation collectively increase the water temperature in the streams. Increases in water temperature reduce the amount of dissolved oxygen that the water can hold.

Decline in Abundance and Biodiversity - Wherever there is a reduction in the quality and quantity of habitat, the diversity of species is correspondingly reduced. The result is a decrease or elimination of sensitive species and an increase of less sensitive species. This creates an imbalance of aquatic population and reduction in biodiversity. A reduction in biodiversity can

directly impact the quality of life for all of us and cause our waterways to be in non-attainment of the OEPA water quality standards.

1.8 Water Quality Impacts

Development also can increase non-point source pollution, which has an adverse effect on water quality. Due to the magnitude of this problem, it is important to understand the causes of water quality degradation.

Reduced Oxygen in the Streams - Reduced oxygen in the stream water is not only a product of water temperature increases; it is caused by decomposing organic matter such as leaves, grass clippings, and pet waste that have been washed off into the stream or dumped there by humans. As stated earlier, reductions in dissolved oxygen can kill fish and weaken other aquatic species.

Nutrient Enrichment - Nutrient enrichment, such as nitrogen and phosphorus, comes from urban runoff containing lawn fertilizers, animal waste, and detergents. These nutrients promote algae blooms in ponds and lakes. Algal growth can deplete the oxygen in the water and block the sunlight for other plants and animals.

Microbial Contamination - Microbial pollutants come from a variety of sources, such as pet waste, failing septic systems, sewage overflows, and urban wildlife. These microbial contaminants can disrupt the food chain, increase the cost of treating water for drinking, and present a hazard for recreational users of our waterways.

Toxic Materials - Besides oil and other fluids leaking from vehicles, urban runoff contains a host of other compounds such as salt, lawn fertilizers, and pesticides. With industrial and commercial development come added pollutants such as heavy metals and hydrocarbon pollutants.

Sedimentation - Sedimentation has several negative attributes that degrade stream water quality. Suspended sediments can block out the sunlight and reduce the ability of aquatic plants from photosynthesizing, stunting their growth and inhibiting reproduction. Sediment particles transport other pollutants that attach themselves to the suspended solids, such as trace metals and hydrocarbons. Sedimentation also makes treatment for drinking water more expensive.

High Water Temperatures - As stated earlier, increased water temperatures decrease the amount of dissolved oxygen in the water, making it difficult for some species of aquatic life to survive. An increase in water temperature also has a negative impact on temperature-sensitive fish and insects that can survive only in a narrow temperature range.

Trash and Debris - Trash and debris can cause a variety of problems. They are an aesthetic eyesore. Large accumulations can block channels and cause localized flooding. Certain types of trash can be dangerous to wildlife as well.

Effective management of stormwater runoff and fulfillment of stormwater regulatory requirements dictate the need to adopt a comprehensive approach to stormwater management that ties together stormwater quantity control with quality protection. Water quantity and quality standards for land-disturbing activities of over one acre must meet Ohio EPA currently

effective Construction General Permit. See Ohio Rainwater and Land Development Manual, Chapter One, for more information on stream impacts due to urbanization.

1.9 Environmental Site Design

The County encourages the use of Environmental Site Design practices that reduce the volume, velocity, and pollutant load of stormwater runoff. Developing a conceptual design and vision for the development will allow for a comparison between the pre-development hydrologic character and the post-development hydrologic character. This site analysis will facilitate the selection of appropriate and suitable Post-construction Stormwater Control Practices (SCPs) for the development site and the regional watershed in which the site is located. Designs should consider the Total Maximum Daily Load (TMDL) Program information available from OEPA to the maximum extent practicable. The County is seeking not only to comply with current regulations but to reduce the volume of stormwater runoff and the pollutant load in stormwater runoff to the maximum extent feasible for each site.

1.9.1 Conservation of Natural Features and Resources

This technique identifies and preserves the natural features and resources of the site and uses them to protect the water resources by reducing stormwater runoff, providing runoff storage, reducing flooding, preventing soil erosion, promoting infiltration, and removing pollutants. Some natural features that should be taken into account are:

1) Areas of undisturbed vegetation
2) Floodplains and riparian areas
3) Ridge tops and steep slopes
4) Natural drainage pathways
5) Intermittent, ephemeral, and perennial watercourses
6) Aquifer recharge areas
7) Wetlands
8) Hydric or HEL (Highly Erodible Lands) Soils

1.9.2 Low Impact Site Design Techniques

After conservation areas have been delineated, there are additional opportunities to integrate these areas into the general stormwater management plan for the site as follows:

1) Fit the design to best match the terrain.
2) Limit clearing and grading.
3) Concentrate the development in less environmentally sensitive areas.

1.9.3 Minimize Impervious Cover

Reducing the site's impervious cover directly reduces the stormwater runoff volume and associated pollutants. It can also reduce the costs of necessary infrastructure. Some of the ways impervious cover can be reduced are as follows:

1) Layout the roads such that their length is minimized.
2) Reduce the roadway widths as much as practical without sacrificing safety and accessibility.
3) Reduce building footprints.
4) Reduce parking footprints.
5) Reduce driveway lengths.
6) Consider specifying pervious pavements for overflow parking areas, driveways, sidewalks, recreation, and pedestrian facilities.

Stormwater Drainage Manual

Part I

Section 2

Stormwater Conveyance

Section 2: Stormwater Conveyance

2.1 General Criteria

The County's stormwater management goals are to prevent hazardous or detrimental flooding, stream bank 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 practices designed in accordance with the requirements specified in Section 3 of the Manual. No Stormwater Management Plan 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 stream,
2) A public open channel system (generally excluding roadside ditches),
3) A public storm sewer system adequately sized for the intended flows,
4) A wetland,
5) A private open channel system with a dedicated drainage easement granted to the party responsible for the long-term operation and maintenance of stormwater drainage, or
6) A private tile system adequately sized for the intended flows, video inspected and with a drainage maintenance easement granted to the party responsible for long term operation and maintenance of stormwater drainage.

Additionally, while infiltration of stormwater is not considered "discharge" per se, it is an acceptable method of removing stormwater from a site where soil and groundwater conditions have been proven to be acceptable for this purpose. See Section 3.4.7 for design considerations.

If none of the options above are 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 uppermost extent of an overland flow path before becoming concentrated. In developed areas, sheet flow lengths are typically no longer than 100 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 another similar device. Flow from drainage areas with overland flow paths greater than 100 feet must discharge into one of the 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 Franklin County Engineer, Drainage Engineer, or floodplain 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, more stringent release rates from onsite detention facilities built for the development site may be required. The Applicant would also need to provide the necessary downstream modifications, in addition to or in place of the stringent release rates, 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 County or municipalities within the County,
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 2.2.1 must be used, and design criteria specified in the Manual shall be used to evaluate the offsite stormwater 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 after approval 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 or other illicit discharge 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 upon discovery to the Franklin County Public Health Department (FCPH) for resolution. Field tiles that exhibit evidence of conveying any illicit discharge as defined by the County's present NPDES Permit shall not be connected for stormwater conveyance and shall be reported upon discovery to the Franklin County Drainage Engineer's Office.

Designers preparing plans for development on existing agricultural lands shall, at a minimum, contact the County Drainage Engineer's Office and respective 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 Plan. 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 pre-development 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 modifications to the downstream system) with the downstream owner is required for discharges to "private" field tile systems.

2.1.5 Combined Sewer Systems

Construction of new combined sewer systems are not acceptable within the unincorporated areas of Franklin County. Proposed drainage systems shall not connect to a combined sewer, and an alternate appropriate connection shall be used.

2.1.6 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, aquatic nuisance species transfer, 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 County will not allow the diversion of stormwater runoff from one major stormwater routing system to another without County approval and documentation that includes proof of benefit. Stormwater system diversions between streams 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 Drainage Engineer or their qualified 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

Table 2-1 indicates 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 Section 2.2.3 shall be used for designing conveyance systems such as stream crossings, storm sewer systems, small open channels, swales, roadside ditches, overland flow, shallow concentrated flow, roadway curbs, and storm sewer inlets. The County allows three methods for calculating stormwater runoff peak flows:

1) The Rational Method described in Section 2.2.3.1,
2) United States Geologic Survey (USGS) Regression Equations 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. Information regarding the

water quality volume and water quality flow used to design water quality facilities is provided in Section 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 Constructed for Streams	2.3.3		√*		√	
Constructed Open Watercourses	2.3.7	√		√	√	
Downstream Analysis	2.1.3				√	
Detention Basins	3.4.1				√	
Water Quality Controls	3.3					√

* For new culvert or culvert replacements developed under the County CIP projects only.

2.2.2 Hydrologic Components

2.2.2.1 Rainfall

The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Rainfall Intensity-Duration-Frequency (IDF) curves for the location of the project 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 the IDF curves, distributed over a 24-hour period with the SCS Type II distribution (**Table 2-2**). 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.

Table 2-2 Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Type II Delta Rain	Type II 24-Hour Rainfall Distribution (in) Frequency: Duration: Depth (in):	100yr 24 hr 5.63	50yr 24 hr 5.02	25yr 24 hr 4.44	10yr 24 hr 3.74	5yr 24 hr 3.24	2yr 24hr 2.63	1yr 24 hr 2.20
0:00	0			0.000	0.000	0.000	0.000	0.000	0.000	0.000
0:15	0.002	0.002		0.011	0.010	0.009	0.007	0.006	0.005	0.004
0:30	0.005	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:45	0.008	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:00	0.0108	0.0028		0.016	0.014	0.012	0.010	0.009	0.007	0.006
1:15	0.014	0.0032		0.018	0.016	0.014	0.012	0.010	0.008	0.007
1:30	0.017	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
1:45	0.02	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:00	0.023	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:15	0.026	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:30	0.029	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
2:45	0.032	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:00	0.0347	0.0027		0.015	0.014	0.012	0.010	0.009	0.007	0.006
3:15	0.038	0.0033		0.019	0.017	0.015	0.012	0.011	0.009	0.007
3:30	0.041	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
3:45	0.044	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
4:00	0.0483	0.0043		0.024	0.022	0.019	0.016	0.014	0.011	0.009
4:15	0.052	0.0037		0.021	0.019	0.016	0.014	0.012	0.010	0.008
4:30	0.056	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
4:45	0.06	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:00	0.064	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:15	0.068	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:30	0.072	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
5:45	0.076	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
6:00	0.0797	0.0037		0.021	0.019	0.016	0.014	0.012	0.010	0.008
6:15	0.085	0.0053		0.030	0.027	0.024	0.020	0.017	0.014	0.012
6:20	0.09	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
6:30	0.095	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:00	0.1	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:15	0.105	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:30	0.11	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
7:45	0.115	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
8:00	0.1203	0.0053		0.030	0.027	0.024	0.020	0.017	0.014	0.012
8:15	0.126	0.0057		0.032	0.029	0.025	0.021	0.018	0.015	0.013
8:30	0.113	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
8:45	0.14	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
9:00	0.1467	0.0067		0.038	0.034	0.030	0.025	0.022	0.018	0.015
9:15	0.155	0.0083		0.047	0.042	0.037	0.031	0.027	0.022	0.018
9:30	0.163	0.008		0.045	0.040	0.036	0.030	0.026	0.021	0.018
9:45	0.172	0.009		0.051	0.045	0.040	0.034	0.029	0.024	0.020
10:00	0.1808	0.0088		0.050	0.044	0.039	0.033	0.029	0.023	0.019
10:15	0.191	0.0102		0.057	0.051	0.045	0.038	0.033	0.027	0.022
10:30	0.203	0.012		0.068	0.060	0.053	0.045	0.039	0.032	0.026
10:45	0.218	0.015		0.084	0.075	0.067	0.056	0.049	0.039	0.033
11:00	0.236	0.018		0.101	0.090	0.080	0.067	0.058	0.047	0.040
11:15	0.257	0.021		0.118	0.105	0.093	0.079	0.068	0.055	0.046
11:30	0.283	0.026		0.146	0.131	0.115	0.097	0.084	0.068	0.057
11:45	0.387	0.104		0.586	0.522	0.462	0.389	0.337	0.274	0.229
12:00	0.6632	0.2762		1.555	1.387	1.226	1.033	0.895	0.726	0.608
12:15	0.707	0.0438		0.247	0.220	0.194	0.164	0.142	0.115	0.096
12:30	0.735	0.028		0.158	0.141	0.124	0.1058	0.091	0.074	0.062
12:45	0.758	0.023		0.129	0.115	0.102	0.086	0.075	0.060	0.051

Table 2-2 Type II SCS Design Storm Hyetograph

Hour	Type II Mass Curve	Type II Delta Rain	Type II 24-Hour Rainfall Distribution (in) Frequency: Duration: Depth (in):	100yr 24 hr 5.63	50yr 24 hr 5.02	25yr 24 hr 4.44	10yr 24 hr 3.74	5yr 24 hr 3.24	2yr 24hr 2.63	1yr 24 hr 2.20
13:00	0.776	0.018		0.101	0.090	0.080	0.067	0.058	0.047	0.040
13:15	0.791	0.015		0.084	0.075	0.067	0.056	0.049	0.039	0.033
13:30	0.804	0.013		0.073	0.065	0.058	0.049	0.042	0.034	0.029
13:45	0.815	0.007		0.062	0.055	0.049	0.041	0.036	0.029	0.024
14:00	0.825	0.01		0.056	0.050	0.044	0.037	0.032	0.026	0.022
14:15	0.834	0.009		0.051	0.045	0.040	0.034	0.029	0.024	0.020
14:30	0.842	0.008		0.045	0.040	0.036	0.030	0.026	0.021	0.018
14:45	0.849	0.007		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:00	0.825	0.01		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:15	0.834	0.009		0.039	0.035	0.031	0.026	0.023	0.018	0.015
15:30	0.869	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
15:45	0.875	0.005		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:00	0.881	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:15	0.887	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:30	0.893	0.006		0.034	0.030	0.027	0.022	0.019	0.016	0.013
16:45	0.898	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:00	0.903	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:15	0.908	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:30	0.913	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
17:45	0.918	0.005		0.028	0.025	0.022	0.019	0.016	0.013	0.011
18:00	0.922	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:15	0.926	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:30	0.93	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
18:45	0.934	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:00	0.938	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:15	0.942	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:30	0.946	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
19:45	0.95	0.004		0.023	0.020	0.018	0.015	0.013	0.011	0.009
20:00	0.953	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:15	0.956	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:30	0.959	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
20:45	0.962	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:00	0.9653	0.0033		0.019	0.017	0.015	0.012	0.011	0.009	0.007
21:15	0.968	0.0027		0.015	0.014	0.012	0.010	0.009	0.007	0.006
21:30	0.971	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
21:45	0.974	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:00	0.977	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:15	0.98	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:30	0.983	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
22:45	0.986	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:00	0.9892	0.0032		0.018	0.016	0.014	0.012	0.010	0.008	0.007
23:15	0.992	0.0028		0.016	0.014	0.012	0.010	0.009	0.007	0.006
23:30	0.995	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
23:45	0.998	0.003		0.017	0.015	0.013	0.011	0.010	0.008	0.007
0:00	1	0.002		0.011	0.010	0.009	0.007	0.006	0.005	0.004

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 (obtained from Bentley's Civil Engineering Staff, *Computer Applications in Hydraulic Engineering*, 9th Edition).

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. 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 Equation (obtained from United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.):

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

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 2-3 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.

Table 2-3 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 3-3** of NRCS TR-55 (obtained from United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986), 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 NRCS TR-55.

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

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

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 follows (obtained from Ohio Department of Transportation, *Location and Design Manual, Volume 2 – Drainage Design*, 2020):

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

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 NRCS Web Soil Survey 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 or flow-through type water quality best management practices within a development. The following sections describe peak flow calculation methods acceptable for use within Franklin County.

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 2-4**

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 2 of **Table 2-4**

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

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 2-4** 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 2-4**.

Table 2-4 Runoff Coefficients "C" for Typical Land Uses in Franklin County

Cover Type and Hydrologic Condition	Average percent impervious area[4]	Runoff Coefficient for Hydrologic Soil Group[2]			
		A	B	C	D
Fully developed urban areas (vegetation established) with average runoff conditions and I_a=0.2S					
Impervious Areas					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		0.94	0.94	0.94	0.94
Gravel streets and parking lots		0.88	0.88	0.88	0.88
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[1]	0.19	0.39	0.50
Commercial and business (TND[3] – Town Center)	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					
Multi-family (TND[3] – Neighborhood Center)[4]	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots (TND[3] – Neighborhood General)[4]	75	0.56	0.70	0.77	0.83
1/8 acre (TND[3] – Neighborhood Edge)	65	0.44	0.60	0.72	0.77
¼ acre	38	0.19	0.40	0.56	0.65
½ acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
Undeveloped or agricultural lands with average runoff conditions and I_a=0.2S					
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					
Poor: <50% ground cover or heavily grazed with no mulch		0.29	0.48	0.63	0.70
Fair: 50 to 75% ground cover and not heavily grazed		0.07	0.30	0.48	0.58
Good: >75% ground cover and lightly or only occasionally grazed		NA[1]	0.19	0.39	0.50
Meadow – continuous grass, protected from grazing and generally mowed for hay		NA[1]	0.16	0.34	0.46
Brush – brush-weed-grass mixture with brush the major element					
Poor: <50% ground cover		0.06	0.27	0.44	0.56
Fair: 50 to 75% ground cover		NA[1]	0.13	0.32	0.44
Good: >75% ground cover		NA[1]	0.06	0.25	0.37
Woods					
Poor: forest litter, small trees, and brush are destroyed by heavy grazing or regular burning		0.06	0.27	0.44	0.56
Fair: woods are grazed but not burned, and some forest litter covers the soil		NA[1]	0.18	0.37	0.48
Good: woods are protected from grazing, and litter and brush adequately cover the soil		NA[1]	0.12	0.32	0.44
Farmsteads – buildings, lands, driveways, and surrounding lots		0.17	0.39	0.54	0.63

1 Method to derive value is not applicable for curve number values less than 40.
2 These runoff coefficients were calculated using curve numbers obtained from the USDA-NRCS Technical Release 55 *Urban Hydrology for Small Watersheds* assuming a 10-year, 24-hour storm. For larger design storms, runoff coefficients shall be increased using the following C value correction factors:
  1.1 for the 25-year design storm
  1.2 for the 50-year design storm
  1.3 for the 100-year design storm
3 TND = Traditional Neighborhood Development
4 The average percent impervious area shown was used to develop the composite CN's which were then used to drive runoff coefficient values. Other assumptions are as follows: impervious areas are directly connected to the stormwater 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.

2.2.3.2 Regression Equations

The regression equations presented in USGS Report 93-135, *Estimation of Peak-Frequency Relations, Flood Hydrographs, and Volume-Duration-Frequency Relations of Ungaged Small Streams in Ohio* 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 the County funded culvert installation and replacement projects.

The following equations shall be used for the various design storms:

$$Q_2 = 155\ (A)^{0.68}\ (P\text{-}30)^{0.5}\ (13\text{-}BDF)^{-0.5}$$
$$Q_5 = 200\ (A)^{0.71}\ (P\text{-}30)^{0.63}\ (13\text{-}BDF)^{-0.44}$$
$$Q_{10} = 228\ (A)^{0.74}\ (P\text{-}30)^{0.68}\ (13\text{-}BDF)^{-0.41}$$
$$Q_{25} = 265\ (A)^{0.76}\ (P\text{-}30)^{0.72}\ (13\text{-}BDF)^{-0.37}$$
$$Q_{50} = 293\ (A)^{0.78}\ (P\text{-}30)^{0.74}\ (13\text{-}BDF)^{-0.35}$$
$$Q_{100} = 321\ (A)^{0.79}\ (P\text{-}30)^{0.76}\ (13\text{-}BDF)^{-0.33}$$

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 stormwater system are then evaluated within each third of the basin and assigned a value of 1 or 0:

1) ***Channel modifications*** 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.
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 2-5 provides an example for calculating the overall BDF for the entire basin that has channel modifications throughout, no channel linings, and storm drains with curb and gutter streets in the lower two-thirds of the basin.

Table 2-5 Example Determination of the Basin Development Factor

Portion of Basin	Channel Modifications	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. Technical Release 55 (TR-55), *Urban Hydrology for Small Watersheds*, incorporates current SCS procedures. TR-55 **Appendix D** includes Worksheets 2 through 6 and are acceptable methods for showing calculations described in this and other applicable sections. The following equation from TR-55 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

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 2-6 (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 2-6** 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:

$$CN = CN_{Impervious} * \% \text{ Imperviousness} + CN_{pervious} * (1 - \% \text{ imperviousness})$$

$$= 98 * 0.7 + 80 * (1-0.7)$$

$$= 93$$

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 2-6**.

Table 2-6 Runoff Curve Numbers (CN) for Typical Land Uses in Franklin County[1]

Cover Type and Hydrologic Condition	Average percent impervious area[2]	Curve Numbers for Hydrologic Soil Group			
		A	B	C	D
Fully developed urban areas (vegetation established) with average runoff conditions and I_a=0.2S7					
Impervious Areas					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Gravel streets and parking lots (excluding right-of way)[3]		96	96	96	96
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[4] – Town Center)	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by Average Lot Size					
Multi-family (TND[4] – Neighborhood Center)[5]	80	86	91	93	94
1/12 to 1/6 acre lots (TND[4] – Neighborhood General)[5]	75	83	89	92	94
1/8 acre (TND[4] – Neighborhood Edge)	65	77	85	90	92
¼ acre	38	61	75	83	87
½ acre	25	54	70	80	85
1 acre	20	51	68	79	84
Undeveloped or agricultural lands with average runoff conditions and I_a=0.2S					
Cultivated Land					
Without conservation treatment		72	81	88	91
With conservation treatment		62	71	78	81
Pasture, grassland, or range – continuous forage for grazing					
Poor: <50% ground cover or heavily grazed with no mulch		68	79	86	89
Fair: 50 to 75% ground cover and not heavily grazed		49	69	79	84
Good: >75% ground cover and lightly or only occasionally grazed		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					
Poor: <50% ground cover		48	67	77	83
Fair: 50 to 75% ground cover		35	56	70	77
Good: >75% ground cover		30[5]	48	65	73
Woods[6]					
Poor: forest litter, small trees, and brush are destroyed by heavy grazing or regular burning		45	66	77	83
Fair: woods are grazed but not burned, and some forest litter covers the soil		36	60	73	79
Good: woods are protected from grazing, and litter and brush adequately cover the soil		30[3]	55	70	77
Farmsteads – buildings, lands, driveways, and surrounding lots		59	74	82	86

1 All CN values are from USDA-NRCS Technical Release 55 *Urban Hydrology for Small Watersheds* unless otherwise noted. Refer to this publication to obtain CN values for conditions not listed.
2 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 stormwater system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.
3 The curve number for gravel streets and parking lots without right-of-way is derived from the TR-55 values for gravel streets and roads that include right-of-way.
4 TND = Traditional Neighborhood Development
5 Curve numbers were calculated based upon percent of impervious area.
6 Actual curve number is less than 30; use CN=30 for runoff computations

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 2-1**)

A_m= drainage area (mi^2)

Q = runoff depth (in)

F_p= pond and swamp adjustment factor (see **Table 2-7**)

Figure 2-1 Unit Peak Discharge Determination

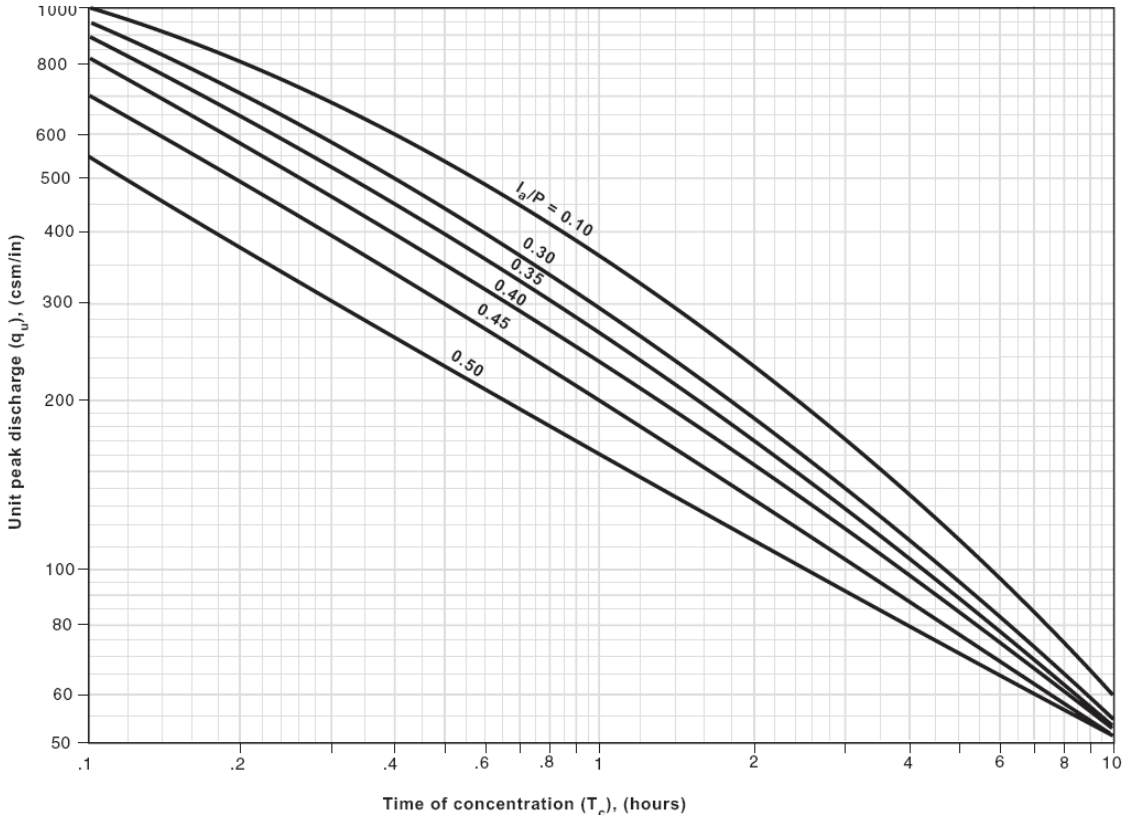


Table 2-7 Adjustment Factor (Fp) for Ponds and Swamps

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 County 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 stormwater 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 stormwater system. The County 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 stormwater system design. Furthermore, hydrograph methods are generally provided by common engineering computer software, such as the NRCS TR-20, the USACE 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 Franklin County extracted from the NOAA Atlas 14 IDF curves with 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 2-2**.

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 County for defining rainfall abstractions. Other methods, including the Green-Ampt and Horton's methods (obtained from Mays, Larry, *Stormwater Collection Systems Design Handbook*, McGraw-Hill, 2001), for determining the change in soil infiltration during a precipitation event may be used with appropriate documentation at the discretion of the County.

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 County will accept the SCS dimensionless unit hydrograph as the basis for developing runoff hydrographs.

This method uses **Table 2-8**, 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:

$t_p = 0.666 * t_c$ 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 County will accept calculations based on computer models that use the SCS unit hydrograph method to develop runoff hydrographs. In addition, the County 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.

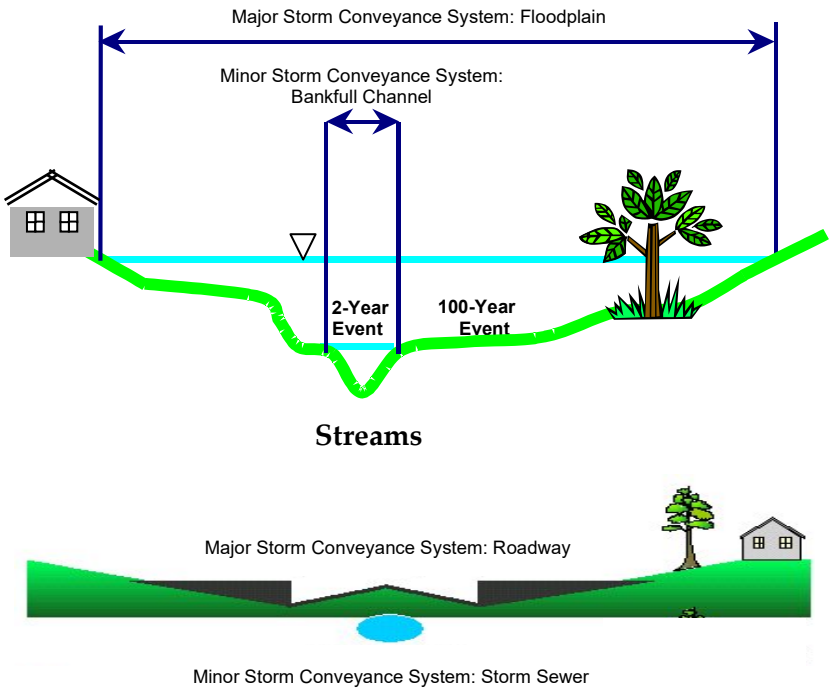
Table 2-8 SCS Dimensionless Unit Hydrograph

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 stormwater 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. Downspouts shall not be allowed to discharge to the foundation of the structure. Downspouts shall be connected to a pipe that either outlets to a curb drain or to an appropriate managed Stormwater Control Practice.

Figure 2-2 Storm Conveyance Systems



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

Proper planning for maintenance of stormwater conveyances is necessary to ensure they function as designed and do not cause inadvertent flooding. Periodic efforts are required to keep the systems clear from trash, sediment, vegetation, and other obstructions. The designer shall give consideration to any easements that may be required to properly maintain the conveyance system.

Effective stormwater 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.

Table 2-9 Pavement Design Criteria

Functional Classification	Design Speed	Design Storm Frequency	Maximum Design Spread (2)	Check Storm Frequency	Check Storm Spread Criteria
Interstate Highways	Refer to *ODOT L&D Manual* Volume 2, Section 1103				
Freeways And Expressways ≥ 4-Lanes (Non Interstate)	≥ 45 mph	10-year	4 feet	25-year	(1)
	< 45 mph	10-year	8 feet	25-year	(1)
	All	50-year	4 feet	Applies at underpasses and sag points	
Major Arterials and	≥45 mph	10-year	4-feet	25-year	(1)
	< 45 mph	10-year	2- lanes, 6 feet 4-lanes, 8 feet	25-year	(1)
	All	50-year	4 feet	Applies at underpasses and sag points	
Minor Arterials and Collectors	≥45 mph	10-year	4-feet	25-year	(1)
	< 45 mph	10-year	2- lanes, 6 feet 4-lanes, 8 feet	25-year	(1)
	All	10-year	4 feet	Applies at underpasses and sag points	
Locals, other parking and development areas	≥ 45 mph	2-year	2- lanes, 6 feet 4-lanes, 8 feet	10-year	One lane free of ponding water
	< 45 mph	5-year	2- lanes, 6 feet 4-lanes, 8 feet	Applies at underpasses and sag points	

Notes to Designer:

1 On roadways with multiple through lanes in each direction, or one direction on a one-way roadway, one through travel lane in each direction must be free of water. Storm water spread on shoulders, full-time parking lanes, and other paved roadside areas and non-traffic lanes is permitted to be full width of that designated pavement area.

2 Spread is considered the encroachment of ponding water in the through travel lane. The allowable depth of water on a roadway, within the design spread, shall be 1” below the top of curb or 5” maximum (i.e., no overtopping of curb allowed). 6” is permissible when a barrier shape is provided adjacent to the pavement.

3 Travel lanes are defined for noted street classifications as follows:
A. Freeways and Expressways – Divided highway with 12-feet travel lanes
B. Major Arterial – Minimum travel lane 11-feet, refer to (STD DWG, 2110, 2115, 2120, and 2125)
C. Minor Arterial – Minimum travel lane 10-feet, refer to (STD DWG, 2110 AND 2115)
D. Locals – Minimum travel lane 9-feet (centered over pavement crown), refer to (STD DWG, 2100, 2105 and 2110)

4 Other pavement spread computation requirements:
- Roughness coefficient (n) = 0.015 to be shown on spread sheet computation table or worksheet.
- Show allowable spread from above Table on spread computation table or worksheet.

5 Rainfall intensities shall be consistent with current NOAA IDF Curves.

6 ODOT CDSS Program is acceptable for use; however, if ODOT CDSS is NOT used, note (5) above prevails.

7 Define and design travel lane configuration in accordance with the requirements herein. Any project specific variations to defined travel lanes shall be submitted in writing to the Division of Design and Construction.

8 Franklin County reserves the option of waiving Table 2-10 and allowing Pavement Spread Design in accordance with the ODOT Location & Design Manual – Volume 2, Section 1103. Said option shall be on a project-by-project basis as authorized by the Franklin County Engineer’s Office.

Table 2-10 Storm Sewers, Culverts, Level Spreaders, and Open Watercourses

Functional Classification	Storm Sewers		Culverts	Level Spreaders	Open Watercourses
	Design Storm	Check Storm			
Freeways and Expressways ≥ 4-Lanes (Non-Interstate)	10-year	25-year	50-year	Used to prevent offsite erosion where onsite discharges cannot be directed to an offsite conveyance system. 1 cfs per 13 feet of level spreader length. Maximum length of level spreader not to exceed 130 feet.	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	10-year	25-year	25-year		
Minor Arterial and Collectors	5-year	25-year	25-year		
Locals, Other Parking and Development Areas	5-year* 2-year **	10-year* 5-year **	10-year		

* Does not apply to storm sewer systems serving as outlets from detention facilities where flows are reduced per the County's stormwater control criteria (See Section 3).

** With approval from FCEO in low volume traffic areas already built up and limited right of way.

2.3.1 Storm Sewers

Storm sewer systems are designed to collect and carry stormwater runoff from the 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 County 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 County 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**).

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 (feet^2)
P = wetted perimeter (feet)
S = Slope of the conduit
= vertical rise of the pipe (feet)/length of the pipe (feet)

The County will accept the City of Columbus approved pipe materials. A Manning's "n" or roughness coefficient of 0.013 shall be used to design storm sewer systems for all City of Columbus-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

A storm sewer shall connect to another with a structure, such as a manhole and/or catch basin. 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 should be matched at junctions where possible. If the outlet elevation permits, the crown of the outlet pipe may be lowered.

All storm sewers, County or privately owned and maintained, shall have a minimum inside diameter of 12 inches. However, flexibility is allowed for engineering judgement in special situations.

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 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 of Columbus'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 alongside 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 or a building setback line. Trench limits for storm and sanitary sewers, as referenced herein, shall be defined as the minimum trench limits listed in the City of Columbus 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)

Applicants must use 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:

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

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)

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 fps. 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.

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 Vol. 2* and the requirements of CMS shall be met. In instances where accepted pipe materials and dimensions are provided in the CMS 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.

In instances where the height of cover from the outside top of pipe to the ground surface or top of pavement surface is 36 inches or less, the engineer of record shall provide one of the following alternatives:

1) Signed and sealed drawings by the pipe manufacturer as part of the design plans,
2) Class A COC 8 concrete encasement per CMSC 901.12 from structure to structure for accepted pipe materials and dimensions, or

3) Reinforced concrete pipe provided proper class of concrete pipe is specified by the engineer of record.

The following table is a guide for the class of pipe to use when the height of cover is 36 inches or less. In no case shall the height of cover be less than 12 inches.

Table 2-11 Acceptable Class of Pipe When Height of Cover is 36 Inches or Less

Pipe Diameter (Inches)	Class of Pipe	Minimum D-Load
12	IV	2000
15	IV	2000
18	III	1250
21	III	1250
24	III	1250
27 or Larger	II	1000

Notes
1 The design of the proper class of concrete pipe is based on ODOT CMS 706.02, ASTM C-76 Specification for reinforced concrete round pipe, ASTM C-507 Specification for horizontal elliptical concrete pipe and ASTM C-655.
2 The installation shall be Type 2.
3 The storm sewers in roadway and outside of roadway are designed for an AASHTO HS-20 live load condition.
4 The height of cover table assumes a soil density equal to 120 pounds per cubic foot.

If casing pipe is required for installation of a section of the storm sewer, then the entire length of the storm sewer from either end of casing pipe to the nearest structure must be encased in Class COC 8 concrete per CMSC 901.12.

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 30 feet centered on the sewer, or 5 feet beyond the minimum trench limits on either side of the trench (as specified in the City of Columbus Division of Sewerage and Drainage 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.

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 of Columbus'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 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)*
CB-1	Round Catch Basin	0.25	1.0	1.0	-	-
CB-2-2A	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-2B	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-2C	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-3	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-4	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-5	Square Catch Basin	2.5	2.3	2.3	-	-
CB-2-6	Square Catch Basin	2.5	2.3	2.3	-	-
CB-3	60" Combination Curb Inlet	3.0	5	1.5	5.0	>4
CB-3A	42" Combination Curb Inlet	1.5	2.5	1.5	3.5	>4
CB-4	Square Catch Basin	11.0	5.33	2.67	-	-
CB-5	Square Catch Basin	6.0	2.67	2.67	-	-
CB-6	Square Catch Basin	1.9	3.0	1.5	-	-
CB-7	Round Catch Basin	1.0	1.83	1.83	-	-
CB-8	Square Catch Basin	6.0	2.67	2.67	-	-

* 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 in accordance with 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 County 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. 5 *Hydraulic Charts for the Selection of Highway Culverts* and in FHWA's HY8 *Culvert Hydraulic Analysis Program.* All materials used in construction of roadway culverts shall conform to the Ohio Department of Transportation CMS.

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 degrees, then either the roadway alignment or the culvert alignment (or both) shall be revised to achieve a skew angle less than 45 degrees.

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 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 County. Culverts spanning open channels conveying onsite flows shall be designed

according to the same method used to design other onsite drainage facilities. Culverts spanning streams 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 Frequency
(Obtained from *ODOT L&D Manual*, Volume 2, Drainage Design)

Functional Class or ADT	Design Storm Event
Interstate highways, other freeways, and expressways	50-year
ADT > 3000	25-year
ADT < 3000	10-year
Bicycle Pathway	5-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*, *Volume 2, Drainage Design.*

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 with the County or a municipality within the County, or
2) FEMA FIRM and data.

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

Maximum Allowable Headwater

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

1) 2 feet below the near, low edge of the pavement for drainage areas 1,000 acres or greater, and 1 foot below for culverts draining less than 1,000 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,
5) at or below the near edge of pavement for driveway culverts conveying runoff along roadside ditches, and
6) zero freeboard or greater on a culvert roadway crossing.

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 and shall be below the edge of pavement. 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 the ODOT CMS Section 611.02, 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 0.013 shall be used for the hydraulic design of culverts.

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

(Obtained from Water Environment Federation and American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992
and
Federal Highway Administration, *Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5*, Report Publication No. FHWA-HIFIP-85-15, Washington DC, 1985)

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

Bankfull Design Considerations

The designer shall check that culverts 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. Exceptions to this requirement include:

1) Culverts with a rise of 30 inches or less,
2) The culvert invert is located on bedrock, and
3) The culvert slope exceeds 1%.

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 (obtained from Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design*, 2025). 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 methodology presented in Section 1105 of ODOT's *L&D Manual* shall be used to analyze bankfull discharge conditions.

The County also requires that the inverts of culverts at 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 Depression
(Obtained from ODOT, *Location and Design Manual, Volume 2, Drainage Design*, 2025)

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.

Where possible, accommodations shall be made to lengthen the culvert to locate the inlet and outlet outside of the roadway clear zone and eliminate the need for guardrail.

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**.

Table 2-16 Minimum Allowable Pipe Size for Various Fill Depths
(Obtained from Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design, 2025)*

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 Ohio Department of Transportation Section 602, including QC1 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 QC1 concrete and designed per ODOT standard construction drawings HW-1.1, HW-2.1 or HW-2.2, dependent on pipe material and headwall height.

Precast pipe culvert endwalls approved for pipe culverts 8 to 60 inches in diameter, shall be constructed per City of Columbus Standard Construction Drawing AA-S169. Precast headwalls approved for pipe culverts 8 to 36 inches in diameter shall be constructed per City of Columbus Standard Construction Drawing AA-S168. Exposed surfaces of headwalls, wingwalls, etc., on public maintained roads shall have a formliner with Ashlar stone pattern.

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 (RCP) suitable for outlet velocities up to 20 fps (obtained from *OEPA Rainwater and Land Development Manual*).
2) Energy Dissipation Devices, suitable for outlet velocities greater than 20 fps.

Table 2-17 Maximum Velocities for Channel Lining Materials
(Obtained from AASHTO, *Model Drainage Manual,3rd Edition*, 2004 and ODOT, *Location and Design Manual, Volume Two – Drainage Design*, 2025)

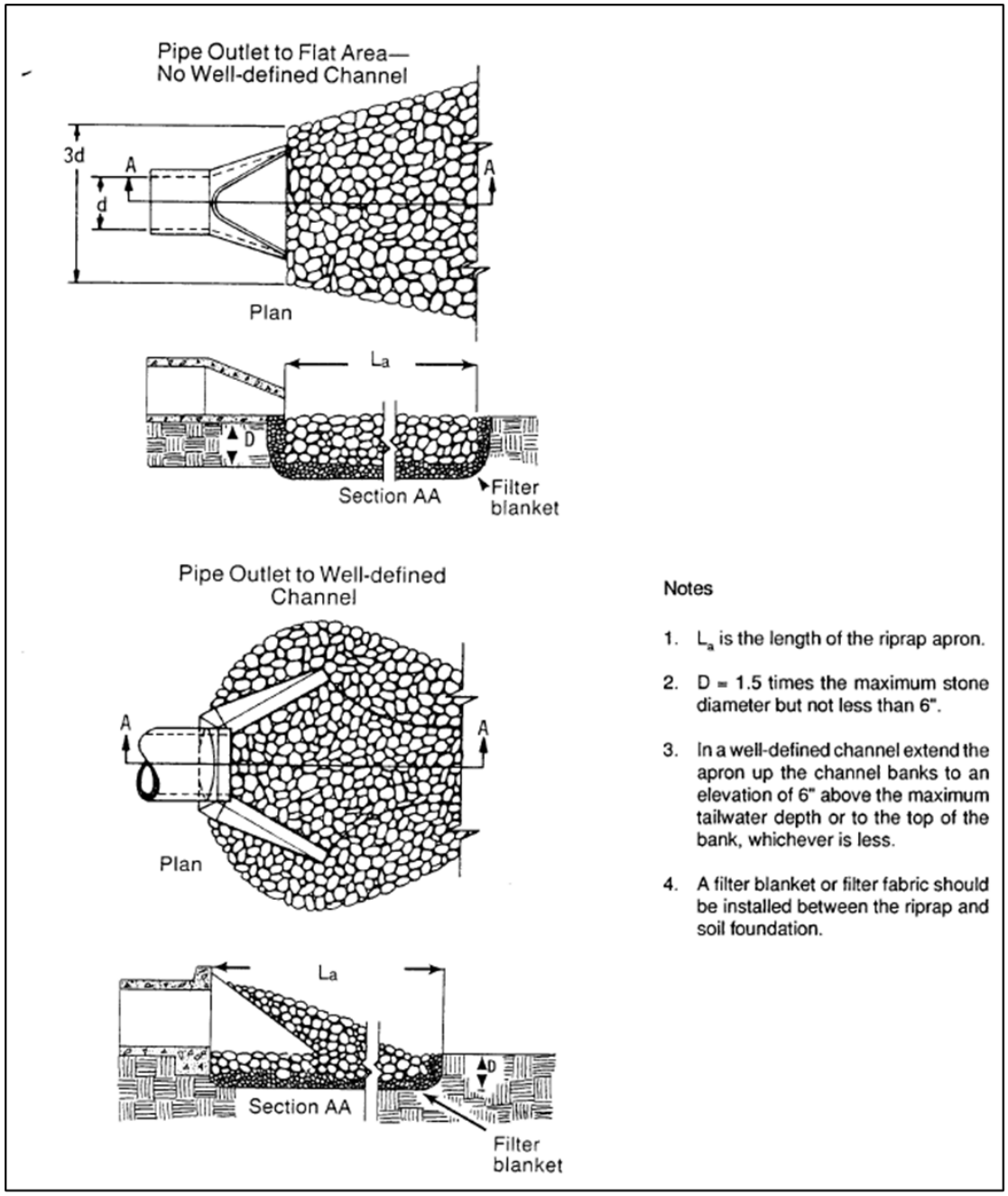
Channel Lining Material	Maximum Allowable Velocity (ft/s)*
Streams	
▪ Sand	2.0
▪ Silt	3.5
▪ Firm Loam	3.5
▪ Fine Gravel	5.0
▪ Stiff Clay	5.0
▪ Graded Loam or Silt to Cobbles	5.0
▪ Coarse Gravel	6.0
▪ Shales and Hard Pans	6.0
Vegetated Channels (per CMSC 659.09)	
▪ Seed mixtures for urban areas	2.5**
▪ Other seed mixtures	2.5**
▪ Established Seed or Sodded Channels	6.0
Flexible Linings	
▪ Slope Erosion Protection	Follow manufacturer's criteria
▪ Erosion Control Matting	
▪ Rock Channel Protection	Use shear stress analysis
Rigid linings ***	
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.
*** Consider concrete lining as a last resort. Approval by FCEO is required.

2.3.5.2 Rock Channel Protection, With Fabric Filter

Rock channel protection (RCP), with fabric filter may be used as transitions from culverts or storm sewer outfalls to stable channel sections. RCP is constructed at a zero grade for a distance related to the outlet flow rate and tailwater depth. The use of this practice is restricted to outlet Froude (Fr) numbers less than or equal to 2.5. RCP is commonly used because of the low cost and ease of installation. Unless otherwise noted below, acceptable design procedures for RCP may be found in the *Ohio Rainwater and Land Development Manual*. See **Figure 2-3**

Figure 2-3 RCP Detail



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 materials and placement of RCP shall conform to the requirements of the Ohio Department of Transportation CMS Section 611.02. At the discretion of the County, the use of flat stones (as referenced in CMS 601.02) 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

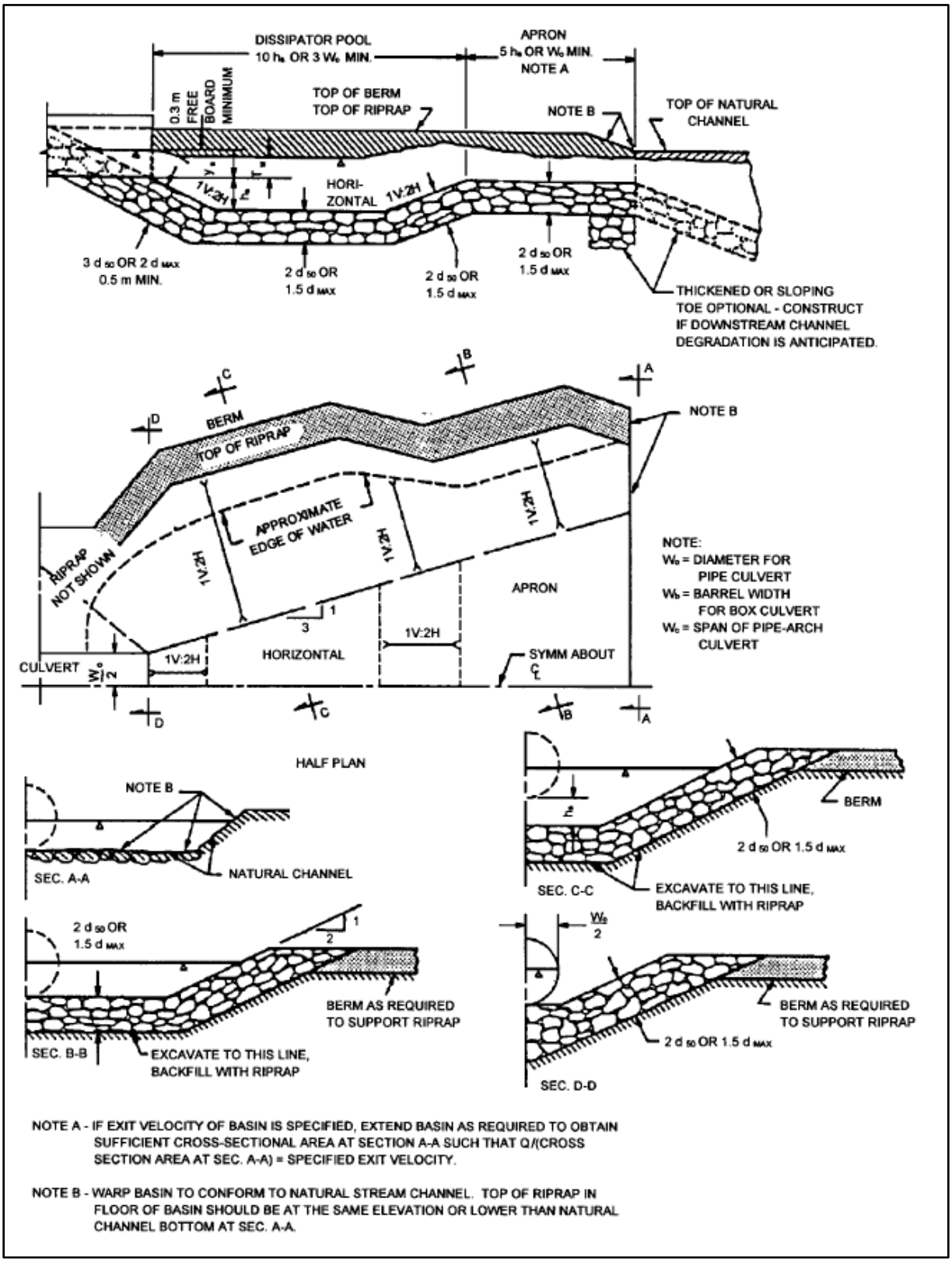
Energy dissipation devices (per ODOT's L&D Manual Volume 2) are required to prevent scour at culvert and storm sewer outlets and minimize potential for downstream erosion whenever the outlet velocity exceeds 20 fps or the outlet discharges under supercritical flow conditions. Since energy dissipaters 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 provides corresponding references for the design of acceptable energy dissipation devices in the County.

Riprap Outlet Basins

One approved method of energy dissipation at storm sewer and culvert outlets is a riprap outlet basin (**Figure 2-4**), 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.

Figure 2-4 Riprap Outlet Basin Detail



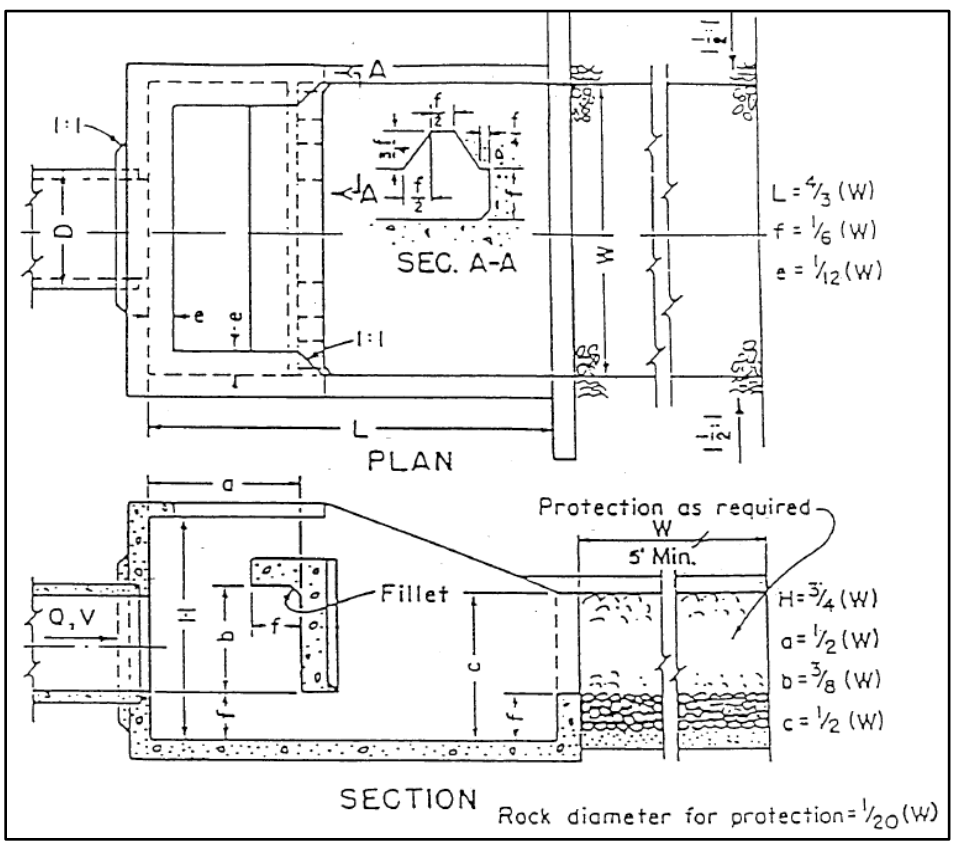
Baffled Outlets

Baffled outlets (also known as Impact Basins – U.S. Bureau of Reclamation Type VI) consist of a boxlike structure with a vertical hanging baffle and an end sill (**Figure 2-5**). Energy is dissipated through the impact of water striking the baffle and the resulting turbulence. Baffled outlets may be used for outlets with a Froude number between 1 and 9 and velocities up to 50 fps. Tailwater does not significantly affect the energy dissipation achieved by these structures. The U.S. Department of Interior's *Design of Small Canal Structures* report shall be used to design baffled outlets.

Forced Hydraulic Jump Basins

A forced hydraulic jump basin utilizes blocks, sills, or other roughness elements to impose exaggerated resistance to flow in order to shorten and stabilize the hydraulic jump. These types of energy dissipation are required where the design velocity and/or Froude Number exceed acceptable criteria for riprap aprons and basins, or when site constraints or environmental factors require that the length of energy dissipation be minimized. Acceptable designs include those developed by the U.S. Bureau of Reclamation, Colorado State University, and the U.S. Natural Resources Conservation Service at St. Anthony Falls Hydraulic Laboratory. The designer shall use design criteria provided in FHWA's HEC-14, Hydraulic *Design of Energy Dissipators for Culverts and Channels, FEMA P-679 Technical Manual: Outlet Works Energy Dissipators,* or other design criteria acceptable to the County Engineer.

Figure 2-5 Baffled Outlet Detail



2.3.6 Level Spreaders

A level spreader is a structure that is designed to convert concentrated flow from stormwater runoff to sheet flow. Level spreaders have traditionally been used at detention basin outfalls where concentrated pipe flows are directed toward a stream or wetland and upstream of water quality SCP where "treatment" of stormwater runoff is dependent on the velocity and depth of flow. The design, materials, and maintenance of level spreaders must follow OEPA's *Rainwater and Land Development Manual***.**

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 practices, 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 Code 412, Grassed Waterways,
2) NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7 – Grassed Waterways,
3) 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 County. 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

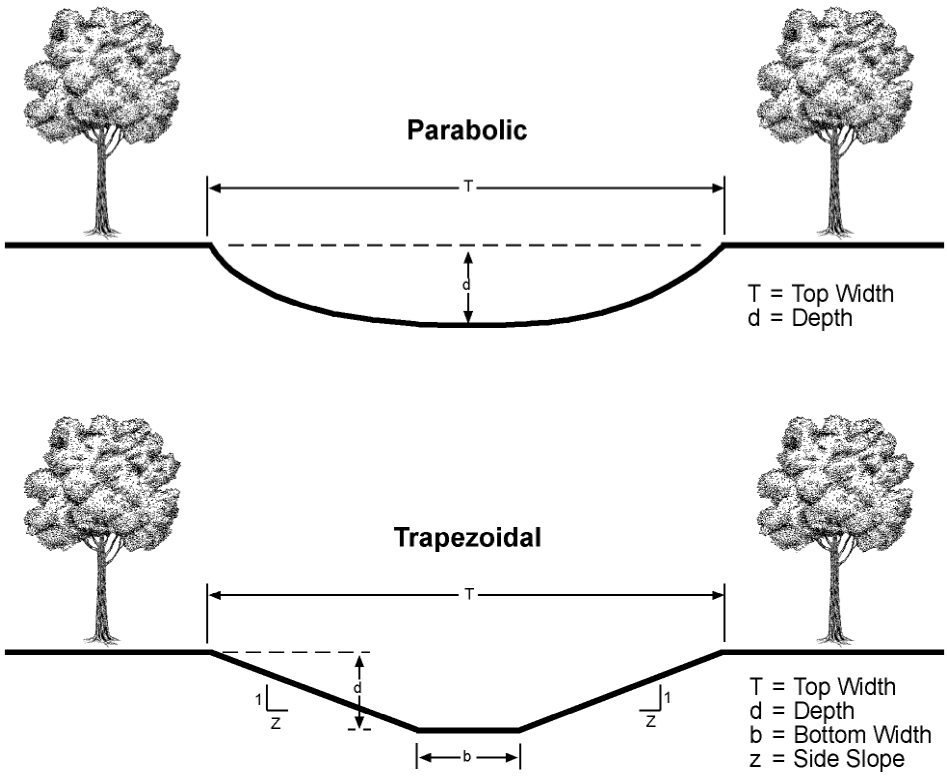
Design Storm Frequency

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 Volume 2, Section 1102 of 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 2-6**) shall be used for open watercourses within development projects. Side slopes shall be 4(H) to 1(V) or milder, with a minimum 2-foot bottom width for trapezoidal channels, unless alternative dimensions are approved by the County due to specific project conditions. Channel cross sections shall be designed such that erosion and sediment deposition is minimized.

Figure 2-6 Parabolic and Trapezoidal Channel Shapes for Open Watercourses



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 such as rock channel protection and cellular soil retaining mats 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 such as concrete and rigid block 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:

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

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 (ft^2)

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 2-18**.

Table 2-18 Manning's Roughness Coefficients (n) for Vegetative and Artificial Channels
(Adapted from FHWA, *Hydraulic Engineering Circular 15*, 3rd Edition**)**

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 Large channels	 0.06 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.

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:

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

where:

F = Froude Number

D = hydraulic depth (ft)

= A / T

A = cross-sectional area of flow (ft^2)

T = top width of water surface (ft)

V = flow velocity (ft/sec)

g = acceleration due to gravity

= 32.2feet/sec^2)

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 Analysis (obtained from Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design* 2020)

Type B, C or D RCP shall be provided in accordance with CMS Section 601.09. Type B, C or D RCP 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 sheer stress (τ_a) listed in **Table 2-19** 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/$feet^2$)

Table 2-19 Allowable Shear Stress for Rock Channel Protection

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

In extreme site conditions, Type B or C RCP 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 County Engineer shall be consulted if RCP 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 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 twenty-five feet on one side, or
2) A minimum width of 30 feet centered along the watercourse, whichever is greater.

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 downstream discharge point meeting the requirements of Section 2.1.3. 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 utilized 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 streets (obtained from Water Environment Federation & American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems,* 1992). 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.

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 discharge point. The County may, at its discretion, require additional detention and/or downstream modifications to provide an adequate major storm routing path downstream of the development.

Stormwater Drainage Manual

Part I

Section 3

Stormwater Controls

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. In many cases, quantity and quality controls are integrated into a single facility.

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.

1) Stormwater quantity control facilities shall not be located within designated FEMA 100-year floodplain boundaries.
2) Discharges from stormwater control facilities shall be directed into an approved stream or wetland, either directly as sheet flow from a level spreader, or via a storm sewer or open channel conveyance system, according to criteria in this Manual. The Franklin County Engineer's Office prohibits the discharge of detention practices directly to a constructed open watercourse, such as an existing open ditch. Any detention-based SCPs must be piped to the nearest natural watercourse wherever possible. Rock channel protection at the pipe's outlet may be necessary depending on the discharge velocity. Non-detention SCPs may outlet to an open watercourse, such as an open ditch, but require appropriately sized rock channel protection at the practice outlet to prevent scour and/or erosion.
3) Wetland hydrology shall be maintained 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 this Manual.
4) When a storm sewer, detention structure, water quality structure, or other appurtenance shall not be located within 30 inches of the exterior wall of any existing or proposed building. The facilities must be shown on the building plan and submitted to the County for approval in addition to including them on the stormwater construction drawings (see Section 7). The stormwater construction drawings will be reviewed for sizing, flow, and detention requirements while the building plan will be reviewed for appropriate material selection and compliance to the Plumbing and Building Codes.
5) Storage capacity below the base flood elevation shall not be included in total storage capacity calculations for stormwater control facilities located adjacent to or vertically within the 100-year floodplain boundary.
6) Stormwater control facilities shall not be located within the public right-of-way when the facility is necessary to satisfy the Manual's requirements for a privately owned project. When improvements such as driveways, to benefit a privately owned project, are located in the public right-of-way, the stormwater control facilities shall not be located in the right-of-way. On site private stormwater control devices shall not detain water in storm

sewer pipe located in the right-of-way.

7) Outlets shall be sized to achieve the release rates required under Sections 3.2 and 3.3. The County will not allow the use of any orifice outlet that is less than 4 inches in diameter unless the design includes an anti-clogging device such as a screen or filter. **Figure 3-3** below displays a typical outlet structure and water quality orifice configuration.

Geotextile fabric is not considered an acceptable screen or filter for use on stormwater control outlets. Outlets and anti-clogging devices shall be accessible for routine maintenance, and any structure in which an outlet is located shall be of sufficient size to allow unobstructed access. Alternative outlet designs (e.g., V-notch weir, perforated) in lieu of orifice diameters smaller than 4 inches may be permitted upon the County approval if acceptable design practice is proven for site conditions. 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, ft^2

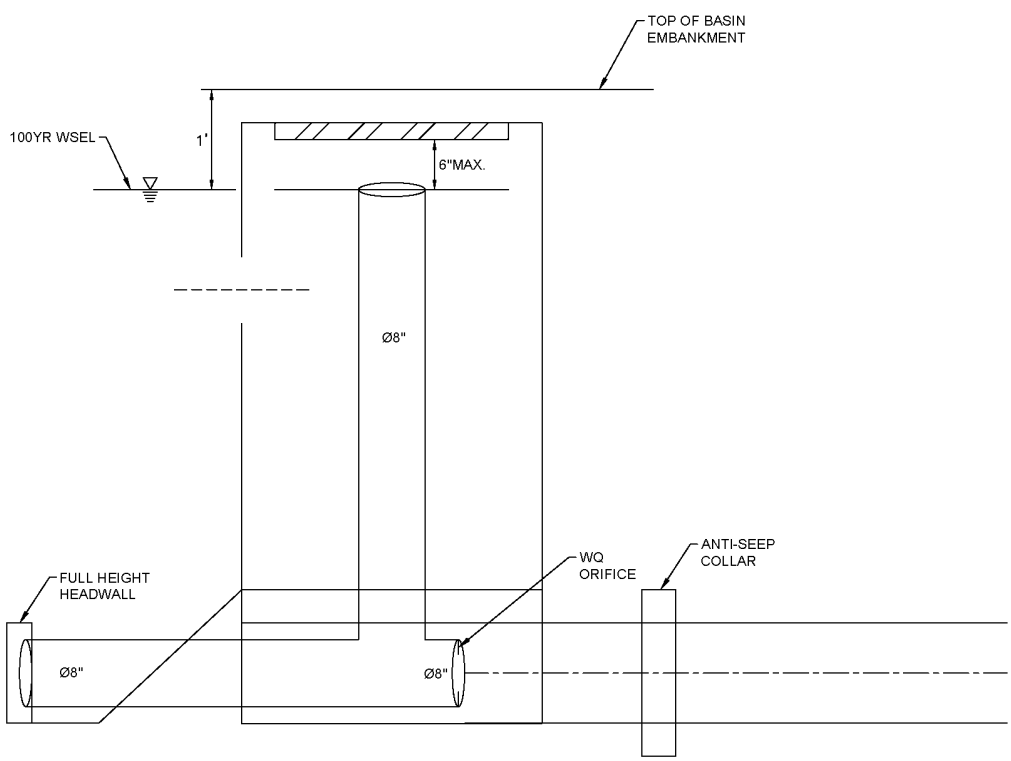
C = orifice coefficient

= 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

Figure 3-1 Outlet Structure



8) Stormwater control facilities that are intended to serve as a water quality SCP only, must be designed to safely bypass all storms in excess of the water quality event, up to and including the 100-year storm event, to an appropriately sized flood control facility.

9) In addition to the criteria required by the incorporation of the Ohio Rainwater and Land Development Manual design criteria herein, additional 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 Stormwater Management Report and Plan:

   a) ***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.

   b) ***Sediment Management*** — Design the facility with pre-treatment for coarse sediments and a sediment storage volume for finer sediments.

   c) ***Health & Safety*** — Design facilities containing a permanent pool with a submerged bench with a maximum slope of 20 (H) to 1 (V) to increase public safety.

   d) ***Aesthetics*** — Provide features that "hide" accumulated silt & debris and integrate the facility with overall site design.

   e) ***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 and are required for all 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.

   f) ***Accessibility*** — Design the facility to eliminate physical barriers (e.g., curbs and steep slopes) to entry for maintenance or emergency access; use strong, lightweight, non-corroding materials at access points (e.g., manhole covers and doors) to underground facilities; and provide legal right of entry for publicly maintained basins.

   g) ***Durability*** — Design the facility to include strong, light-weight materials for "removable" features, reinforced concrete structures for "permanent" features, and hardy, disease-resistant native vegetation.

   h) ***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.

   i) ***Cold Weather Issues*** — Stormwater quality control facilities shall be designed to operate effectively under cold weather conditions. Design considerations include outlet configurations less susceptible to clogging due to ice formation, 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.

   j) ***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 principles apply:

i. 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.

ii. 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.

iii. 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. Screened vents or 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.

iv. 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.

10) Access to stormwater control practices shall be provided as required per Section 4.3.

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) Single-family residential development sites that are less than one (1) acre in size and not part of a larger common plan of development.
2) Construction, reconstruction, improvement, routine maintenance, and/or modification of all public transportation and transit facilities that do not result in increased impervious area.
3) Construction or reconstruction on an existing impervious surface which does not add any new impervious surface.

See Section 3.3 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 NOAA Atlas 14 Rainfall Intensity-Duration (IDF) curves. 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 2-2**), 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. 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**.

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 conditions. (For development sites discharging into a field tile system, refer to Section 2.1.4 for more information regarding additional restrictions to the release rate.) Storms of less frequent occurrence than the critical storm, up to the 100-year storm, shall have peak runoff rates no greater than the peak runoff rates from the equivalent size storms under pre-development conditions. 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 under pre-development conditions. Franklin County 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 County, the County 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 Franklin County Drainage Engineer 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.

3.2.3 Acceptable Methods and Criteria

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

1) Dry Detention Basins (those that drain completely dry after a precipitation event),
2) Wet Detention Basins (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 County may give consideration to the use of other stormwater quantity control technologies provided they meet the requirements of this section.

Table 3-2 Characterization of Post-Construction Stormwater Controls

SCP Category	SCP Type	Quantity Control	Quality Control	Design Requirements/Guidelines	Green Infrastructure
Surface Controls	Dry Detention Pond	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	
	Wet Detention Pond	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	
	Constructed Wetland	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	
	Shallow Constructed Wetland	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	●
	Infiltration basin		●	➢ OEPA CGP/Supplements	
Underground Controls	Underground Detention System	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	
	Pervious Pavement	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	●
Media Controls	Bioretention	●	●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM ➢ Rainwater and Land Development Manual	●
	Sand/Media Filter		●	➢ OEPA CGP/Supplements ➢ Franklin County SWDM	
	Swales/Filter Strips		●	➢ OEPA CGP/Supplements	
Rooftop Controls	Green Roof	○	○	➢ OEPA CGP/Supplements	●
	Rainwater Harvesting	○	○	➢ OEPA CGP/Supplements	●
Other Controls	Runoff Reduction	○	○	➢ OEPA CGP/Supplements	
	Soil Management	○	○	➢ OEPA CGP/Supplements	
	Pretreatment	○	○	➢ OEPA CGP/Supplements	

● – Practice is considered a stand-alone SCP per OEPA Construction General Permit.
○ – Practice is not considered a stand-alone post-construction SCP per OEPA Construction General Permit.

3.3 Stormwater Quality Controls

Stormwater quality control facilities shall be designed to control runoff from small storm events before being discharged offsite. The design criteria provided in this section are in addition to the criteria detailed in the Ohio Construction General Permit and the *Ohio Rainwater and Land Development Manual*. 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.

All runoff from development sites shall be directed to one or more stormwater quality control designed according to:

1) Appropriate currently effective OEPA Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit),
2) Supplemental documents prepared by OEPA pertaining to the currently effective Construction General Permit Post-Construction criteria,
3) Appropriate currently effective Ohio Rainwater and Land Development Manual, and
4) Criteria provided in Section 3.

For projects where stormwater control practices providing water quality treatment have already been constructed, redevelopment of the site shall provide treatment of a water quality volume that is the greater of either treatment required as part of a previous design or as specified in the current Construction General Permit. In instances where conflicts exist between OEPA criteria and the criteria presented in this section, the more stringent standards shall apply.

3.4 List of Controls

3.4.1 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. 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.

3.4.1.1 General Requirements

All proposed dry and wet detention basins shall be designed according to the general criteria in this section, as well as any additional specific requirements from Sections 3.4.1.2 and 3.4.1.3.

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 unincorporated area of Franklin County:

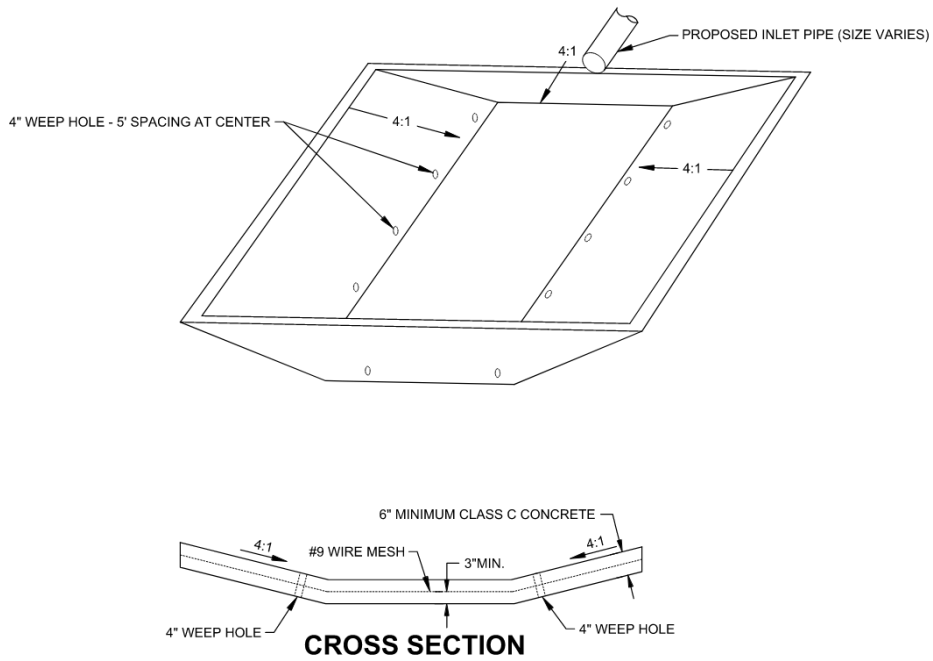
1) Detention basins shall not be located on uncompacted fill, on slopes 2(H) to 1(V) or

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. Ohio law prohibits the redirecting of water to public right-of-way.

3) To make sediment removal easier, all detention basins that are publicly maintained require a concrete lined forebay. A forebay is a settling pond located at the inlet of a detention basin. It is separated from the rest of the basin by a level dike often planted with emergent wetland vegetation. Forebays are primarily used to improve the settling efficiency of a basin but they also reduce maintenance by promoting settling in a confined, easily accessible location.

Figure 3-2 Forebay Detail



Forebays promote settling by segmenting or diving the pond into cells which reduce mixing and promote plug flow; by converting the high velocity concentrated inflow from a pipe to wide uniform slow flow to the normal pool area; and by dissipating flows through emergent vegetation. Detention basin inlet pipes shall discharge directly to the forebay. The inlet elevation shall be above the concrete to prevent water backup. Channels shall not be used to route stormwater from the inlet pipe to the forebay edge.

The concrete forebay shall be constructed of a minimum of 6″ thickness, class C concrete with #9 wire mesh completely contained in the concrete, no closer than 3″ from the bottom of the concrete slab. Concrete used for forebay construction must be completely discharged from each delivery truck within 90 minutes after combining the water and the cementitious material. See **Figure 3-2** for spacing of weep holes and design of concrete lined forebay.

The forebay shall have 4″ weep holes spaced every 5′ along the leading edge of the

forebay to allow infiltration of standing water and prevent floatation of the concrete forebay. Privately maintained basins require a concrete lined forebay or gravel berm with energy dissipation to slow water velocity and separate the forebay from the rest of the basin.

A forebay for a single inlet should occupy from 8-25% of the normal pool area. Forebays should be large enough to avoid scour and resuspension of trapped sediment and sized for ease of construction and cleanout. Forebays should have a water depth of at least 3 feet. Calculations and associated documentation verifying forebay sizing and design, as well as sediment storage calculations as required by the OEPA Construction General Permit shall be included in the project stormwater report.

Provide an outlet to the main basin, consisting of a level spreader or submerged level dike. When possible, it should also be planted with hardy emergent wetland vegetation.
To accommodate relatively frequent sediment cleanout, easy equipment access should be provided to the forebay. This should include gradual slopes without obstructions and an access easement. Additionally, a drain should be installed under the dike so that the forebay can be drained during maintenance operations.

4) For both wet and dry detention basins, a micropool shall be provided at the outlet end of the basin. The micropool allows a reverse slope pipe or other non-clogging outlet to be used. The micropool should be 4-6 feet deep and equal to 10% of the volume of the water quality volume.
    a. Direct maintenance access shall be provided to the micropool at a slope no steeper than 10(H) to 1(V). Micropool side-slopes shall not exceed 4(H) to 1(V).
    b. If a micropool is not used, an animal guard must be installed on the outlet structure.
5) Extended detention outlets often require small orifices or controls and must be designed to be non-clogging. A reverse flow pipe is one way to configure an outlet to better trap floating pollutants and to be less clogging. Reverse flow pipes draw water from below the water surface to trap floating debris that would otherwise clog the outlet.
A reverse flow pipe is designed to draw water below the basin surface and above the midpoint of the normal permanent pool elevation. They may be constructed with a pipe on a negative slope or with a turned pipe elbow. Reverse flow outlets may be constructed with a straight pipe set on a negative slope. A pipe with a 90-degree elbow also may be used either inside the riser and facing upward or outside the riser facing down.
6) The basin shall be designed with an emergency spillway for storms that exceed the basin capacity. The emergency spillway shall be designed to direct the flow exceeding basin capacity to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet Applicable Ohio Dam Safety requirements. Directing flow from emergency spillway on neighboring property is not allowed. Emergency spillway design should assume that flow from an entire 100-year, 24-hour event is conveyed through the spillway while the basin is at its 100-year flood capacity. Ohio law prohibits redirecting water to the public right-of-way.
7) 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.
8) **Table 3-3** provides the peak water surface requirements for basins with different design intent.

Table 3-3 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.

1 Requirements for a 1-foot freeboard will be waived if the detention basin is to outlet directly to a 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.

9) Side slopes within, above, and adjacent to dry detention basins and those side slopes above the permanent pools of wet detention basins shall be 4 (H) to 1 (V) or flatter to prevent bank erosion and minimize safety risks. The maximum cross slope for the vehicle access way shall be 10(H) to 1(V). Side slopes shall also include a minimum of 3″ of topsoil per CMS Item 653.

10) When converting temporary sediment traps or basins to a permanent dry extended detention basin or wet retention basin, side slopes shall have No. 2 or No. 4 limestone with filter fabric installed 4′ above and below the normal pool elevation. This conversion process must be specified and shown in the construction plans.

11) Detention basins shall be designed to limit the migration of groundwater from the basin towards sanitary sewers and building basements. In these cases, the County 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.

12) 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 County with documentation of ODNR's determination of the 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. See Ohio Revised Code Section 1521 for additional information.

13) 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. RCP 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.
14) 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. Sheer stress calculations and mitigation practices such as Ditch Erosion Protection Mats shall be provided for all open channel water courses. Outlet 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. Outlet 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.
15) 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.
16) 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 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 shall 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, 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 210-60*, dated March 2019, Chapter 45 of NEH Part 28, dated January 2007, and NRCS *Conservation Practice Standard Code 378*, dated July 2022.

3) Open channels receiving discharges from the facility shall be protected with RCP designed according to criteria in Section 2.3.5.
4) 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.
5) With exception of the emergency spillway, outlet devices that control 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) 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.

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 611 of the ODOT CMS. 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.

3.4.1.2 Additional Requirements for Dry Extended Detention Basins

Dry extended 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 3-3** provides a schematic drawing of a dry extended detention basin. Configure the basin so that water quality treatment is optimized through basin shape and flow length. Improved settling of pollutants occurs as the flow length is maximized. Optimally, designs will avoid the problems of dead storage or incoming water short-circuiting through the basin and the resuspension of deposited sediments. Forebays and micropools pool water at the inlets and outlet of a basin improve the effectiveness and ease of maintenance of water quality basins. The shape and grade of side slopes also strongly influence basin effectiveness and potential safety.

The following criteria shall be used in addition to those found in Section 3.4.1.1 to design dry

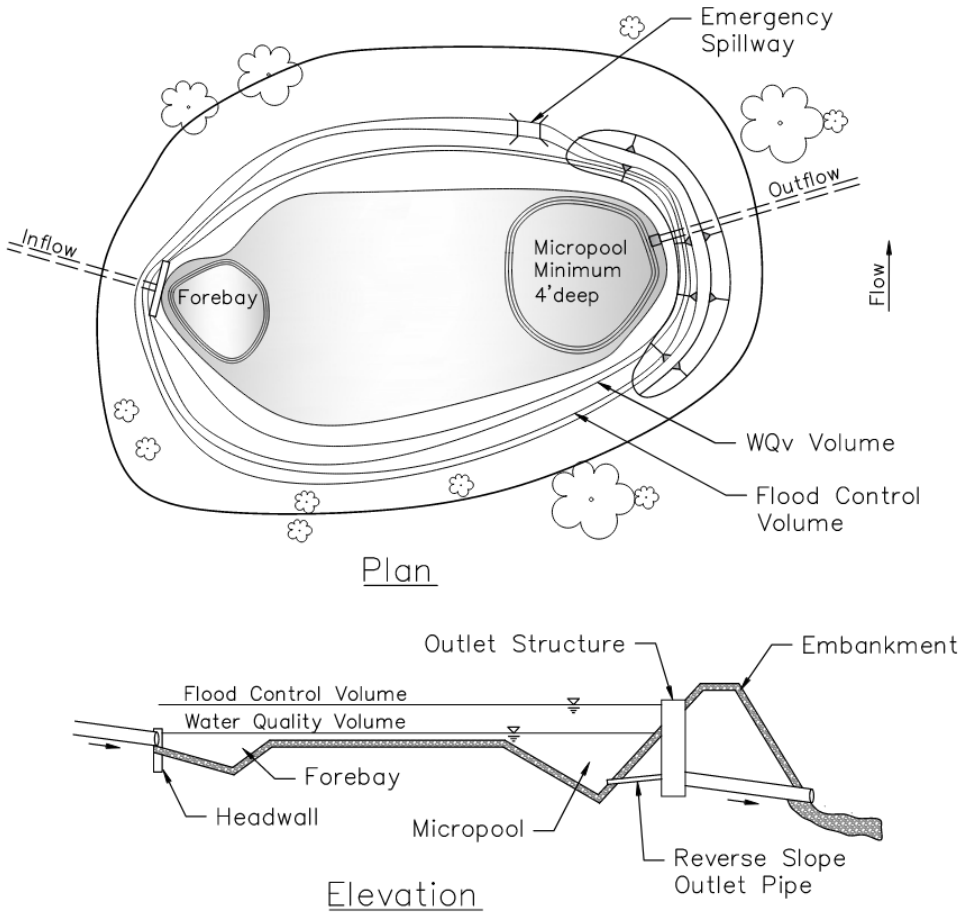
extended detention basins intended to serve as water quality SCPs.

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) In publicly maintained dry detention basins, a concrete low flow channel shall be constructed between the forebay and micropool. The channel shall be trapezoidal in form, with a minimum bottom width of 3′. Concrete low flow channels are recommended for privately maintained detention facilities.
   Low flow channels shall be designed per the following requirements:
   a. Bottom width – minimum width shall be 3 feet.
   b. Side slopes – shall not be steeper than 4 (H) to 1 (V) or shallower than 12 (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 CMS Section 509) to accommodate temperature stresses and composed of air-entrained Class C concrete (per CMS Section 499); weep holes shall be designed in the concrete side walls.

   The maintenance plan for dry basins that do not include a concrete low flow channel shall describe how the basin will be maintained and drain efficiently.
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 CMS 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
5) Dry extended detention basins do not have a permanent pool except for the establishment of forebays at inlets and a micropool at the outlet. More information is provided on forebays in the design criteria applicable to all detention basins as outlined in Section 3.4.1.1.
6) Outlet designs shall provide the necessary drawdown time, route flood flows, resist clogging, and facilitate maintenance. Dry extended detention basins that are intended to serve as a stormwater quality control only, must be designed to safely bypass all storms larger than the WQv, up to and including the 100-year storm event (Section 2.2) to an appropriately sized stormwater quantity control facility.

Figure 3-3 Schematic of a Dry Extended Detention Basin



3.4.1.3 Additional Requirements for Wet Extended Detention Basins

Wet extended 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 3-5** provides a schematic drawing of a wet extended detention basin. The following criteria shall be used in addition to those in Section 3.4.1.1 to design extended wet detention basins.

1) Extended wet detention basins shall only be allowed under the following conditions:
   - Where existing soils are categorized as hydrologic soil group C (HSG-C) or hydrologic soil group D (HSG-D),
   - Where gravelly sands or fractured bedrock are not present, or
   - 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.
2) The depths of open water areas within the basin shall be between 4-feet and 12-feet on average to prevent thermal stratification.
3) If desired, wetland plants may be incorporated into the basin design. A landscape plan for

the basin shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. A list of approved Native Plant Species for the Central Ohio area is provided in **Appendix B.**

4) The depth of wet detention basins shall be no more than 12 feet below the basin's normal water elevation. The County may approve deeper basins that are to be privately owned and operated where practices (e.g., aeration) are proposed to prevent thermal stratification.

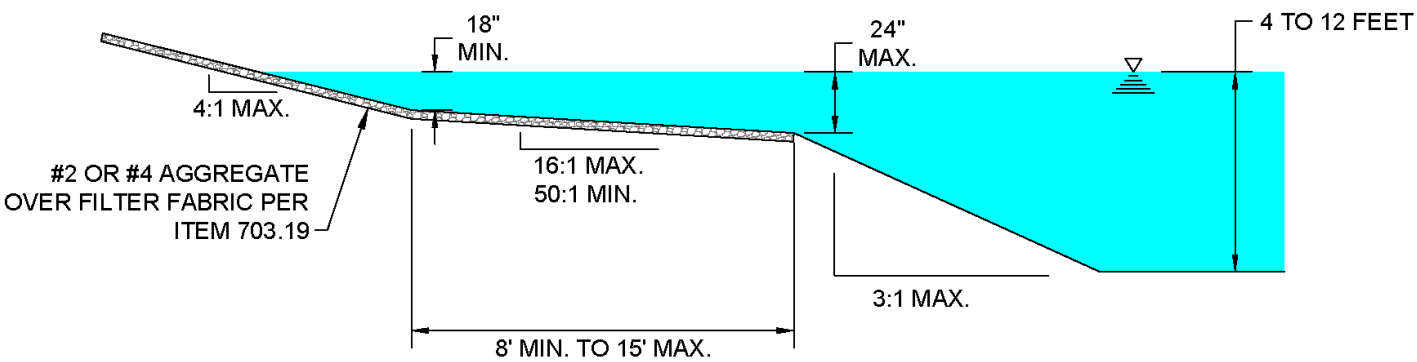
5) The perimeter of all permanent pool areas deeper than 4 feet shall be surrounded by a submerged bench that extends at least 8 feet and no more than 15 feet outward from the base of the adjacent slope, as illustrated in **Figure 3-4**. The submerged bench shall fall into one of two categories:

   a. Planted Bench – the submerged bench shall be planted with wetland vegetation. The designer shall develop a planting plan for the proposed vegetation on the submerged bench.

   b. Unplanted Bench – an unplanted submerged bench shall include a protective layer of filter fabric or other erosion control matting and stone to protect the bench from erosion.

   The bench shall be no more than 24 inches below the permanent pool to enhance public safety and to limit growth of undesired vegetation. The submerged bench shall be sloped inward, and for unplanted benches shall be no steeper than 15(H) to 1(V) and no flatter than 30(H) to 1(V).

Figure 3-4 Schematic of a Submerged Bench



6) If plantings on the submerged bench are desired, the portion of the submerged bench within 6 feet of the base of the adjacent slope shall have an average depth of 6 inches below the permanent pool and the designer shall prepare a landscape plan. No portion of a bench that has been planted shall have a slope steeper than 10(H) to 1(V) or flatter than 50(H) to 1(V). Plantings on the submerged bench shall be selected from the shallow water-emergent species in the list of Native Plant Species for the Central Ohio area, which 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.

7) Side slopes for wet basins shall be 4(H) to 1(V) down to the submerged bench, and 3(H) to 1(V) from the submerged bench to the bottom of the basin.

8) The purpose of the submerged bench is to promote public safety. If an applicant seeks a variance from the requirement of having a bench, the variance application shall specifically address this issue.

9) 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.

10) Wet detention basins and stormwater wetlands should 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 150/5200-33C. As an alternative, dry detention facilities and green roofs are stormwater control practices that do not maintain a permanent pool of water and are not as likely to attract large numbers of waterfowl.

Figure 3-5 Schematic of a Wet Extended Detention Basin

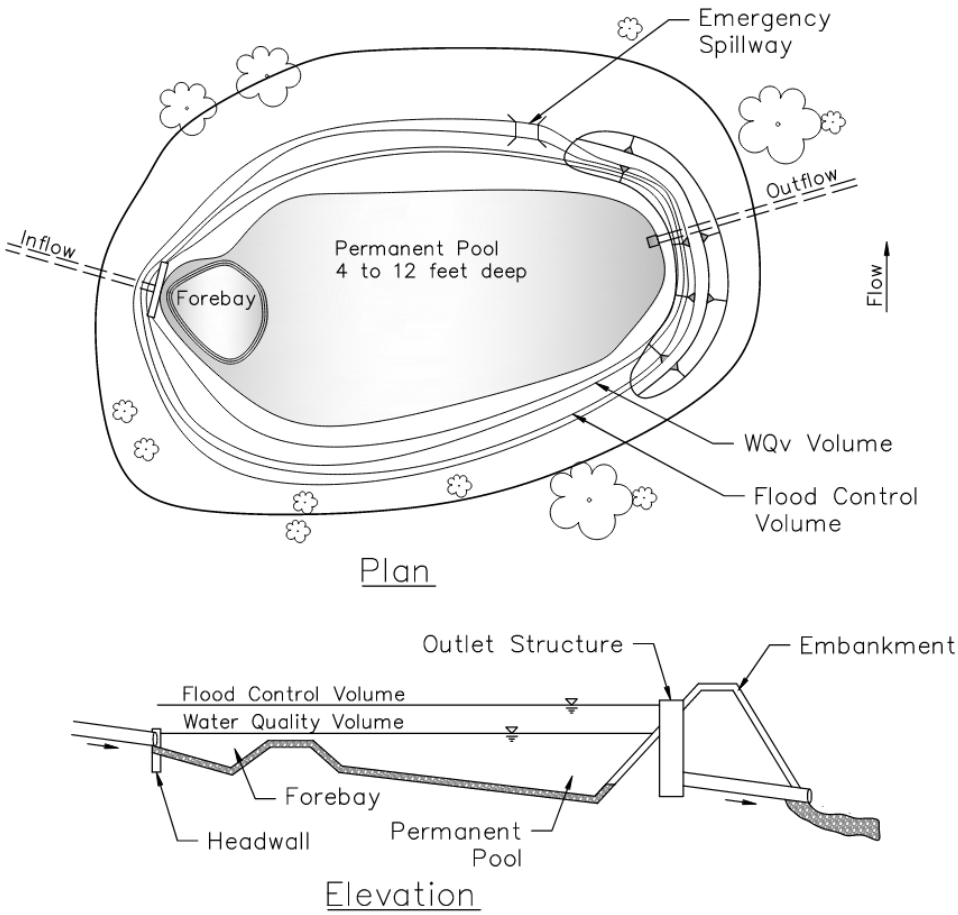
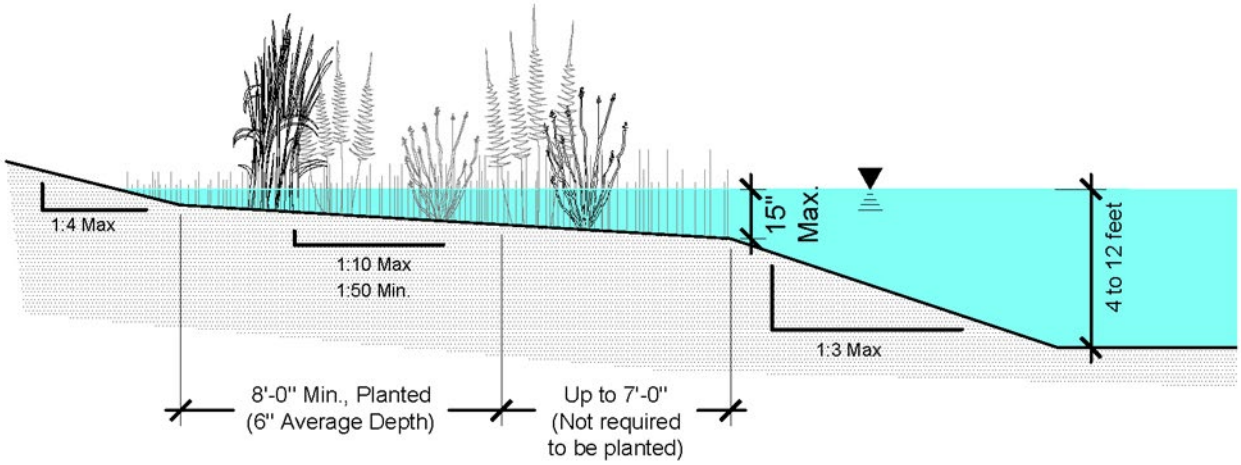


Figure 3-6 Schematic of a Submerged Bench with Plantings



3.4.2 Parking Lot Storage

Parking lot surface 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) A site with a parking lot storage facility shall employ a separate water quality treatment SCP that meets the water quality treatment criteria presented in Section 3.3. This SCP may be located downstream of the parking lot.

3.4.3 Underground Detention System

An underground storage system is any stormwater quantity or quality control method that employs underground chamber or chambers, either prefabricated or constructed in place, and has a designed release feature to control stormwater discharge. Underground storage may also include any void space of aggregate that is utilized in water quantity or water quality calculations. This method is most applicable where land is valuable or the site is constrained, such as in industrial, commercial, and redevelopment areas.

1) Design Criteria
    a) Underground detention systems must provide a temporary storage volume equal to the Water Quality Volume prior to the invert of a peak discharge control structure or emergency spillway. The storage of the Water Quality Volume is included within the void space of the aggregate backfill and enclosed chambers, or the aggregate backfill and perforated chambers.
    b) Prevent stormwater detained in the facility from bypassing the water quality outlet control through nearby sub-surface drains or unconsolidated backfill. Maintain a horizontal separation distance of 10 feet of in-situ soil from all utilities and

foundations or install an impermeable liner. Use disconnection measures such as anti-seep collars to prevent bypassing through the unconsolidated backfill of in-coming and out-going storm pipe. Avoid locating an underground storage facility above other utilities.

c) Underground storage facilities must comply with the minimum drawdown time outlined in the Ohio EPA Construction General Permit.

d) All underground storage facilities must utilize a pre-treatment practice to improve efficacy of the system and facilitate maintenance.

2) Conditions on Use

a) Underground storage systems may not be placed in the public right-of-way unless the facility will be owned and operated by the County and the function of the facility is associated with a green infrastructure practice.

b) The use of over-sized storm sewer pipes within the public right-of-way is not permitted, without prior County approval.

c) If the storage associated with bioretention basins and tree box systems is located within a 1:1 influence of roadway pavement, then structural measures to support the pavement load must be provided.

d) Underground detention systems shall not be placed beneath a building or similar structure unless an appropriate operation and maintenance plan is developed for the system and demonstrates that maintenance will not be hindered.

3) Materials

a) Storage vessels can be made from a variety of materials, but due to concerns with corrosion and longevity corrugated steel or aluminum coated steel systems are not permitted unless the corrugated material is made of solid aluminum.

b) Manufacturer's recommendation shall be used for open graded backfill and stone per CMS 703 shall be specified.

c) All aggregate used for stormwater storage shall be crushed stone or river rock that is course, uniform, and open-graded to create a significant void content. Aggregate shall be clean and free from fines, having less than 0.5 percent wash loss, by mass, when tested per the AASHTO T-11 wash loss test.

d) The use of recycled concrete is not permitted.

e) Varying types of storage vessels may be used to develop the required storage volume. Often, these are proprietary systems of prefabricated modules with adaptable configurations and a unique stage-storage relationship. The use of proprietary systems requires careful coordination between the designer and the manufacturer to assure the proper storage volume and drawdown time are provided. Site-specific volumes, dimensions, elevations, layout, inlet details, and outlet details must be determined and given in both the construction plans and the Stormwater Pollution Prevention Plan, whether provided by the project engineer or the manufacturer. Underground storage systems or vessel sizes cannot be interchanged after regulatory approvals without redemonstrating the substitution still achieves Water Quality Volume storage and drawdown criteria.

4) Construction Details

a) Closed conduit systems

i. Shall have an internal slope of not less than 0.20 percent generally in the direction from inlet to outlet to avoid negative slope installations.

ii. Perforated closed conduit systems are permitted but the storage in the surrounding stone backfill may not be included when calculating total system volume.

b) Open Bottom Systems

i. May use 3-sided or arched conduits.

ii. May be installed flat to promote infiltration potential.

iii. The maximum porosity value to use for stone storage is 30 percent to account for potential sediment build-up in the stone storage.

iv. When underdrains are used as an outlet device, the area of the perforations shall be twice the area of the outlet device to account for clogging and blockages caused by the stone backfill. The perforation area requirement shall be listed on the plans.

v. For every 0.5 acre of infiltration bed, one observation well shall be installed in the stone aggregate to observe water levels during inspections. Observation wells must be at least six (6) inches in diameter and large enough to insert basic inspection equipment.

c) All Systems

i. Underground systems shall have at least two man access points per system with a minimum inside diameter of 48 inches. Man access points shall be located at the main inlet to the system and at the outlet(s) for access, inspection, and maintenance. Additional points of entry are required based on the following:

1. An additional man access point within the interior of the system is required for every 10,000 square feet of system area to check for sediment buildup and have an additional access point for cleaning.

2. Systems shall have a chamber for pre-treatment at each point of inflow. Minor inlets may be excluded but may not in sum exceed 5 percent of the facility's total contributing drainage area and must not include area that will contribute an excessive sediment load. Each chamber shall have a man access point at each end if the length of the chamber is greater than 150 feet. If the row length is less than 150 feet then only one man access point must be provided. A man access point shall be located over a sump if one is provided in the chamber. Additional information for pre-treatment practices for Underground Detention Systems is included below.

3. The additional man access requirements may be waived for athletic and recreational field safety considerations.

4. Each water quality chamber shall have a man access point for inspection and cleaning.

ii. Weir walls used for outlet structures shall have sufficient access to both sides of the weir wall for inspection, repair, and maintenance activities.

iii. Weir walls may be required in situations where failure or blockage of a small diameter outlet is anticipated to create a hazardous situation (e.g., flooding of public streets) or damage to property.

iv. A minimum 24-in-deep sump shall be provided in front of any outlet orifice of the system or from one chamber to another. Sufficient access to the sump shall be provided for maintenance.

v. When using man access structures as the maintenance and inspection access point, lid size should be per AA-S112 or equivalent weight unless otherwise approved by the County as larger castings are more difficult to remove during inspections.

d) Pre-Treatment Requirements for Underground Detention Systems

i. An underground storage facility must utilize a pre-treatment practice or a treatment train of practices. Select a pretreatment practice capable of addressing the expected stormwater pollutants and loading. Use bioretention cells or another practice capable of providing diverse treatment mechanisms where the contributing drainage area includes a pollutant hot spot or to address a specific total maximum daily load established for the receiving waters.

ii. Pre-treatment practices for underground storage facilities include:

1. Bioretention
2. Manufactured Treatment Device
3. Geotextile Filter Forebay
4. Grass Swale or Filter Strip

iii. Per the Ohio EPA, the pre-treatment practices must:

- be proven capable of removing at least 50 percent [80 percent for an infiltration facility] of the total suspended solids (TSS) as defined in Ohio EPA's NPDES Construction General Permit.
- prevent large debris that could clog the water quality outlet from entering the underground storage.
- provide sustainable storage for accumulated sediment and debris with direct access for its routine removal.

3.4.4 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. Designers are encouraged to consider using approved plants from the list of Native Plants for the Central Ohio area that is found in **Appendix B,** but it is recognized that the use of plants other than those provided on this list may be necessary. Green roofs shall be designed according to the criteria in the Ohio Rainwater and Land Development Manual.

3.4.5 Pervious Pavement (GI)

Pervious pavement systems shall be designed according to applicable criteria in the *Ohio Rainwater and Land Development Manual*. The use of pervious pavement systems for publicly maintained roadways shall be limited to those approved by the County.

3.4.6 Rainwater Harvesting (GI)

Rainwater harvesting systems function by capturing stormwater runoff and directing it into a designated storage reservoir, typically a cistern. This stored water is then utilized for various beneficial purposes. Potential applications include supplying non-potable water for tasks such as toilet flushing, irrigation of landscapes, gardens, or greenhouses, vehicle washing, street cleaning, cooling systems like HVAC, industrial processes, maintaining decorative water features, and other consumptive needs. Whether implemented on a small scale with residential rain barrels or through more complex graywater plumbing systems, rainwater harvesting contributes to water conservation, environmental preservation, and financial benefits. Rainwater harvesting systems shall be designed according to the criteria in the *Ohio Rainwater and Land Development Manual*.

3.4.7 Infiltration Basin

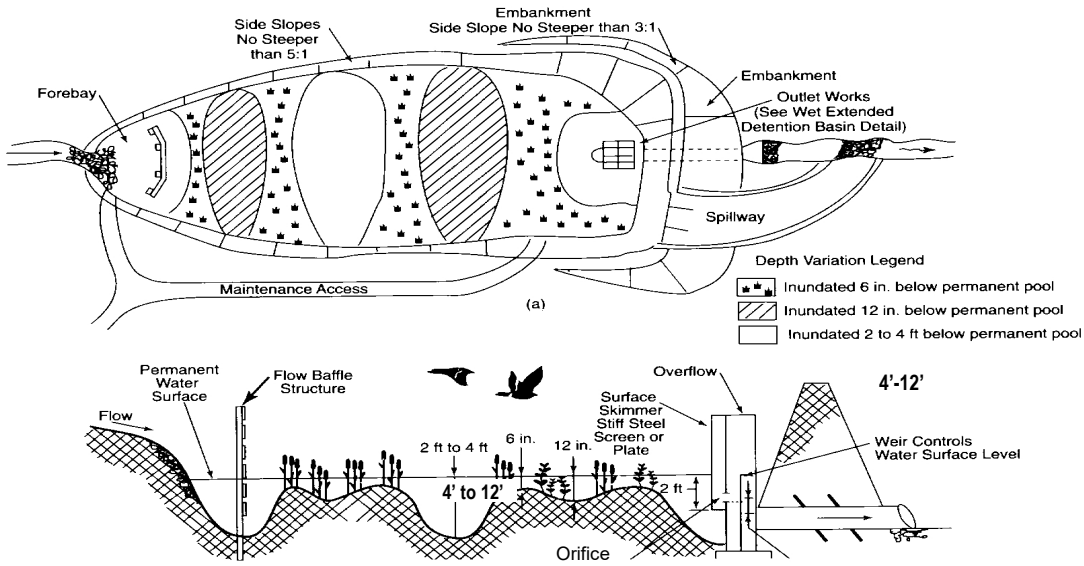
Infiltration basins are vegetated open reservoirs strategically positioned on native soils with high infiltration rates, typically soils that are classified as Type A or B Hydrologic Soil Groups. Their primary function is to capture and facilitate the infiltration of runoff into the underlying soil strata. Apart from their role in managing water quality runoff events, these basins are also engineered to fulfill quantity control requirements and regulate peak discharge rates. To ensure optimal performance, infiltration basins necessitate sediment pretreatment measures aimed at eliminating the majority of suspended solids before ingress into the basin. This typically involves directing runoff through designated sediment removal structures such as grass filter strips, swales, or forebays prior to its discharge into the basin. Infiltration basins shall be designed according to the criteria in the *Ohio Rainwater and Land Development Manual*.

3.4.8 Constructed Wetlands

Constructed wetlands are systems that mimic the functions of natural wetlands by using physical and biological processes to treat stormwater. Constructed wetlands have both permanent pool zones and an extended detention zone which are sized to capture and release the calculated WQv. The shallow water zones in the permanent pool support emergent and riparian vegetation and the deep water zones in the permanent pool provide sediment and stormwater storage. Together, the diverse vegetative community and the storage provided combine to form an ideal environment for the removal of pollutants in stormwater. 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 WQv. Constructed wetlands are depressed, heavily planted areas that are designed to receive flow during dry periods in order to support aquatic vegetation. In terms of size, the amount of surface area required for a constructed wetland is typically larger than that of a wet basin due to the limited allowable depths required for wetland design. Constructed wetlands that are

supplied by surface water runoff from drainage areas less than 20 acres must rely on groundwater sources to sustain a permanent pool.

Figure 3-7 Schematic of Typical Stormwater Wetland



Layout and Geometry Requirements

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

1) 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. This requirement does not apply to pocket wetlands where the permanent pool is sustained by a groundwater source. Do not rely solely on USGS Web Soil Survey data to characterize the engineering properties of soils for design purposes. Geotechnical samples shall be collected to classify soils at the elevations of the wetlands.
2) The minimum length-to-width ratio for a constructed wetland shall be 3:1. 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.
3) Constructed 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 3.4.1.

4) Deep water zones shall be placed within the forebay and around the primary outlet to minimize disruption to wetland vegetation during sediment removal operations. 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. The bottom of the permanent pool between the deep and shallow water zones shall be sloped no steeper than 3(H) to 1(V).
5) The maximum depth of the extended detention zone above the permanent pool shall not exceed 2 feet to reduce stress on herbaceous wetland plants.
6) Permanent pool areas of wetlands that are deeper than 4 feet must be provided with a submerged bench per Section 3.4.1.3.
7) Wetland plants shall be placed in shallow pool areas (less than 4 feet). In instances where the basin is designed to support aquatic vegetation, a landscape 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 approved Native Plant Species for the Central Ohio area 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 each inlet of all constructed wetlands.

Landscape Requirements

1) A landscape 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) The shallow water zone shall be planted at a minimum density of 50 herbaceous plants per 200 square feet.
3) If a minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, reinforcement planting will be required.
4) Matted cattails detritus (cattails) shall not be planted in the wetland due to their invasive properties and their abilities to provide excellent mosquito habitats.
5) It is important to meet the required 0 to 12 inch depth for the shallow water zone correctly because plants installed there will not survive if the soils are dry of if the plants are covered by more than 12 inches of water.
6) At least six varied species of plants should be installed in the constructed wetland. A greater diversity of plant species will increase the resilience of the wetland to changing environmental conditions.

7) The timing of installation for herbaceous plant survivability is from the average last spring frost for the wetland location until several weeks before the average first fall frost for the wetland location
8) All landscape and reinforcement plans shall be signed by a registered landscape architect, with direction provided by an experienced wetland scientist.

Outlet Facility and Outfall Protection Requirements

The outlet design requirements provided in Section 3.4.1.3 for wet extended detention basins shall apply to constructed wetlands. In addition, the outlet structure shall be designed to conduct continuous dry weather flow through the wetland system while maintaining normal pool elevations.

3.4.9 Shallow Constructed Wetlands (GI)

This section of the Manual describes a stormwater wetland design intended to more closely resemble a natural wetland system, but which captures and treats stormwater runoff from surrounding new or redevelopment areas. Due to the treatment of direct runoff from urbanized areas, a wetland designed in accordance with these criteria is not suitable as mitigation for impacts to other existing wetlands, nor are these features intended to become jurisdictional waters of the United States.

Constructed wetlands are systems that mimic the functions of natural wetlands by using physical and biological processes to treat stormwater. Shallow constructed wetlands, illustrated in **Figure 3-8**, have both permanent pool zones and an extended detention zone, which are sized to capture and release the calculated WQv. The shallow water zones in the permanent pool support emergent and riparian vegetation and the deep water zones in the permanent pool provide sediment storage. Together, the diverse vegetative community and the storage provided combine to form an ideal environment for the removal of pollutants in stormwater.

In terms of size, the amount of surface area required for a shallow constructed wetland is typically larger than that of a wet basin, or a typical constructed wetland, due to the limited allowable ponding depths required for wetland design. Shallow constructed wetlands that are supplied by surface water runoff from drainage areas less than 20 acres are defined as shallow pocket wetlands. Pocket wetlands must rely on groundwater as an alternative source to sustain wetland hydrology. The following criteria shall apply to the design of shallow constructed wetlands and pocket wetlands.

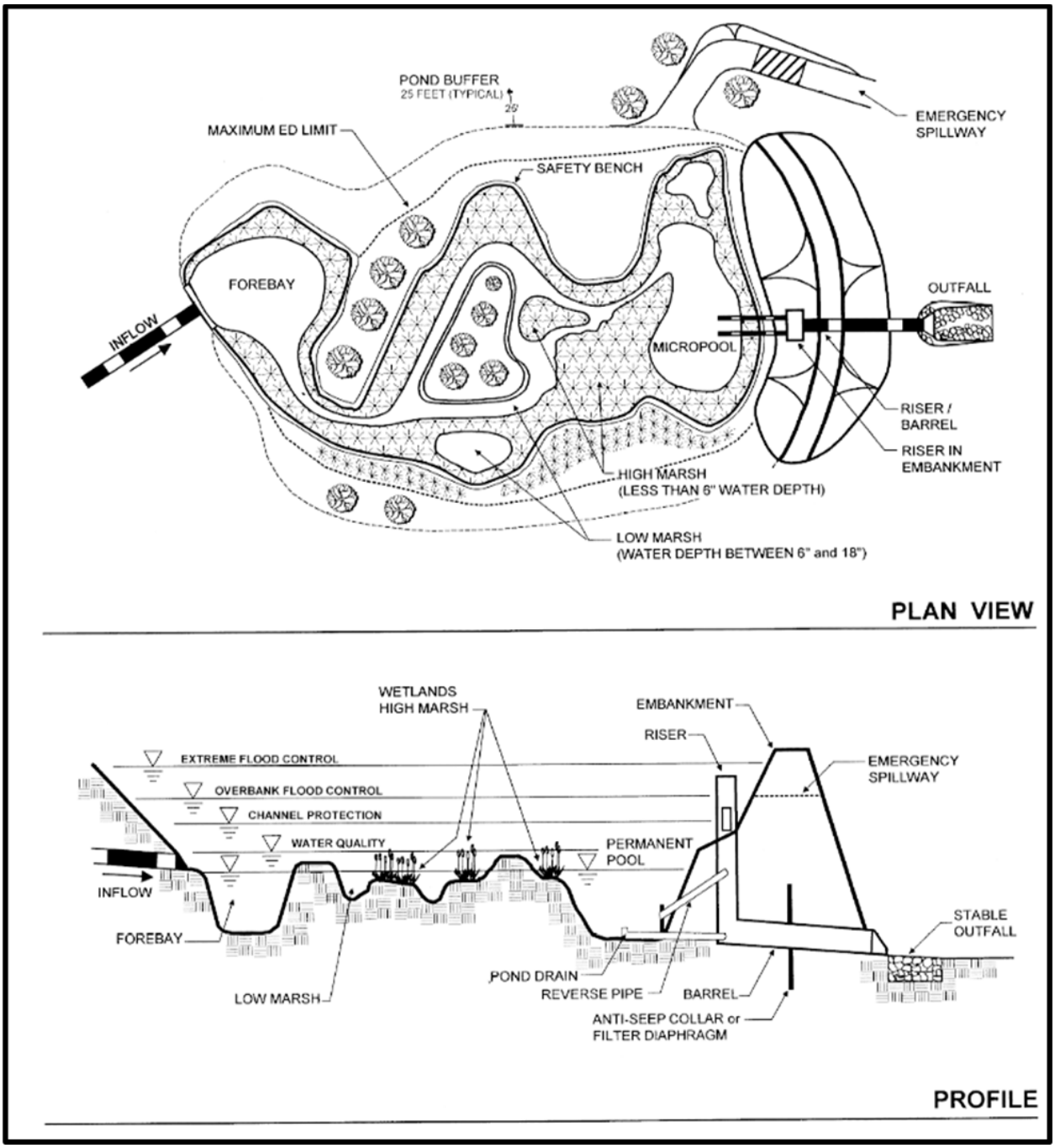
General Criteria

All shallow constructed wetlands shall be designed according to the general criteria listed in Section 3.4.1.1, as well as specific criteria in this section.

Layout and Geometry Requirements

The layout and geometric requirements of shallow constructed wetlands shall meet the following minimum requirements.

Figure 3-8 Schematic of a Typical Shallow Constructed Wetland



1) Same as requirement number 1 shown in Section 3.4.8.
2) Same as requirement number 2 shown in Section 3.4.8, except the minimum length-to-width ratio for a shallow constructed wetland shall be 2:1, although a length-to-width ratio of 3:1 or greater is preferred.
3) Same as requirement number 3 shown in Section 3.4.8.
4) Same as requirement number 4 shown in Section 3.4.8, with the exception of shallow pocket wetlands, 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 WQv, shall be placed in deep water zones (areas with depths greater than 18 inches). 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.
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) shall vary to provide microtopography and promote the establishment of dense and diverse vegetative cover. Permanent pool depths of no more than 6 inches shall comprise at least 35 percent of the wetland surface area (the "high marsh zone"). Provision of depths of 3 inches or less in the high marsh zone is preferred for vegetation establishment. Depths of 6 to 18 inches (the "low marsh zone") shall comprise an additional 35 percent minimum of the wetland surface area.

For shallow pocket wetlands requiring a permanent pool volume equivalent to the WQv, approximately 25 percent of the permanent pool volume, plus a sediment storage volume equal to at least 20 percent of the WQv, shall be placed in deep water zones (areas with depths greater than 18 inches). As with larger wetlands, the deep water zones shall be placed with the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations. The remaining 75 percent of the permanent pool volume shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e., areas less than 18 inches deep) shall vary to provide microtopography and promote the establishment of dense and diverse vegetative cover. Permanent pool depths of no more than 3 to 6 inches shall comprise at least 35 percent of the wetland surface area (the "high marsh zone"). Provision of depths of 3 inches or less in the high marsh zone is preferred for vegetation establishment. Depths of 6 to 18 inches (the "low marsh zone") shall comprise an additional 35 percent minimum of the wetland surface area.

5) Same as requirement number 5 shown in Section 3.4.8.
6) Same as requirement number 6 shown in Section 3.4.8.
7) Same as requirement number 7 shown in Section 3.4.8, except wetland plants shall be placed in all shallow pool areas (less than 18 inches deep). A landscaping plan for the wetland shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation, as described under the Landscape Requirements provided herein. 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 plant species is provided in **Table B-3** in **Appendix B**.
8) Same as requirement number 8 shown in Section 3.4.8.

Pretreatment

Due to the sensitivity of wetland vegetation to sedimentation, a forebay or other pretreatment feature, shall be provided at the inlets of all constructed wetlands that are to be either publicly or privately owned. Wetland forebays shall be no more than four feet in depth and shall meet the minimum requirements listed in Section 3.4.8.

Landscape Requirements

1) A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of the plan shall include:
   a) A scaled construction drawing that accurately delineates the landscaping zones and represents the plant material to be installed in each.
   b) A key/legend that identifies the plant material used in the planting plan. The symbols or hatching used to identify the plants will correlate with the plants and/or groups of plants identified in the plant list/table.
   c) A list/table of the selected native plant species, including scientific name, common name, quantity, container size, container type (e.g., bare root, plug, container, etc.), appropriate planting window and any other relevant information.
   d) Soil media specifications, topsoil stockpile location and/or source of topsoil if imported to the site.
   e) Notes with sequencing, soil and plant installation instructions and initial maintenance requirements (mulching, watering, installation of goose fence, etc.).
   f) Any other necessary information to communicate unique requirements, materials or methods, such as specific plants that must be field located or approved.
   g) A description of the warranty period stipulating requirements for plant survival/replacement.
2) All shallow water zones 12 inches deep or less shall be planted at a minimum density of 50 herbaceous plants per 200 square feet.
3) Plant species and sizes must be selected based on the permanent pool depths. Woody plants should be installed at or above the normal pool elevation. Emergent wetland vegetation should be installed in depths of no more than 6 inches, such that no more than 50 percent of the plant height is submerged. Floating aquatic plants may be installed in zones 6 to 12 inches deep.
4) At least six varied species of plants should be installed in the shallow constructed wetland. A greater diversity of plant species will increase the resilience of the wetland to changing environmental conditions. A list of approved Native Plant Species for wetlands in Central Ohio is provided in **Table B-3** in **Appendix B**.
5) Invasive species listed in **Table B-1** in **Appendix B**, including cattail species, shall not be planted in the wetland due to their invasive properties and support of mosquito habitat.
6) The timing of installation for herbaceous plant survivability is from the average last spring frost to the wetland location until several weeks before the average first fall frost for the wetland location.
7) The required 0 to 12 inches depth for the shallow water zone must be met; plants installed there will not survive if the soils are dry or if the plants are typically covered by more than 12 inches of water.
8) Soils may be severely compacted during the construction process, which may prevent root penetration and lead to premature mortality or loss of vigor of planted species. Accordingly, planting sites should be over-excavated and backfilled with uncompacted topsoil following the requirements of CMS 659.05 prior to planting. A minimum of 12 inches of topsoil should be provided in all planting areas.

9) Predation by Canada geese can decimate newly installed wetland vegetation. All landscape plans shall include provisions for goose exclusion fencing, with instructions for installation, maintenance, and removal once vegetation is fully established.
10) If 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.
11) 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 3.4.8 shall apply to shallow constructed wetlands.

Summary of Design Requirements

The design requirements for shallow constructed wetlands and pocket wetlands are summarized in **Table 3-4**.

3.4.10 Bioretention Facilities (GI)

A bioretention system consists of a soil bed planted with native vegetation located above an underdrained gravel layer. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Stormwater quantity controls may either be integrated into the bioretention system or provided in a separate downstream facility. Sites utilizing bioretention facilities for water quantity control must also meet the stormwater quantity control requirements of Section 3.2.

Layout and Geometry Requirements

The side slopes for bioretention facilities shall not exceed 4(H) to 1(V). In retrofit situations where 4(H) to 1(V) slopes are not obtainable, side slopes shall be landscaped to eliminate need for mowing and stabilized to prevent erosion. Above grade or landscape buffers shall be used in bioretention facilities directly adjacent to sidewalk, driveway, or street pavement when bioretention facilities have side slopes greater than 4(H) to 1(V) or a greater than 6-inch drop from top of pavement to top of bioretention facility installation.

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. Unless otherwise approved by the County, the filter media shall meet the requirements of City of Columbus Supplemental Specification 1604.

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**.

Table 3-4 Summary of Design Requirements for Shallow Constructed Wetlands

	Shallow Constructed Wetlands	Shallow Pocket Wetlands
Drainage Area	• Minimum 20 acres	• Less than 20 acres
Footprint	• Wetland area footprints should be 5-12% of the area draining to the wetland	
Side Slope	• No greater than 4(H) to 1(V), flatter is recommended	
Soil	• HSG-C or HSG-D soils • Pond liner required for HSG-A soils • No gravelly sands or fractured bedrock	• Soil requirements do not apply to shallow pocket wetlands where the permanent pool is sustained by groundwater
Conveyance	• Minimum length-to-width ratio of wetland to be 2(L) to 1(W): 3(L) to 1(W) or greater is preferred. • Basins should be wedge-shaped, narrowest at the inlet and widest at the outlet	
Design Flows	• For extended detention, release 50% WQ_v in 8 hours and release 100% WQ_v in 24 hours	
Pre-treatment	• Size pre-treatment forebay to provide a minimum of 10% WQ_v • Forebay side slopes shall not exceed 4:1	
Outlet	• Outlet shall conduct continuous dry weather flow through wetland system while maintaining normal pool elevation	
Sizing	• Permanent pool (whichever is greater) o Sized to hold 2 times the volume of evapotranspiration during a 30-day drought at summer evaporation rates OR o The calculated WQ_v • Extended Detention: Equal to WQ_v	
Deep Water Zone	• 50% of permanent pool volume • Inundated 1 to 4 ft below permanent pool • 10-30% of wetland surface area • Sediment storage volume equal to at least 20% of WQ_v • Deep water zones shall be placed within the forebay and around the primary outlet at a minimum	• 25% or permanent pool volume • Inundated 1 to 4 ft below permanent pool • 10-30% of wetland surface area • Sediment storage volume equal to at least 20% of WQ_v • Deep water zones shall be placed within the forebay and around the primary outlet at a minimum
Shallow Water Zone	• 50% of permanent pool volume • 35-45% of wetland surface area inundated 0-6 inches below permanent pool • 35-45% of wetland surface area inundated 6-18 inches below permanent pool • Variable depths to provide microtopography • Shallow water zone occupies in total 70-90% of the wetland surface area	• 75% of permanent pool volume • 35-45% of wetland surface area inundated 0-6 inches below permanent pool • 35-45% of wetland surface area inundated 6-18 inches below permanent pool • Variable depths to provide microtopography • Shallow water zone occupies in total 70-90% of the wetland surface area
Landscaping	• The shallow water zone 12 inches deep and less shall be planted at a minimum density of 50 herbaceous plants per 200 square feet • Plant species and sizes must be selected based on the permanent pool depths • At least six different species of native plants shall be planted in the shallow water zone • Invasive species (Table B-1) are prohibited • Minimum of 12 inches of topsoil shall be provided in all planted areas • Goose exclusion fencing shall be provided	

Underdrain and Outlet Requirements

1) A perforated pipe underdrain shall be provided beneath the planting soil. The pipe shall be generally orientated in the horizontal center and must extend at least 85% of the longitudinal length of the facility.
2) The perforated pipe shall have a minimum diameter of 6 inches and shall meet the requirements of City of Columbus Supplemental Specification 1610.
3) The pipe shall be surrounded by granular backfill of durable No. 57 aggregate, in accordance with CMS Section 703.01, at least 4 inches beyond the outside diameter of the pipe. The use of crushed steel slag shall not be permitted where it will be routinely

submerged.

4) The filter media and granular backfill shall be separated by at least 4 inches of durable No. 8 or 89 aggregate in accordance with CMS Section 703.01. Depending on the gradation of the filter media, it may be necessary to provide a 4-inch-thick layer of sand, in accordance with CMS Section 703.06, between the layer of No. 8 or 89 aggregate and the filter media. The designer shall use the methodology found in Chapter 26 of the USDA National Engineering Handbook Part 633 to confirm that water will flow through the system without causing movement of the filter media into the aggregate layers or loss of any material into the underdrain.
5) 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 or the energy of the flow shall be dissipated so that erosion within the facility does not occur.

3.4.11 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.

Hydrology Requirements

Sand filters shall be designed to operate with consideration given to the different filtration rates of unclogged (new) and clogged (maintenance needed) media.

Filter Media Requirements

1) Sand (CMS 703.02(A)) and gravel (CMS 703.04(A)) meeting the County's material specification shall be used. The use of crushed steel slag shall not be permitted where it will be routinely submerged.
2) Geotextile fabrics shall not be used as a filter or material separator in sand filters. Established designs, such as the Austin and Delaware sands filters, that incorporate a geotextile fabric shall be redesigned to replace the specified geotextile fabric with graded aggregate layers that achieve the same intended function.

Underdrain and Outlet Requirements

All piping shall be Schedule 40 PVC per CMS 707.41. The underdrain piping consists of 4-inch diameter perforated PVC pipe and each underdrain pipe should be wrapped in a geotextile fabric meeting ASTM D-751 and ASTM D-1682, with a minimum of 2 inches of gravel covering

the top surface of the PVC pipe. Each pipe must have a minimum slope of 1 percent (1/8 inch per foot), and each individual underdrain pipe shall have a cleanout access location.

Pretreatment

A fixed vertical sediment depth marker should be installed in the settling basin to indicate when 20 percent of the basin volume has been lost because of sediment accumulation.

3.4.12 Other Practices

The following practices do not qualify for use as primary, stand-alone SCPs and are not covered elsewhere in this regulation. When used in combination with stand-alone SCPs, these practices can reduce the size and maintenance frequency of primary structural controls.

3.4.12.1 Runoff Reduction and Soil Management

Use of the following practices shall be in accordance with the OEPA's criteria for runoff reduction practices and soil management:

1) Impervious Area Disconnection
2) Grass Filter Strips
3) Grass Swales
4) Soil Management

3.4.12.2 Pretreatment practices

In most cases the aforementioned stand-alone SCPs require that stormwater be "pre-treated" before it reaches the facility. A variety of pretreatment practices are available to remove sediment and other pollutants that may clog or foul the SCP. Each of the following practices shall be designed as specified in the Ohio Rainwater and Land Development Manual and accordance with the listed criteria below, where applicable:

1) Swales
2) Forebays
    a) Direct maintenance access shall be provided to the forebay at a slope no steeper than 10(H) to 1(V).
    b) Forebay side-slopes shall not exceed 4(H) to 1(V).
    c) A fixed vertical sediment depth marker shall be installed in the forebay to measure sediment deposition over time.
    d) Forebays of basins must be constructed to provide an access point of sufficiently compacted material to support equipment necessary to perform the necessary routine maintenance for cleaning the structure.
3) Sumps
4) Flow-through devices
5) Grass filters

3.5 Water Quality Controls for Commercial Activity Areas

The stormwater quality controls defined in the previous sections are appropriate for most commonly occurring stormwater pollutants. Some pollutant sources, however, are more difficult to control 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 standard SCPs.

A high-risk pollutant source is one possessing pollutant loads and/or concentrations that are different than typical urban runoff, as characterized by the U.S. EPA 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 County.

3.5.1 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 OEPA 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 OEPA, shall meet all applicable requirements of OEPA's permit for stormwater discharges from industrial activities. To obtain coverage, a discharger must complete and submit the NOI form available from OEPA along with the appropriate fee at https://epa.ohio.gov/dsw/ebs. A copy of the NOI shall be submitted to Franklin County 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 County with significant outdoor material or waste storage, handling, or disposal

Table 3-5 Control Requirements for Materials Handling Areas

High Risk Materials	Low-Risk Materials	Exempt Materials
Required controls: Conduct activities indoors, as allowed by County regulations, or outdoors with controls defined in this section.	***Required controls***: Use temporary covers of plastic film or sheeting, with runoff directed to approved SCPs for the site.	***Required controls***: Direct runoff to approved SCPs for the site.
Materials to control: • Recycled materials with potential effluent • Corrosive materials (e.g., lead-acid batteries • Scrap or salvage goods • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human waste • Refuse as defined in CCC 4501.	***Materials to control:*** • Recycled materials without potential effluent • Asphalt concrete • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products without potential effluent • Unwashed gravel/rock • Compost	***Materials to control:*** • Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Clean concrete products (blocks, pipe, etc.) • Glass products (new clean, or free of residual product) • Inert products • Materials with no measurable solubility or mobility in water • Materials with no hazardous, toxic, or flammable properties • Gaseous materials

3.5.2 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 3-5** (obtained from City of Portland, OR, "2020 *Source Control Manual*",) 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.

3.5.3 Requirements for Commercial Activity Areas

Commercial activity areas that, in the judgment of the County 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.
2) The area shall be paved with asphalt or concrete unless otherwise approved by the County.
3) Non-stormwater discharges from commercial activity areas shall be directed to separate treatment systems that are able to adequately control stormwater pollutants generated within these areas. These systems include, but are not limited to the following:
    a) A separate sanitary sewer system, providing the discharge is regulated with a shutoff valve. Disposal of stormwater runoff from commercial activity areas to a sanitary sewer is limited to runoff from commercial activity areas associated with businesses covered under SIC 4952 Sewerage Systems and SIC 4953 Refuse Systems.
    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 OEPA.
4) For areas with potential to generate oil, grease, or high levels of trash and that have a drain connected to the storm sewer system, an oil/water separator shall be installed. High risk areas include:
    a) Trash receptacle areas for fast food restaurants.
    b) Outdoor vehicle recycling storage facilities.
    c) Other areas as determined by the County.
5) 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; no wash water, spills, leaks, etc.) should enter storm drains unless specifically allowed under the County'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.

6) Minimize potential exposure of commercial activity areas to stormwater by the following methods (obtained from City of Portland, OR, "2020 S*ource Control Manual*", Adopted August 2016):

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 stormwater system. The overhang shall be measured relative to the perimeter of the hydraulically isolated area it is to cover.

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 through the use of berms or providing grade breaks around the area perimeter.

7) Where wash waters or comingling of precipitation or stormwater runoff with commercial activity areas 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 County regulations:

a) Dispose in a sanitary sewer, with appropriate restrictions and/or pretreatment. Disposal of stormwater runoff from commercial activity areas to a sanitary sewer is limited to runoff from commercial activity areas associated with businesses covered under SIC 4952 Sewerage Systems and SIC 4953 Refuse Systems.

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.

3.6 Applicant-Proposed Stormwater Controls

Applicants proposing to use alternative SCPs must obtain approval from OEPA. In addition to OEPA's approval, applicants proposing to use alternative SCPs must demonstrate that alternative or manufactured controls meet the performance standards specified in Section 3.1.

3.7 Illicit Discharge and Illegal Dumping Control

Illicit discharges to the storm sewer are prohibited.

Stormwater Drainage Manual

Part I

Section 4

Construction Verification, Operation, Maintenance, and Monitoring Of Stormwater Control Practices

Section 4: Construction Verification, Operation, Maintenance, and Monitoring of Stormwater Control Practices

This section provides requirements to verify the completion and ensure successful performance of stormwater control practices once they have been constructed. Included in this section are requirements for construction performance surety, as-built surveys and construction certification, practice inspection and maintenance, and maintenance and access easement requirements to allow for construction and maintenance in and around stormwater control practices. The County will utilize the drainage improvements petition process described in Section 4.3.1.

County maintenance shall include the functionality of the SCPs and infrastructure but not the aesthetic maintenance. Homeowners or Homeowner Associations (HOA) will be responsible for the aesthetic maintenance of all SCPs. Stormwater control practices located on other types of properties such as high density residential, commercial or industrial sites will be maintained by the property owner and will report annually. The certificate of zoning compliance will require the owner of the property to maintain the SCP. Failure to maintain the SCP will result in enforcement action. The development of a standalone Operation and Maintenance Manual is required for all SCPs.

4.1 Construction Surety for Stormwater Control Practices

A construction performance guarantee in a form acceptable to the County shall be provided by the applicant, where applicable, to guarantee the construction of the required stormwater control practices in the event that the applicant fails to do so in accordance with approved plans. Any revisions to the plans after approval by FCEO shall be made in red ink. The Utilities Department within the FCEO will receive performance guarantees for construction and post-construction stormwater control practices.

4.1.1 Requirement to Provide Surety

Applicants proposing to construct temporary sediment settling ponds and sediment traps or post-construction stormwater control practices on private development sites shall furnish to the County a construction performance guarantee in the amount of 100% of the cost of construction for excavation, water pumping and/or the conversion or removal of the pond, prior to commencement of construction activity. The performance guarantee shall be in the form of a surety bond in a form acceptable to the County from a surety bonding company authorized to do business in the State of Ohio. The bond shall name the FCEO as Obligee and shall be signed by authorized representatives of the Owner and the surety company. The person signing on behalf of the surety shall provide evidence of authority to bind the surety. The surety bond shall be in the

appropriate amount specified herein and will be released upon completion of the items specified under Section 4.1.2.

4.1.2 Construction Guarantee Process

Applicants providing a surety bond for the construction of temporary sediment settling ponds, temporary sediment traps, and permanent stormwater control practices under this regulation shall comply with the following standards.

The surety bond will be returned to the applicant when all of the following criteria are met.

1) The temporary sediment settling ponds and sediment traps are either removed or converted to post-construction stormwater control practices based on the County approval.
2) The stormwater control practices are constructed and permanently stabilized.
3) An as-built survey and engineering certification attesting to the conformity of construction to the approved plans or this regulation for all post-construction stormwater control practices, in accordance with Section 4.2, is received and accepted by the County.
4) A Stormwater Control Practice Maintenance Plan, revised to reflect as-built conditions, has been received and approved by the County.

A new surety bond for an existing project will be required in instances where:

1) A new temporary sediment settling pond, temporary sediment trap, or post-construction stormwater control practice is constructed to serve an added phase of a multiphase project, or
2) The ownership of an existing temporary sediment settling pond, temporary sediment trap, or post-construction stormwater control practice changes.

No surety bond will be released without prior approval from the County.

4.2 Stormwater Control Practice Construction Verification

As-built surveys and certification are required to demonstrate that the construction of post-construction stormwater control practices was performed per the approved construction drawings, specifications, and contracts. Applicants shall submit an as-built survey and engineering certification to the FCEO for post-construction stormwater control practices installed as part of any private development or public improvement project covered under this regulation.

4.2.1 Timing of As-Built Survey and Certification

As-built survey and certification for post-construction stormwater control practices shall be performed upon conversion of temporary sediment settling ponds and sediment

traps, where applicable, the installation of all drainage components, and at the conclusion of grading and stabilization of the practice. Practice conversion and finalization will include, but not be limited to:

1) Removal of the temporary riser and skimmer assembly,
2) Installation of the permanent outlet control structure, including any orifices or weirs,
3) If required through as-built survey to achieve compliance with this regulation, removal of sediment from storage areas, including the bottom of permanent pool areas, and
4) Final stabilization of disturbed areas in and around the practice.

Submittal of a certified as-built plan and approval by the County are required before a project is determined to be in compliance with this regulation. The certified as-built plan is to be submitted prior to release of the surety bond for commercial development or subdivision projects and final pay requests for public improvement projects by the County.

4.2.2 Post-Construction Stormwater Control Practice As-Built Survey Contents

As-built survey information shall be collected by, or under the direct supervision of, a licensed surveyor registered in the State of Ohio. Horizontal locations and vertical elevations shall be based on the same coordinate system and vertical datum used on the approved plans. The as-built survey is to be submitted to the FCEO in the form of red-lined construction drawings, in electronic format, and shall include the following items:

1) Location and type of practice inlet and outlet structures including but not limited to: catch basins, manholes, headwalls, inlets, standpipes, level spreaders, and spillways.
2) Invert elevations of practice inlet and outlet structures; orifice plate openings; weirs; and pipes, including underground storage chambers and underdrains located within the perimeter of the control practice. Elevations will be surveyed to a tolerance of 0.1′ utilizing instrumentation tied to County monuments and able to provide the required accuracy.
3) Topographic survey will be collected within the project limits to verify that positive drainage has been established, to the direction as shown in the construction documents.
4) For underground stormwater control practices, sizes and material of pipes, including underground storage chambers and underdrains associated with the control practice; orifice plate openings; weir openings; grate openings; and window openings that comprise the stormwater control practice.
5) Top of casting elevations of inlet and outlet structures including but not limited to: catch basins, manholes, headwalls, inlets, and standpipes that comprise the stormwater control practice.

6) Elevations along embankments and crests of level spreaders.
7) Cross sections of spillways, weirs, and open channels that enter or exit the stormwater control practice.
8) Topography and storage volume of practices where above-ground stormwater storage is provided including grades below the normal pool of water, where applicable. Above-ground stormwater control practices shall include, but is not limited to, green roofs, blue roofs and above-ground storage components of bioretention facilities.
9) Topography and storage volume of practices where underground stormwater storage is provided. Underground storage areas include, but are not limited to: underground detention facilities, storage layers for pervious pavement systems, bioretention facilities, and underground cisterns. This information must be obtained before the underground components and storage areas are buried.
10) Location and material of energy dissipation systems associated with inlets and outlets to and from the stormwater control practice.
11) Location and size of impervious reduction areas for previously developed areas.
12) A list of planted vegetation including plant species and number provided, if applicable.
13) Only when variations exist that are not in reasonably close conformity with the originally approved construction plans, an updated stormwater management report that includes calculations for the stormwater system that reflect field changes to demonstrate site compliance with the County stormwater regulations that were in effect at the time of plan approval, reviewed and signed by the certifying Professional Engineer.

The approved *.TIFF drawings on file with the FCEO shall be used as the basis for the as-built survey plans. Deviations from the approved plans shall be noted as redline mark-ups on the approved *.TIFF drawings and stamped or labeled as "As-Built" on each page.

4.2.3 Stormwater Control Practice Certification

The Professional Engineer or an engineer employed by the Engineering Firm that prepared and signed the construction drawings shall certify, under seal, that the as-built post-construction stormwater control practices and associated components are in compliance with the approved construction drawings and with the requirements of this regulation. In instances where the Engineering Firm that prepared and signed the construction drawings is no longer in business, a Professional Engineer selected by the Applicant shall certify construction of the post-construction stormwater control practices. Where deviations from the approved construction plans are identified, the Professional Engineer shall submit supporting documentation with the as-built plans, which proves that the post-construction stormwater control practices will operate in compliance with the requirements specified in this regulation. The Professional Engineer shall include a signed and sealed Stormwater Control Practice As-built

Certification form, with the as-built survey drawings to the Highway Design Department. The Professional Engineer shall include a signed and sealed Stormwater Control Practice As-built Certification form, available in **Appendix F**.

4.3 Stormwater Control Practice Maintenance Responsibilities

It is essential that any approved stormwater control practice be properly maintained in order to ensure its performance. The County will utilize the County Drainage Improvement Petition process as described in Section 4.3.1 (ORC 6131 and 6137) to establish a maintenance fund for the purpose of maintaining eligible infrastructure and SCPs designed to serve single-family residential developments. To be eligible for County maintenance services, the owner of the stormwater infrastructure must:

1) Have established vegetation within and around the drainage facility, if applicable,
2) Have designed and constructed the facility in accordance with County standards and proven by as-built survey,
3) Have the facility in proper working order at the time the County accepts maintenance responsibilities, and
4) Provide to the County stormwater easement rights sufficient to perform required maintenance of stormwater infrastructure. It is preferred that easements and stormwater infrastructure be placed on public property or in dedicated reserves as opposed to easements on private property. Provide the County property/easement rights from the outlet of the stormwater infrastructure to an approved stream or public stormwater infrastructure with sufficient available capacity. This shall be one continuous easement that allows for maintenance of the entire improvement and associated structures.
5) Working with the Franklin County Drainage Engineer's Office, petition the County to place the infrastructure under maintenance. (See Section 4.3.5)
6) Drainage easements in subdivisions shall be delineated with signs.

4.3.1 Establishing a Maintenance Fund for Public Maintenance of Stormwater Infrastructure and Stormwater Control Practices

The following process shall be followed to petition for drainage maintenance from the County. Establishing a Maintenance Fund is only required for the development of new subdivisions. Drainage maintenance will apply to stormwater infrastructure including but not limited to swales, inlet structures, pipes, and post-construction SCPs.

1) Collaborate with the Franklin County Drainage Engineer to create the agreement, schedules, cost estimate, and plan delineating all storm sewers, easements, and maintenance responsibilities in accordance with ORC 6131.63. The approved exhibit shall be included in the final plat.
2) Upon the engineer filing this certificate of acceptance and the schedule of maintenance assessments with the Board of County Commissioners, the owner shall petition the board to accept the drainage improvement into the drainage

improvement maintenance program outlined in ORC 6137. Upon receiving the petition, the board shall set a hearing date as outlined in ORC 6131.63. The hearing must occur before the commissioners approve and sign the final plat.

3) Before the hearing date, the owner shall pay to the drainage engineer the maintenance assessment for the first year as it is outlined in the schedule of maintenance assessments.

4) Upon approval of the petition by the commissioners, the owner shall continue to be responsible for maintenance of the system until such time as the civil infrastructure has been accepted as outlined in the Franklin County Stormwater Manual (Maintenance and Inspection Requirements - see Section 4.3.5).

Parcels benefiting from the proposed drainage system to be placed under County maintenance will be assessed a prorated share of the maintenance assessment as outlined in ORC 6137. The construction cost estimate will provide the permanent base for the maintenance assessment. The Base Construction Cost for stormwater infrastructure shall be calculated using the most up to date and most applicable average prices reported by ODOT for each item.

4.3.2 Stormwater Easements, Access, and Maintenance Requirements

After plan approval, the Applicant shall submit the following to the FCDE:

1) Legal descriptions, associated exhibits, and plats describing and depicting all required stormwater infrastructure easements. The Applicant shall convey, or cause to be conveyed, any required storm easements. The applicant shall prepare the easements and submit them for approval by the FCEO. The easements shall grant the FCDE the rights but not obligation, at any time, to:
    a) Inspect the stormwater control practices to ascertain whether the stormwater control practice and appurtenant facilities are built and functioning in accordance with any approved Plans, the Stormwater Control Practice Inspection and Maintenance Agreement, requirements of the then-current FCEO Stormwater Drainage Manual and generally accepted engineering standards.
    b) Construct the stormwater control practice in accordance with approved plans under the surety agreement should the Applicant fail to do so.
    c) Maintain the stormwater control practice in accordance with approved maintenance plans should the owner of the stormwater control practice fail to perform maintenance activities.

2) A stormwater control practice inspection and maintenance agreement between the FCEO and the Applicant for FCEO signature. The inspection and maintenance agreement shall obligate each owner to inspect and maintain the stormwater control practice in accordance with approved stormwater control practice maintenance plans and shall be signed by each property owner served by the stormwater control practice. The stormwater practice inspection and maintenance

agreement will be recorded by the FCEO.

3) Reciprocal easement agreements for developments where runoff from multiple parcels under different ownership are controlled by a stormwater control practice located on a separate parcel. The reciprocal easement agreements shall be signed by each property owner whose property is served by the stormwater control practice. The reciprocal easement shall allow each property owner to access the stormwater control practice for the purpose of inspecting and maintaining the practice in accordance with the stormwater control practice inspection and maintenance agreement and stormwater control practice maintenance plan.

4.3.3 Easement and Access for Stormwater Control Practices

Unless otherwise required by the County, easements shall be provided around the perimeter of each stormwater control practice. They shall extend 20 feet beyond the practice's maximum designed flood limits and appurtenances. For stormwater control facilities that are to be operated and maintained by the County, the Property Owner shall provide the County with an easement that includes the area of the control facility when flooded during the 100-year event. Appurtenances to the facility shall include but are not limited to, pretreatment measures such as forebay(s), benches, risers, outlet pipes, etc. 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.

Applicants shall provide the County with specific dedicated stormwater easement rights sufficient to perform the required maintenance of the stormwater control practice. It is preferred that easements and stormwater control practices be placed on public property or in a dedicated reserve instead of on private property. The drainage reserves shall be adjacent to the property line where possible and shall not split a property into multiple pieces.

Pipes, ditches, swales, and inlet and outlet structures located in the public road right of way will be maintained by the entity responsible for maintaining the road.

Pipes, ditches, swales, and inlet and outlet structures that are not located in a public road right of way and are not located on private residential lots shall be maintained by the County. Such infrastructure must be located in a dedicated stormwater easement that is a minimum of 20 feet wide.

For facilities that are to be maintained by a homeowner's association, the developer shall provide the County with a minimum 20-foot-wide dedicated drainage easement.

Applicants shall provide to the County a maintenance vehicle accessway with a minimum width of 15 feet centered within the access easement. The accessway shall be located around the perimeter of each practice 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 the stormwater control practice. All access routes shall be designed to allow the turn-around of maintenance vehicles. The maintenance

plan for the stormwater control practice shall address how maintenance access and operations will be performed if alternative measures are used.

4.3.4 Stormwater Control Practice Maintenance Plan

A maintenance plan for each stormwater control practice must be prepared and submitted for review by the County during the plan approval process. The maintenance plan shall include all elements specified in the latest version of OEPA's Construction General Permit. Inspection frequencies, maintenance frequencies, and maintenance activities specified in stormwater control practice maintenance plans shall be in accordance with this Manual.

The model available in **Appendix H** shall be used as the basis for the SCP Maintenance Plans. Submitted SCP maintenance plans shall be customized to appropriately suit the individual practice(s) that are to be constructed. Methods and frequencies for inspections and maintenance activities for stormwater control practices that are not presented in the County's Post-Construction SCP Maintenance Manual shall be provided by the Applicant.

Stormwater Control Facility Maintenance plans shall be updated after construction of the stormwater practice to reflect any changes made to the original design during construction. The updated Stormwater Control Facility Maintenance Plan shall be submitted to the FCEO along with the as-built survey drawings and completed Stormwater Control Facility Certification Form.

4.3.5 Maintenance and Inspection Requirements

The purpose of maintenance inspections is to assure safe and proper functioning of the stormwater control practices. The Property Owner shall perform periodic inspections of the stormwater control practice and its appurtenances at a frequency stipulated in the approved Stormwater Control Maintenance Plan. Inspections shall cover all elements for the stormwater control practice as defined in the stormwater control practice maintenance plan. Inspections shall include the completion of dated and signed inspection checklists provided in the Stormwater Control Practice Maintenance Plan and the notation of all deficiencies observed during the inspection. On an annual basis, SCP inspections and associated documentation shall be submitted to the County by December 31. Suggested Inspection and Maintenance schedules for each approved SCP are included in **Appendix H**. 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 County upon request.

The County will inspect, at a frequency determined by the County, the stormwater control practice to determine whether the practice and appurtenant facilities are built

and functioning in accordance with any approved Plans. The following records shall be maintained onsite and made readily available for review by the County during inspections:

1) The approved stormwater control practice maintenance plan, and
2) A complete and up-to-date maintenance inspection log that documents inspection and maintenance activities performed by the owner.

The County will provide written or electronic notification to owners of stormwater control practices of any deficient items noted during the inspection. In the event the stormwater control practice is not functioning properly and requires repair, the owner upon notice from the County, or otherwise, shall commence such repairs as needed in a timely manner. The owner shall use commercially reasonable efforts to timely perform the repairs, but except for events of force majeure, under no circumstances shall the time exceed ninety (90) days unless otherwise agreed in writing by the County.

4.4 Stormwater Control Practice Monitoring Requirements

As directed by the County or other governing body of jurisdictional entity (e.g., OEPA), applicants that are developing lands within sensitive or protected watersheds may be required to implement separate stormwater runoff monitoring.

Monitoring may include activities such as the following: rainfall data, flow rate, dry or wet weather discharge sampling, seasonal monitoring, sampling of new stormwater conveyance systems, and/or sampling of effluent at stormwater outfalls that are constructed as part of the development project. Samples may be analyzed to determine amount of any constituents of concern as determined by a governing body or jurisdictional entity. Reporting of monitoring results may also be required.

4.4.1 Construction Monitoring

The monitoring of stormwater discharges and associated record-keeping of monitoring results during construction activities shall be conducted in accordance with OEPA's National Pollutant Discharge Elimination System (NDPES) General Permit Authorization for Storm Water Discharges Associated with Construction Activity.

4.4.2 Post-Construction Monitoring

Applicants proposing to develop within the Big Darby Accord planning area, are required to implement post-construction stormwater monitoring as prescribed in the development site level monitoring requirements specified in the Big Darby Accord Watershed Master Plan. In instances where the collection of data using automatic sampling equipment is specified, flow-weighted composite samples shall be collected for analysis. Samples collected for flow-weighted composite shall be taken during the entire event or during the first three hours, whichever occurs first. Each sample shall be

separated by a minimum period of fifteen minutes, or a maximum period of forty-five minutes, with a minimum of three samples per event.

Wet weather precipitation events shall be defined as greater than or equal to 0.25 inches of precipitation in 24-hours. Dry weather flow conditions shall be characterized as flows that occur seventy-two (72) hours or longer following the end of the last precipitation event. Analysis and collection of samples shall be performed in accordance with the methods specified in 40 CFR, Part 136. Where an approved Part 136 method does not exist, a suitable method shall be used and referenced in the annual sampling report described in this section.

Applicants shall submit an annual sampling report to the Franklin County Drainage Engineer that includes an evaluation of the monitoring data to characterize the seasonal quality of storm water discharges.

The Annual Report shall contain:

1) Project location
2) Sample location
3) The date and duration (in hours) of the storm event(s) sampled
4) Measurements or estimates of rainfall depths in inches of the storm event which generated sampled runoff
5) The duration (in hours) between the storm event sampled and the end of the previous measurable storm event
6) Analytical results

The annual sampling report for each calendar year January 1 through December 31 must be submitted not later than January 31 of the following year. Applicants must submit annual sampling reports to the following address:

Franklin County
Franklin County Drainage Engineer
970 Dublin Road
Columbus, Ohio 43215

Stormwater Drainage Manual

Part II

Submittal Requirements

Part II – Submittal Requirements

Part II – Submittal requirements of the Manual contain guidelines and standards necessary to successfully navigate the County's process for review and approval of proposed development with regard to stormwater management. Section 5 discusses the County's approval process from the various departments prior to construction. Section 6 defines the information that shall be provided in a Stormwater Management Report accompanying required submittals. Section 7 presents stormwater construction drawing submittal requirements details regarding the stand-alone stormwater pollution prevention plan (SWPPP or SWP3) that is required for those projects subject to the OEPA Construction General Permit. Additional questions covering these sections should be directed to the Franklin County Economic Development and Planning Department.

Stormwater Drainage Manual

Part II

Section 5

Private and Public Development Review Processes

Section 5: Private and Public Development Review Processes

Any new development, either public or private, subject to the Manual and required to construct stormwater infrastructure within the County, must receive approval from some or all of the following County departments/divisions prior to construction, including, but not necessarily limited to: Franklin County Planning Commission, Franklin County Economic Development and Planning Department, Franklin County Engineer's Office, Franklin County Drainage Engineer's Office, Franklin County Public Health Department, and the Franklin County Sanitary Engineer. In addition, development projects located in Townships that administer their own zoning must be approved by the applicable Township. The developer/consultant shall submit certificate of zoning compliance applications and subdivision construction plans to the applicable zoning authority and Franklin County Engineer's office. Stormwater plans shall be submitted as individual submittals directly to the Franklin County Economic Development and Planning Department, at 150 South Front Street, FSL Suite 10, Columbus, Ohio 43215 and the Franklin County Engineer's Office at 970 Dublin Road, Columbus, Ohio 43215.

In the case of a major subdivision proposal, the applicant is required to procure approval of a preliminary plan for the development prior to the submission of construction plans.

A stormwater management plan is required for review and approval of stormwater systems. The elements of the stormwater management plan, such as stormwater calculations, maps, permits, etc., are outlined in Section 6.

Where applicable, the applicant is required to submit proof of receipt of the following to the Franklin County Economic Development and Planning Department:

1) Proof of coverage under a Federal Individual or Nationwide (404) Permit submitted prior to earth disturbing activities and the preconstruction meeting, if a meeting is required.
2) OEPA Water Quality (401) certification.
3) Written OEPA approval for use of alternate post-construction SCP on large sites or for small site plans submitted as part of a larger plan of development, if used.
4) Written OEPA approval for any exception, waiver, or other variance from conditions contained in the applicable Construction General Permit.
5) Written OEPA approval of mitigation of isolated wetlands and/or isolated streams.

Stormwater Drainage Manual

Part II

Section 6
Stormwater Management Report

Section 6: Stormwater Management Report

A stormwater system shall be designed and incorporated into each development project proposed within the County. The design of proposed stormwater systems shall be summarized in a bound Stormwater Management Report (Report) and submitted in digital (pdf) versions to the County 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 stormwater control practices (SCPs) 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 SCP Maintenance Plan(s),
4) Drainage Easements (if applicable),
5) Subsurface investigation reports (if applicable),
6) Wetland/Stream delineation reports,
7) Non-County Submittals/Permits,
8) Supporting documents from OEPA, USACE, and any other state or federal agency, and
9) Stormwater Design Summary.

The master drainage plan shall be included with the digital submittal of the report. Construction plans, including Stormwater Pollution Prevention Plans, 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 and a digital copy of the report. 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. The master drainage plan shall 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 one-foot contour intervals covering the total development area and any offsite drainage areas tributary to the development site. Under circumstances where topographical datasets with a one-foot resolution are not accessible for the project area, two-foot contour intervals may be permitted on a case-by-case basis. The total upstream watershed(s) tributary to the development site shall be delineated,

5) Predevelopment 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 stormwater system, if requested by the County,
7) Predevelopment and post development major flood routing flow paths to and from stormwater control facilities,
8) Any streams that traverse the property and respective riparian setbacks or buffer zones required by County regulations or local zoning,
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) Existing trees,
12) Lines designating the phases of multiphase development projects,
13) Street layouts and existing and proposed utility lines,
14) Flood Hazard limits and classifications, (floodway, 100-year and 500-year)
15) The boundary of each wetland on the site and, if required by local zoning or ordinance, the associated buffer or riparian setback. If a jurisdictional determination has been made under Section 401/404 permitting requirements that should also be noted, and
16) Identify all stormwater outfalls and provide state plane coordinates, size (e.g., diameter), and type (open channel or piped) for each outfall.

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 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 Franklin County Drainage Engineer's Office.

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 County's stormwater management requirements. Specific requirements follow.

6.2.1 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.

6.2.2 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 without surcharging. Calculations shall be prepared on the tabulation sheet provided in **Appendix A**.
2) ***Hydraulic and Energy Grade Line*** — Demonstrate that the sewer system is designed to convey the design storm on **Table 2-10** 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 2.3.1.2. The HGL and EGL shall be shown on the tabulation sheet provided in **Appendix A.**
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.

6.2.3 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.

6.2.4 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.

6.2.5 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.

6.2.6 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 County include, but are not limited to, SWMM, TR-20, PONDPAK, HYDROCAD and HEC-1. The County 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 100-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 County 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.

6.2.7 Water Quality Volume (WQv) and Water Quality Flow (WQ_f) Calculations for Post-Construction SCPs

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. At a minimum, the following calculations shall be provided in accordance with Section 3.

1) ***Water Quality Volume Calculations*** — Show the calculations of extended detention, permanent pool, forebay, and sediment storage volumes and depths.
2) ***Water Quality Drawdown*** — Show calculations or model output that demonstrates the release of the WQ_v over the time period(s) specified.
3) ***Area of Sand Filter and Bioretention Facilities*** — Provide calculations used to determine the size of sand filter and bioretention facilities.
4) ***Water Quality Flow Calculations*** — Show the calculations of the water quality flow (WQ_f).
5) ***Design Flow Rate*** — Show the calculations of the design flow rate using the Rational Formula for SCPs sized using WQ_f.
6) ***Geometry*** — Show the calculations of the swale cross-section geometry using the Manning Equation. Demonstrate that the flow depth is no greater than the maximum flow depth specified for the design storm calculated above.

6.3 Stormwater Control Practice Maintenance Plan Requirements

The maintenance plan for the stormwater control practices on single-family residential, commercial, or industrial sites shall be prepared as required by Section 4.

6.4 Drainage Easement Preparation Requirements

Dedicated drainage easements to the County shall be provided to allow construction, maintenance, and access to all publicly-owned stormwater control practices located outside of public right-of-way and for all privately owned stormwater control practices. 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, deed book and page number, or official record number of the deed. The instrument number of the instrument used to perform the survey must also be identified and recorded on the plans. Preliminary legal description and survey plat exhibits for proposed easements shall be included with the stormwater management report submittal and construction drawings.

All legal descriptions and survey plats for proposed drainage easements involving County owned property rights shall apply standard survey techniques. When preparing easement documents for acceptance by the Franklin County Drainage Engineer, the following guidelines must be followed:

1) ***Legal Descriptions*** — Shall be the original typed document prepared and submitted; signed, sealed, and dated by a registered surveyor in blue ink, single spaced on letter size or legal size paper. Metes and bounds descriptions are required; centerline descriptions will not be accepted.
2) ***Survey Plat Exhibit*** — Shall be the original document prepared and submitted on legal size paper, signed, sealed, and dated by a registered surveyor. Each drainage easement and associated legal description shall warrant a separate exhibit for submission.
3) ***Format*** — Documents are not to be labeled or referenced to as exhibit A, B, or so on. This requirement does not apply to easements allowing, but not obligating, the County to access, construct, and maintain stormwater control practices.
4) ***Required Language*** — Legal descriptions and/or survey plat 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 or ditch.
5) ***Contacts*** — For private stormwater development plans, the name, mailing address, email, and phone number of the person who will sign or obtain the signatures on the easement document shall be provided.

When approved by the Franklin County Drainage Engineer, easement information will be sent to the Real Estate Department of the County Engineer's Office for preparation of the easement instrument(s). When the instrument(s) is prepared, the Real Estate Department will contact the designated contact person to obtain signatures. The Real Estate Department will record the instrument(s). Signed easements must be returned to the Real Estate Department prior to the payment of construction inspection fees.

6.5 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.

6.6 Wetland/Stream Delineation Reports

A copy of the wetland/stream delineation report shall be included in the Stormwater Management Report.

6.7 Non-County 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 ODNR for detention pond embankments meeting ODNR dam criteria,
2) 401 Water Quality Certification Permits issued by the OEPA,
3) Industrial NPDES Stormwater Permit application to OEPA,
4) 404 Permits for impacts to regulated streams and wetlands issued by the USACE, and
5) Notice of Intent for coverage under the OEPA NPDES Construction General Permit, and a copy of the stormwater pollution prevention plan prepared under this permit.

Stormwater Drainage Manual

Part II

Section 7

Stormwater Construction Plan Requirements

Section 7: Stormwater Construction Plan Requirements

All Certificate of Zoning Compliance site plans and Subdivision construction plans, subject to the Manual, shall be prepared, signed, and sealed by a Professional Engineer who is licensed in the State of Ohio. Plans shall be prepared in accordance with the Design Standards published on the FCEO website. In addition to plan submissions to the applicable zoning or platting authority, plans along with a signed Plan Review Checklist **Appendix E** shall be submitted digitally as flattened PDFs to hwydes@franklincountyengineer.org.

Title blocks shall be in accordance with Franklin County Engineer's Office standard. Stick on notes of signature block, and/or details will not be accepted. The tracings become the property of the County, upon approval of the drawings by the Franklin County Drainage Engineer. Copies of approved plans can be obtained from the Franklin County Drainage Engineer's Office. Final submittals shall include digital files of all plan sheets in PDF and CAD format, and a digital copy of the stormwater management report, stormwater pollution prevention plan, and SCP O&M Plan in PDF format.

All revisions to the tracings, after they have been signed by the County Drainage Engineer, shall be made in red ink. The original approved alignment, easement limits, manholes, structure numbers, etc., shall be revised as directed by the County Drainage Engineer's Office 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 at the discretion of the County Drainage Engineer's Office.

The following minimum for requirements applies to all construction plans submitted for review to the Franklin County Engineer's Office and are included in the Plan Submittal Checklist as shown in **Appendix E**.

7.1 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 certified 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 County at a quick glance. Corporation limits shall be included and shown on the Location Map and associated legend as a hatched boundary.
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. Benchmarks shall be on or within 100 feet of project limits.

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. Stormwater Control Practice quantities taken from the individual SCP Tables of Quantities must be carried over into the Estimate of Quantities. Refer to Section 7.4 for information on the Tables of Quantities for Stormwater Control Practices.
5) ***Standard Drawings —*** All plans shall have a listing of the applicable Standard Construction Drawings which apply to the proposed work. Copies of standard drawings shall not be placed on the plan sheets.
6) ***General Notes —*** The general notes 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 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."
9) ***Index Map –*** This map shall show the proposed storm sewers and stormwater control practices on the site. Map shall include proposed and existing storm sewers, structure numbers, property owners, and parcel numbers for the subject site and adjacent properties, public right of ways, corporation limits, street names, and where applicable streams/ditches and floodplain boundaries. The proposed stormwater improvements are to be the most prominent features.
10) ***Designer Contact Information –*** For the Professional Engineer signing the plan provide name, company, address, phone number, and email address
11) ***100 Year Detention Table –*** Table shall include the required and proposed 100-year detention volume and elevations for each proposed stormwater detention feature on the site.
12) ***Summary of Post Construction Stormwater Control Facilities Table –*** This table shall provide the Control Function, Drainage Area, Facility Type, Green Infrastructure and plan page number for each stormwater control/outlet structure on the plan.
13) ***Project Description –*** The title sheet shall include a project description outlining the proposed project improvements and project location.
14) ***Pre-Construction and Post-Construction Site Data –*** Pertinent information for the site including total project area, estimated project disturbed area, and pre- and post-developed impervious areas shall be included on the title sheet.

7.2 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 shall be the heaviest line weight used. Existing objects shall use a dashed line type, while proposed objects shall be solid.
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" with the size of pin also marked on the plans.
7) ***Impervious Surfaces*** — All impervious areas on the project site shall be shown and labeled. 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 and Wetlands*** — All streams, wetlands, and petition ditches shall be identified and shown and labeled on the plan.
9) ***Stormwater Control Practices*** — The size, location, and 100-year and maximum ponding limits of all proposed stormwater SCPs shall be provided on the plans. Easements for County access and maintenance (if required) to and around each facility shall also be shown.
10) ***Agricultural Field Tiles*** — All known 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. 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.

13) ***Impervious Area Reduction –*** An exhibit shall be provided that makes clear which areas are used to provide the requisite water quality volume, in full or in part, by removal of existing impervious areas. This exhibit shall be provided separate from other details and may not be part of the demolition plan.

7.3 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 the Franklin County Engineer's Office. 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 rights-of-way 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. Where the proposed storm sewer will be in fill areas less than 36″ above the proposed top of the pipe, the fill shall be designated to be placed to this level prior to installation of the pipe.

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.

7.4 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) ***Post-Construction Stormwater Control Practices*** — Dimensioned cross sections, elevation views, and plan views for each SCP 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. A detailed plan view of the basin is also required. Pertinent information such as, but not limited to, dimensions, spot elevations, material information, limits of topsoil, seed type, and seeding window shall be notated on the plans. 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. A separate section of the emergency overflow width shall be provided. Finally, specific details for the forebay and micropool shall be provided. Dimensions, material information, side slopes and key elevations must be notated on the details.

5) ***Tables of Quantities for Stormwater Control Practices*** – All proposed post-construction SCPs shall have individual Tables of Quantities detailing line items required to be constructed to complete the SCP in accordance with the plans and/or plan details based on the current CMSC. The quantities from such tables must be carried over to the overall Estimate of Quantities table as described under Section 7.1. Refer to **Appendix D** for a matrix of typical CMSC bid items which may be required with different types of SCPs.

7.5 Stormwater Pollution Prevention Plan

The Applicant shall prepare and submit to the County a complete stand-alone Stormwater Pollution Prevention Plan (SWP3) in accordance with OEPA's Construction General Permit with every submittal. A SWP3 shall be developed for each site covered by the CGP and shall be submitted to the Ohio EPA at the time of Notice of Intent submission.

The complete stand-alone SWP3 shall be submitted to the County in PDF format.

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Stormwater Drainage Manual

Appendix A

Operation and Maintenance Inspection Report Checklists

A-1 DRY DETENTION BASIN INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Plant Cover			
	Vegetation Health			
	Weeds/Invasives			
	Mosquito Proliferation			
Inflow Points	Inlet Functionality			
	Erosion			
Outlet / Overflow Structures*	Outlet Functionality			
	Structural Condition			
	Erosion / Undercutting			
	Slope Stability & Grading			
Bottom of System	Drainage			
	Sediment Buildup			

*Reference the outlet structure details provided within the County approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Watering	☐	☐	
Minor Erosion Repair	☐	☐	
Trimming	☐	☐	
Weeding	☐	☐	
Trash & Debris Removal	☐	☐	
Sediment / Leaf Removal	☐	☐	
Reseed Exposed Soil	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Rock Channel Replacement	Slope Slippage Repair	Pest/Disease/Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

DRY DETENTION BASIN INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Plant Cover	80-100%	60-80%	40-60%	20-40%	0-20%
	Vegetation Health	Well Established / Mature	Mostly Healthy	Sparse / Stressed	Many Dying	Dead / Absent
	Weeds/Invasives	None		Slight		Overgrown
	Mosquito Proliferation	Absent				Present
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
	Erosion	None		Minor – Lack of Vegetated Cover		Major – Erosion Rills and Gullies
Outlet/ Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
	Structural Condition	Excellent		Deteriorating		Poor
	Erosion / Undercutting	None	Ground Cover Missing	Slight Channelization	Heavily Channelized	Substantial Scouring
	Slope Stability / Grading	Well Defined		Moderately Defined		Poorly Defined
Bottom of System	Drainage	Drains ≤ 48 Hours		Ponding > 72 Hours		No Drainage / Extensive Ponding
	Sediment Buildup**	None	<5%	50-10%	10-20%	>20%

**Reference the basin forebay, micropool, or alternative pretreatment SCP details, elevations and sediment monitoring procedures provided within the County approved engineering plan and/or Stormwater Control Practice Maintenance Plan.

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

A-2 WET DETENTION BASIN INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Weeds/Invasives			
	Mosquito Proliferation			
Inflow Points	Inlet Functionality			
	Erosion			
Outlet / Overflow Structures*	Outlet Functionality			
	Structural Condition			
Perimeter / Embankment	Erosion / Undercutting			
	Slope Stability & Grading			
	Submerged Bench			
Bottom of System	Drainage			
	Sediment Buildup			

*Reference the outlet structure details provided within the County approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Watering	☐	☐	
Minor Erosion Repair	☐	☐	
Trimming	☐	☐	
Weeding	☐	☐	
Trash & Debris Removal	☐	☐	
Sediment / Leaf Removal	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Plant Replacement	Rock Channel Replacement	Slope Slippage Repair	Pest/Disease/Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

WET DETENTION BASIN INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Weeds/Invasives	None		Slight		Overgrown
	Mosquito Proliferation	Absent				Present
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
	Erosion	None		Minor – Lack of Vegetated Cover		Major – Erosion Rills and Gullies
Outlet/ Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
	Structural Condition	Excellent		Deteriorating		Poor
Perimeter / Embankment	Erosion / Undercutting	None	Ground Cover Missing	Slight Channelization	Heavily Channelized	Substantial Scouring
	Slope Stability / Grading	Well Defined		Moderately Defined		Poorly Defined
	Submerged Bench**	Plant Coverage >80%		Plant Coverage >50%		Plant Coverage <25%
Bottom of System	Drainage	Drains ≤ 24 Hours		Ponding > 72 Hours		No Drainage / Extensive Ponding
	Sediment Buildup**	Storage Zone Reduction of <25%		Storage Zone Reduction of >50%		Storage Zone Reduction of >100%

**Reference the City's approved engineering plan and/or Stormwater Control Practice Maintenance Plan for the submerged bench planting plan.

***Reference the City's approved engineering plan and/or Stormwater Control Practice Maintenance Plan for basin elevations and sediment monitoring procedures.

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

A-3 CONSTRUCTED WETLAND INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Maintenance Access			
	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Plant Cover			
	Vegetation Health			
	Mosquito Proliferation			
	Weeds/Invasives			
	Animal Burrows			
	Water Depth			
Inflow Points	Inlet Functionality			
	Erosion			
Pre-Treatment Area & Forebay	Sediment Buildup			
Bottom of System / Pond	Drainage/Water Level			
	Sediment Buildup			
Berm / Embankment	Erosion / Undercutting			
	Slope Stability & Grading			
Spillways / Outfalls & Risers*	Outlet Functionality			
	Structural Condition			

*Reference the outlet structure details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Watering	☐	☐	
Trimming	☐	☐	
Embankment / Nuisance Wildlife Repair	☐	☐	
Weeding	☐	☐	
Trash & Debris Removal	☐	☐	
Sediment / Leaf Removal	☐	☐	
Plant Pruning	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Plant Replacement	Rock Channel Replacement	Slope Slippage Repair	Pest/Disease/Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

CONSTRUCTED WETLAND INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Maintenance Access	Clear		Overgrown		Blocked
	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Plant Cover**	80-100%	60-80%	40-60%	20-40%	0-20%
	Vegetation Health	Well Established / Mature	Mostly Healthy	Sparse / Stressed	Many Dying	Dead / Absent
	Mosquito Proliferation	Absent				Present
	Weeds/Invasives	None		Slight		Overgrown
	Animal Burrows	None		<10		≥10
	Water Depth	Average		Nearing Berm Height		Flooding
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
	Erosion	None		Minor – Lack of Vegetated Cover		Major – Erosion Rills and Gullies
Pre-Treatment Area & Forebay	Sediment Buildup	Empty / Minimal Accumulation		Moderate / Half Full		Full / Nearly Full
Bottom of System	Drainage	Drains ≤ 24 Hours		Ponding > 72 Hours		No Drainage - Extensive Ponding
	Sediment Buildup***	Storage Zone Reduction of <25%		Storage Zone Reduction of >50%		Storage Zone Reduction of >100%
Berm / Embankment	Erosion / Undercutting	None	Ground Cover Missing	Slight Channelization	Heavily Channelized	Substantial Scouring
	Slope Stability / Grading	Well Defined		Moderately Defined		Poorly Defined

Spillways / Outfalls & Risers	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
	Structural Condition	Excellent		Deteriorating		Poor

**Reference the City's approved engineering plan and/or Stormwater Control Practice Maintenance Plan for the wetland planting plan.
***Reference the City's approved engineering plan and/or Stormwater Control Practice Maintenance Plan for basin elevations and sediment monitoring procedures.

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

A-4 SWALE / FILTER STRIP INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Vegetation Health			
	Weeds/Invasives			
	Mosquito Proliferation			
Inflow Points	Inlet Functionality			
Outlet / Overflow Structures*	Outlet Functionality			
Pre-Treatment Area	Sediment Buildup			
Perimeter / Embankment	Erosion / Undercutting			
	Slope Stability & Grading			
Bottom of System	Soil Moisture			
	Drainage			
	Soil Compaction			
	Sediment Buildup			

*Reference the outlet structure details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Trash & Debris Removal	☐	☐	
Weeding	☐	☐	
Trimming	☐	☐	
Minor Erosion Repair	☐	☐	
Sediment / Leaf Removal	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Plant Replacement	Rock Channel Replacement	Slope Slippage Repair	Pest/Disease/Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

SWALE / FILTER STRIP INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Vegetation Health	Well Established / Mature	Mostly Healthy	Sparse / Stressed	Many Dying	Dead / Absent
	Weeds/Invasives	None		Slight		Overgrown
	Mosquito Proliferation	Absent				Present
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
Outlet / Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
Pre-Treatment Area	Sediment Buildup	Empty / Minimal Accumulation		Moderate / Half Full		Full / Nearly Full
Perimeter / Embankment	Erosion / Undercutting	None	Ground Cover Missing	Slight Channelization	Heavily Channelized	Substantial Scouring
	Slope Stability / Grading	Well Defined		Moderately Defined		Poorly Defined
	Soil Moisture	Moist		Dry and Cracked		Cracked Soil - Extremely Hard
	Drainage	Under 24 Hours	Ponding > 24 Hours	Ponding > 48 Hours	Ponding >72 Hours	No Drainage - Extensive Ponding
	Soil Compaction	None		Slight		Extreme
	Sediment Buildup	None	<2”	2”-4”	4”-6”	>6”

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

A-5 UNDERGROUND STORAGE INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Aesthetics			
	Uneven Settling			
	Access			
Inflow Points	Inlet Functionality			
Outlet / Overflow Structures*	Outlet Functionality			
Bottom of System	Drainage			
	Sediment Buildup			

*Reference the outlet structure details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Trash & Debris Removal	☐	☐	
Filter Cleaning / Replacement	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Rock Channel Replacement	Slope Slippage Repair	Pest/Disease/Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

UNDERGROUND STORAGE INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Uneven Settling	None		Observed		Excessive
	Access	Unobstructed		Obstructed		Blocked
Inflow Points**	Inlet Functionality	Unobstructed		Obstructed		Blocked
Outlet/ Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
Bottom of System***	Sediment Buildup	None	<5%	50-10%	10-20%	>20%

**Reference the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan to determine if a pretreatment SCP is installed prior to the storage chamber and needs to be inspected.

***Reference the SCP details, elevations and sediment monitoring procedures provided within the City approved engineering plan and/or Stormwater Control Practice Maintenance Plan.

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

A-6 PERMEABLE PAVEMENT INFILTRATION TESTING FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Refer to the Permeable Pavement Simplified Infiltration Testing Methodology for infiltration testing instructions.

	Infiltration Time (seconds)									
	Test Site 1	Test Site 2	Test Site 3	Test Site 4	Test Site 5	Test Site 6	Test Site 7	Test Site 8	Test Site 9	Test Site 10
Infiltration Time										
Check boxes below if the infiltration time above meets the following criteria										
60-90 sec										
>90 sec										

Note: Refer to the Permeable Pavement Simplified Infiltration Testing Methodology to determine the number of test site locations required. Perform testing at a minimum of 3 test sites. Use additional forms if the number of test sites exceeds 10.

As-Needed Maintenance *(Check all that apply and describe in comment box below)*

Surface Sweeping *(check if any site infiltration times exceed 60 seconds)*	Pressure Washing	Other

Comments/Description of As-Needed Maintenance
(Provide enough detail for a follow-up work order to be created)

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

A-7 PERMEABLE PAVEMENT INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Evaluation

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
Pavement Surface	Sediment Accumulation			
	Debris / Trash & Oil / Chemical Accumulation			
	Standing Water			
	Weeds/Vegetation Growing in Pavement			
	Damaged Surface			
	Stone Missing Between Pavers			
	Heavy Vehicles Parked			
Adjacent Area	Evidence of Erosion			
Underdrains and Outlet Structure*	Underdrain Failure			
	Outlet Functionality			

*Reference the outlet structure details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Log *(Check if these tasks were performed while on-site)*

Trash & Debris Removal	Vegetation/Weed Removal

As-Needed Maintenance *(Mark all that apply & describe in the comment section below)*

Stone Replacement	Structure / Underdrain Repair	Pressure Washing	Surface Sweeping	Adjacent Site Restoration	Other

Comments / Description of As-Needed Maintenance

PERMEABLE PAVEMENT INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
Pavement Surface	Sediment Accumulation	None	<2”	2”-4”	4”-6”	>6”
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Standing Water	None		Ponding		Flooding
	Weeds / Vegetation Growing in Pavement	None		Slight		Overgrown
	Damaged Surface	None		Minor Damage Observed		Major Damage Observed
	Stone Missing Between Pavers	None		Slight		Severe
	Heavy Vehicles Parked	None		One		Several
Adjacent Area	Evidence of Erosion	None		Channelization / Sedimentation		Exposed Soil / Displaced Materials
Underdrains and Outlet Structure	Underdrain Failure	None		Slight Clogging		Severe Clogging
	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Sever Obstruction	Blocked

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

A-8 SAND FILTER INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Evaluation

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Mosquito Proliferation			
Inflow Points	Inlet Functionality			
	Erosion			
Outlet / Overflow Structures and Underdrains*	Outlet Functionality			
Pre-Treatment Area	Sediment Buildup			
Bottom of System	Drainage			

*Reference the outlet structure details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan for structure features to inspect and maintain.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Inlet Cleaning	☐	☐	
Minor Sediment Removal	☐	☐	
Trash & Debris Removal	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet/Outlet Cleaning	Media Replacement	Major Trash & Debris Removal	Major Sediment / Leaf Removal	Other

Comments / Description of As-Needed Maintenance

SAND FILTER INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Mosquito Proliferation	Absent				Present
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
	Erosion	Absent				Present
Outlet / Overflow Structures and Underdrains	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
Pre-Treatment Area	Sediment Buildup	Empty / Minimal Accumulation		Moderate / Half Full		Full / Nearly Full
Bottom of System	Drainage	Under 24 Hours	Ponding > 24 Hours	Ponding > 48 Hours	Ponding >72 Hours	No Drainage - Extensive Ponding

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

A-9 GREEN ROOF INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Evaluation

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview	Aesthetics			
	Debris/Trash & Oil/Chemical Accumulation			
	Plant Cover			
	Vegetation Health			
	Weeds/Invasives			
	Mosquito Proliferation			
Inflow Points	Inlet Functionality			
Outlet / Overflow Structures	Outlet Functionality			
Bottom of System	Soil Media			
	Soil Moisture			
	Drainage			
	Soil Compaction			
	Sediment Buildup			

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Watering	☐	☐	
Weeding	☐	☐	
Trimming	☐	☐	
Trash & Debris Removal	☐	☐	
Plant Pruning	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Plant Placement	Media Replacement	Major Trash & Debris Removal	Major Sediment / Leaf Removal	Pest / Desease / Invasive Species Management	Other

Comments / Description of As-Needed Maintenance

GREEN ROOF INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview*	Aesthetics	Excellent	Good	Neglected	Deteriorating	Poor
	Debris/Trash & Oil/Chemical Accumulation	None		Slight		Excessive
	Plant Cover	80-100%	60-80%	40-60%	20-40%	0-20%
	Vegetation Health	Well Established / Mature	Mostly Healthy	Sparse / Stressed	Many Dying	Dead / Absent
	Weeds/Invasives	None		Slight		Overgrown
	Mosquito Proliferation	Absent				Present
Inflow Points	Inlet Functionality	Unobstructed		Obstructed		Blocked
Outlet/ Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
Bottom of System	Soil Media	Good		Deteriorating / Sparse		Absent
	Soil Moisture	Moist		Dry and Cracked		Cracked Soil - Extremely Hard
	Drainage	Under 24 Hours	Ponding > 24 Hours	Ponding > 48 Hours	Ponding >72 Hours	No Drainage / Extensive Ponding
	Soil Compaction	None		Slight		Extreme
	Sediment Buildup	None	<2”	2”-4”	4”-6”	>6”

*Reference the details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan.

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

A-10 RAINWATER HARVESTING SYSTEM INSPECTION FORM

Date: _____ Time In: _____ am/pm Out: _____ am/pm
Facility Name & Address: _____
Owner Name & Contact Information: _____
Inspector Name & Contact Information: _____

Inspection & Maintenance Type (Check One)	Weather	Temp (°F)	Days Since Last Rainfall	Most Recent Precipitation (in)
☐ Establishment ☐ Routine				

Site Inspection

Category	Assessment Metric	Frequency	Rating 1 (poor) – 5 (excellent)	Comments
System Overview*	Debris / Trash & Oil / Chemical Accumulation			
Inflow Points	Inlet Functionality			
Outlet / Overflow Structures	Outlet Functionality			
Bottom of System	Sediment Buildup			

*Reference the cistern details provided within the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan.

Maintenance Performed (Check all that apply)	Establishment	Routine	Date
Exercise Valves	☐	☐	
Filter Cleaning / Replacement	☐	☐	

As-Needed Maintenance *(Check all that apply & describe in comment box)*

Inlet / Outlet Cleaning	Major Trash & Debris Removal	Major Sediment / Leaf Removal	Other

Comments / Description of As-Needed Maintenance

RAINWATER HARVESTING SYSTEM INSPECTION FORM RATING SYSTEM

Category	Assessment Metric	Rating Scale				
		5	4	3	2	1
System Overview	Debris / Trash & Oil / Chemical Accumulation	None		Slight		Excessive
Inflow Points**	Inlet Functionality	Unobstructed		Obstructed		Blocked
Outlet/ Overflow Structures	Outlet Functionality	Clear	Sediment Buildup	Slight Obstruction	Severe Obstruction	Blocked
Bottom of System	Sediment Buildup	None	<2”	2”-4”	4”-6”	>6”

**Reference the City approved engineering plan and/or Stormwater Control Practice (SCP) Maintenance Plan to determine if a pretreatment SCP is installed prior to the cistern and needs to be inspected.

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

Stormwater Drainage Manual

Appendix B

Native Plant Species
For Stormwater Control Practices

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 soils[1]. 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 thousands 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, eventually, 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 non-native plants introduced into environments where they did not evolve or are likely to cause economic or environmental harm or harm to human health. 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 Ohio that should be avoided.

[1] The Ohio State University Extension Bulletin 865

Table B-1 Common Invasive Plants Found in Franklin County	
Botanical Name	**Common Name**
Ailanthus altissima	Tree of Heaven
Alliaria petiolata	Garlic Mustard
Ampelopsis brevipedunculata	Porcelainberry
Azolla pinnata	Pinnate Mosquitofern
Berberis vulgaris	Common Barberry
Butomus umbellatus	Flowering Rush
Celastrus orbiculatus	Asian Bittersweet
Centaurea stoebe ssp. micranthos	Spotted Knapweed
Dipsacus fullonum	Common Teasel
Dipsacus laciniatus	Cutleaf Teasel
Egeria densa	Brazilian Waterweed
Eichhornia azurea	Anchored Water Hyacinth
Elaeagnus angustifolia	Russian Olive
Elaeagnus umbellata	Autumn Olive
Epilobium hirsutum	Hairy Willowherb
Fallopia japonica	Japanese Knotweed
Ficaria verna	Lesser Celandine
Heracleum mantegazzianum	Giant Hogweed
Hesperis matronlis	Dames Rocket
Hydrilla verticillata	Hydrilla
Hydrocharis morsus-ranae	European Frogbit
Hygrophila polysperma	Indian Swampweed
Iris pseudacorus	Yellow Flag Iris
Lagarosiphon major	African Oxygen Weed
Ligustrum vulgare	Common Privet
Limnophila sessiliflora	Asian Marshweed
Lonicera japonica	Japanese Honeysuckle
Lonicera maackii	Amur Honeysuckle
Lonicera morrowii	Morrow's Honeysuckle
Lonicera tatarica	Tatarian Honeysuckle
Lythrum salicaria	Purple Loosestrife
Lythrum virgatum	European Wand Loosestrife
Marsilea guadrifolia	European Water-Clover
Microstegium vimineum	Japanese Stiltgrass
Monochoria hastata	Arrowleaf False Pickerelweed
Monochoria vaginalis	Heartshape False Pickerelweed
Morus alba	White Mulberry
Myriophyllum aquaticum	Parrot Feather Watermilfoil
Myriophyllum spicatum	Eurasian Watermilfoil
Najas minor	Brittle Waternymph
Nymphoides peltata	Yellow Floating Heart

Table B-1 Common Invasive Plants Found in Franklin County	
Botanical Name	**Common Name**
Ottelia alismoides	Duck Lettuce
Paulownia tomentosa	Princess Tree
Persicaria perfoliata	Mile-A-Minute
Phalaris arundinacea	Reed Canary Grass
Phragmites australis ssp. australis	Common Reed
Pistia stratiotes	Water Lettuce
Potamogeton crispus	Curly Pondweed
Pueraria montana var. lobata	Kudzu
Pyrus calleryana	Callery pear
Rhamnus cathartica	European buckthorn
Rosa multiflora	Multiflora rose
Sagittaria sagittifolia	Arrowhead
Salix fragilis	Crack Willow
Salvinia minima	Common Salvinia
Salvinia molesta	Giant Salvinia
Sparganium erectum	Simple Bur-Reed
Stratiotes aloides	Water Soldier
Trapa natans	Water Chestnut
Typha angustifolia	Narrowleaf Cattail
Typha x glauca	Hybrid Cattail
Ulmus pumila	Siberian Elm
Vincetoxicum nigrum	Black Swallowwort

Table B-2 lists native plant species that are approved for use in stormwater control practices in Franklin County. 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.

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Acorus americanus	Sweet flag	Wet				x	x	x	
Agastache nepetoides	Yellow giant hyssop	Dry							
Agastache scrophulariaefolia	Purple giant hyssop	Dry							
Alisma subcordatum	Common water plantain	Wet		x	x	x	x	x	
Allium canadense	Wild onion	Dry							
Allium cernuum	Nodding wild onion	Medium	x						
Amorpha fruticosa	Indigo bush	Wet							x
Andropogon gerardii[4]	Big bluestem grass	Medium	x					x	
Andropogon virginicus	Broom sedge	Medium							x
Anemone canadensis	Meadow anemone	Wet							
Anemone cylindrica	Thimbleweed	Dry	x						
Anemone virginiana	Tall anemone	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

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Anemonella thalictroides	Rue anemone	Dry							
Angelica atropurpurea	Great angelica	Wet		x					
Apocynum androsaemifolium	Spreading dogbane	Dry							
Aquilegia canadensis	Wild columbine	Medium	x						x
Asclepias incarnata	Swamp milkweed	Wet		x		x			
Asclepias purpurascens	Purple milkweed	Dry							
Asclepias sullivantii	Prairie milkweed	Dry							
Asclepias syriaca	Common milkweed	Dry	x						
Asclepias tuberosa	Butterfly weed	Dry	x						x
Asclepias verticillata	Whorled milkweed	Dry	x						
Aster cordifolius	Heart-leaved aster	Dry							
Aster divaricatus									
Aster ericoides	Heath aster	Dry							x
Aster firmus	Shining aster	Wet							
Aster laevis	Smooth blue aster	Dry						x	x
Aster lanceolatus								x	
Aster lateriflorus	Side-flowering aster	Medium							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Aster macrophyllus	Big-leaved aster	Dry							
Aster novae-angliae	New England aster	Wet		x				x	
Aster oolentangiensis	Sky-blue aster	Dry	x						x
Aster praealtus	Willow aster	Wet							
Aster puniceus	Bristly aster	Wet		x					x
Aster sagittifolius	Arrow-leaved aster	Dry							
Aster shortii	Short's aster	Dry							
Aster umbellatus	Flat-top aster	Wet		x	x				
Astragalus canadensis	Canadian milk vetch	Dry							
Baptisia australis	Blue wild indigo	Dry	x						x
Baptisia lactea	White wild indigo	Medium	x						
Baptisia tinctora	Yellow wild indigo	Dry							
Bidens cernua	Nodding beggars tick	Wet		x	x			x	x
Bidens coronata	Tall swamp marigold	Wet							
Bidens frondosa	Common beggars tick	Wet						x	
Blephilia hirsuta	Wood mint	Dry							
Boltonia asteroides	False aster	Wet							
Bouteloua curtipendula	Side-oats grama	Dry	x					x	x

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Brasenia schreberi	Water shield	Wet							
Bromus ciliatus	Fringed brome	Wet							
Bromus pubescens	Woodland brome	Medium							
Cacalia atriplicifolia	Pale indian plantain	Dry	x						
Cacalia muhlenbergii	Great indian plantain	Dry							
Cacalia plantaginea	Prairie indian plantain	Medium							
Cacalia suaveolens	Sweet indian plantain	Wet							
Calamagrostis canadensis [3]	Blue joint grass	Wet		x	x			x	
Caltha palustris	Marsh marigold	Wet			x	x			
Campanula americana	Tall bellflower	Medium							
Carex annectens	Large yellow fox sedge	Wet							
Carex aquatilis	Long-bracted tussock sedge	Wet							
Carex atherodes	Hairy-leaved lake sedge	Wet							
Carex bebbii	Bebb's oval sedge	Wet							
Carex bicknellii	Copper-shouldered oval sedge	Dry							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Carex brevior	Plains oval sedge	Dry							
Carex cephaloidea	Rough-clustered sedge	Medium							
Carex comosa	Bristly sedge	Wet		x			x	x	
Carex crinita	Fringed sedge	Wet			x		x		
Carex cristatella	Crested oval sedge	Wet						x	
Carex crus-corvi	Crowfoot fox sedge	Wet							
Carex davisii	Awned graceful sedge	Medium							
Carex emoryi	Riverbank sedge	Wet							
Carex frankii	Bristly cattail sedge	Wet							
Carex granularis	Pale sedge	Wet						x	
Carex grayi	Common bur sedge	Wet							
Carex haydenii	Long-scaled tussock sedge	Wet							
Carex hystericina	Porcupine sedge	Wet			x				
Carex interior	Prairie star sedge	Wet							
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							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
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 panicled sedge	Wet							
Carex projecta	Loose-headed oval sedge	Wet							
Carex rosea	Curly-styled wood sedge	Dry							
Carex scoparia	Lance-fruited oval sedge	Wet							
Carex shortiana									
Carex squarrosa	Narrow-leaved cattail sedge	Wet			x				
Carex stipata	Common fox sedge	Wet						x	
Carex straminea	Awned oval sedge	Wet							
Carex stricta	Common tussock sedge	Wet		x					
Carex tribuloides	Awl-fruited oval sedge	Wet							
Carex typhina	Common cattail sedge	Wet			x				

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Carex utriculata	Common yellow lake sedge	Wet							
Carex vesicaria	Tufted lake sedge	Wet							
Carex viridula	Green yellow sedge	Wet							
Carex vulpinoidea	Brown fox sedge	Wet			x	x	x	x	
Chamaecrista fasciculata	Partridge pea	Dry	x						
Chelone glabra	Turtlehead	Wet			x				
Cinna arundinacea	Common wood reed	Wet			x				
Clematis virginiana	Virgin's bower	Medium							
Coreopsis palmata	Prairie coreopsis	Dry	x						
Coreopsis tripteris	Tall coreopsis	Medium		x				x	
Crotalaria sagittalis	Rattlebox	Dry							
Cyperus esculentus	Field nut sedge	Medium					x	x	
Danthonia spicata									
Decodon verticillatus	Swamp loosestrife	Wet					x		
Deschampsia caespitosa glauca	Tufted hair grass	Wet							x
Desmanthus illinoensis	Illinois sensitive plant	Dry	x						

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Desmodium canadense	Showy tick trefoil	Medium							
Desmodium canescens	Hoary tick trefoil	Dry							
Desmodium illinoense	Illinois tick trefoil	Dry	x						
Desmodium sessilifolium	Sessile-leaved tick trefoil	Dry							
Diarrhena americana	Beak grass	Dry							
Dodecatheon meadia	Shooting star	Medium	x						
Dulichium arundinaceum	Three-way sedge	Wet							
Echinacea pallida	Purple coneflower	Dry							
Echinacea purpurea	Broad-leaved purple coneflower	Dry	x						x
Echinochloa crus-galli	Barnyard grass	Wet		x	x				x
Eleocharis acicularis	Needle spike rush	Wet					x		
Eleocharis obtusa	Blunt spike rush	Wet				x	x	x	
Eleocharis palustris major	Great spike rush	Wet					x		x

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Eleocharis smallii	Creeping spike rush	Medium						x	
Elymus canadensis	Canada wild rye	Medium	x	x	x			x	
Elymus riparius [3]	Riverbank wild rye	Medium							
Elymus villosus	Silky wild rye	Dry							
Elymus virginicus [3]	Virginia wild rye	Medium			x	x		x	
Epilobium coloratum	Cinnamon willow herb	Wet							
Equisetum hyemale	Tall scouring rush	Medium		x					
Eryngium yuccifolium	Rattlesnake master	Medium							
Eupatorium coelestinum	Blue mistflower	Medium	x						
Eupatorium fistulosum	Hollow joe-pye weed	Wet							
Eupatorium maculatum	Spotted joe-pye weed	Wet		x				x	
Eupatorium perfoliatum	Common boneset	Wet		x		x		x	x
Eupatorium purpureum	Purple joe-pye weed	Dry	x						
Eupatorium rugosum	White snakeroot	Dry							
Eupatorium serotinum	Late boneset	Medium	x						

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Euphorbia corollata	Flowering spurge	Dry	x						
Filipendula rubra	Queen of the prairie	Wet		x					
Gentiana andrewsii	Bottle gentian	Wet		x					
Gentiana flavida	Cream gentian	Medium							
Geranium maculatum	Wild geranium	Dry							
Geum triflorum	Prairie smoke	Dry							
Glyceria canadensis	Rattlesnake grass	Wet							
Glyceria grandis	Reed manna grass	Wet							
Glyceria pallida	Pale manna grass	Wet							
Glyceria striata	Fowl manna grass	Wet		x	x	x		x	
Helenium autumnale	Sneezeweed	Wet		x	x	x		x	x
Helianthus giganteus	Tall sunflower	Wet							
Helianthus grosseserratus	Sawtooth sunflower	Medium	x					x	
Helianthus mollis	Downy sunflower	Dry	x						
Helianthus occidentalis	Western sunflower	Dry	x						
Helianthus rigidus	Prairie sunflower	Dry							
Helianthus strumosus	Pale-leaved sunflower	Dry							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Helianthus tuberosus	Jerusalem artichoke	Medium	x						
Heliopsis helianthoides	False sunflower	Dry							
Heracleum maximum	Cow parsnip	Dry							
Heuchera richardsonii	Prairie alum root	Medium							
Hibiscus laevis	Halberd-leaved rose mallow	Wet					x		
Hibiscus moscheulos	March hibiscus	Wet							
Hibiscus palustris	Swamp rose mallow	Wet					x		x
Hierochloe odorata	Sweet grass	Wet							x
Hypericum pyramidatum	Great St. John's wort	Medium							x
Hypericum virginicum	Marsh St. John's wort	Wet							x
Hypernicum prolificum	Shrubby St. John's wort	Dry	x						
Hystrix patula	Bottlebrush grass	Dry							
Ilex verticillata	Winterberry	Wet							x
Iris virginica shrevei	Blue flag iris	Wet		x		x	x	x	

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Iris versicolor									
Juncus canadensis	Canadian rush	Wet							x
Juncus dudleyi	Dudley's rush	Medium							
Juncus effusus	Common rush	Wet		x		x	x	x	
Juncus tenuis	Path rush	Medium							
Juncus torreyi	Torrey's rush	Wet						x	x
Justicia americana	Water willow	Wet					x		
Koeleria cristata	June grass	Dry							
Kuhnia eupatoroides corymbulosa	False boneset	Dry							
Lathyrus palustris	Marsh vetchling	Wet							x
Leersia oryzoides	Rice cut grass	Wet		x	x	x	x	x	
Lemna minor	Duckweed, floating								
Lespedeza capitata	Round-headed bush clover	Dry	x						
Liatris aspera	Rough blazing star	Dry	x						x
Liatris cylindracea	Cylindrical blazing star	Dry	x						
Liatris pycnostachya	Prairie blazing star	Medium	x						
Liatris scariosa nieuwlandii	Savanna blazing star	Dry							
Liatris spicata	Marsh blazing star	Medium	x						

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Lobelia cardinalis	Cardinal flower	Wet		x		x			
Lobelia inflata	Indian tobacco	Dry	x						
Lobelia siphilitica	Great blue lobelia	Wet		x	x	x			
Lobelia spicata	Pale spiked lobelia	Medium	x						
Ludwigia alternifolia	Seedbox	Wet		x		x			
Lupinus perennis occidentalis	Wild lupine	Dry	x						
Lycopus americanus	Common water horehound	Wet							
Lythrum alatum	Winged loosestrife	Wet							
Matteuccia struthiopteris									
Mentha arvensis villosa	Wild mint	Wet							
Mertensia virginica	Virginia bluebells	Wet							
Mimulus ringens	Monkey flower	Wet			x	x			
Monarda fistulosa	Wild bergamot	Dry	x					x	
Monarda punctata	Horse mint	Dry							
Napaea dioica	Glade mallow	Medium							
Nelumbo lutea	Lotus (clay ball)	Wet							
Nuphar advena	Yellow pond lily	Wet					x		x
Nymphaea tuberosa	White water lily (rooted buds)	Wet					x		

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Nymphaea oderata									
Oenothera biennis	Common evening primrose	Dry							
Onoclea sesabilis									
Opuntia humifusa	Eastern prickly pear	Dry							
Osmorhiza claytonii	Hairy sweet cicely	Dry							
Osmunda cinnomomea									
Osmunda regalis									
Oxypolis rigidior	Cowbane	Wet							
Panicum clandestinum	Deer-tongue grass	Wet							
Panicum rigidulum	Munro grass	Wet							
Panicum virgatum [3]	Switch grass	Medium	x	x	x			x	x
Parthenium integrifolium	Wild quinine	Dry	x						
Parthenocissus quinquefolia	Virginia creeper	Medium							x
Pedicularis lanceolata	Fen betony	Wet							
Peltandra virginica	Arrow arum	Wet		x			x		
Penstemon calycosus	Smooth beard tongue	Dry	x						

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Penstemon digitalis	Foxglove beard tongue	Medium	x						
Penstemon hirsutus	Hairy beard tongue	Dry	x						
Penthorum sedoides	Ditch stonecrop	Wet							
Petalostemum candidum	White prairie clover	Dry							
Petalostemum purpureum	Purple prairie clover	Dry	x					x	x
Phlox divaricata	Woodland phlox	Dry							
Phlox pilosa	Sand prairie phlox	Medium							
Physostegia virginiana	Obedient plant	Wet							x
Physostegia virginiana arenaria	Prairie obedient plant	Dry	x						
Polygonatum canaliculatum	Smooth Solomon's seal	Dry							
Polygonum amphibium stipulaceum	Water knotweed	Wet					x	x	
Polygonum pensylvanicum	Pinkweed	Wet							x
Pontederia cordata	Pickerel weed	Wet				x	x		
Potamogeton natans	Common pondweed	Wet					x		

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Potamogeton pectinatus	Sago pondweed	Wet					x		x
Potentilla arguta	Prairie cinquefoil	Dry							
Prenanthes altissima	Tall white lettuce	Dry							
Pycnanthemum muticum	Broad-leaved mountain mint	Wet							
Pycnanthemum tenuifolium	Slender mountain mint	Medium							
Pycnanthemum virginianum	Common mountain mint	Wet		x				x	
Ranunculus fascicularis	Early buttercup	Dry							
Ratibida pinnata	Yellow coneflower	Dry						x	
Rhynchospora macrostachya	Horned beak rush	Wet							x
Rosa carolina	Pasture rose	Dry							
Rosa palustris	Swamp rose	Wet				x			
Rudbeckia hirta	Black-eyed susan	Dry	x					x	x
Rudbeckia laciniata	Wild golden glow	Wet			x	x			
Rudbeckia speciosa sullivantii	Showy black-eyed susan	Wet							
Rudbeckia subtomentosa	Sweet black-eyed susan	Medium	x						
Rudbeckia triloba	Brown-eyed susan	Medium							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Rumex altissimus	Pale dock	Medium							
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
Scrophularia marilandica	Late figwort	Dry							
Senecio aureus	Golden ragwort	Wet							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Senna hebecarpa	Wild senna	Wet		x		x			
Silene regia	Royal catchfly	Dry							
Silene stellata	Starry campion	Dry							
Silene virginica	Fire pink	Dry							
Silphium integrifolium	Rosin weed	Dry							
Silphium laciniatum	Compass plant	Dry	x					x	
Silphium perfoliatum	Cup plant	Medium		x					
Silphium terebinthinaceum	Prairie dock	Dry						x	
Sisyrinchium angustifolium	Stout blue-eyed grass	Medium							
Sisyrinchium atlanticum	Eastern blue-eyed grass	Wet							
Sium suave	Tall water parsnip	Wet							x
Smilacina racemosa	Feathery false Solomon's seal	Dry							
Solidago altissima	Tall goldenrod	Dry							
Solidago caesia	Blue-stemmed goldenrod	Dry							
Solidago canadensis	Canadian goldenrod	Dry							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Solidago flexicaulis	Broad-leaved goldenrod	Dry							
Solidago gigantea	Late goldenrod	Medium						x	
Solidago graminifolia	Common grass-leaved goldenrod	Medium							
Solidago juncea	Early goldenrod	Dry							
Solidago nemoralis	Old-field goldenrod	Dry							
Solidago ohioensis	Ohio goldenrod	Wet							
Solidago patula	Swamp goldenrod	Wet							
Solidago riddellii	Riddell's goldenrod	Wet							
Solidago rigida	Stiff goldenrod	Dry	x					x	x
Solidago rugosa	Rough goldenrod	Medium							
Solidago speciosa	Showy goldenrod	Dry							x
Sorghastrum nutans [3]	Indian grass	Medium						x	
Sparganium americanum	American bur reed	Wet					x		
Sparganium eurycarpum	Common bur reed	Wet				x	x	x	
Spartina pectinata [3]	Prairie cord grass	Wet		x	x			x	x
Sporobolus heterolepis	Prairie dropseed	Dry							x
Stipa spartea	Porcupine grass	Dry							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Styloforum diphyllum	Calendine poppy	Dry							
Tephrosia virginiana	Goat's rue	Dry							
Teucrium canadense	Germander	Wet							x
Thalictrum dasycarpum	Purple meadow rue	Medium	x						
Thalictrum dioicum	Early meadow rue	Medium	x						
Tradescantia ohiensis	Common spiderwort	Medium	xx					x	
Triglochin maritima	Common bog arrow grass	Wet							
Triosteum aurantiacum	Early horse gentian	Dry							
Typha latifolia									
Uniola latifolia	Spike grass	Wet							
Vallisneria american							x		
Verbena hastata	Blue vervain	Wet		x		x	x	x	
Verbena stricta	Hoary vervain	Dry							x
Verbesina alternifolia	Wingstem	Wet			x	x			
Vernonia altissima	Smooth tall ironweed	Medium							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Vernonia altissima taeniotricha	Hairy tall ironweed	Medium							
Vernonia fasciculata	Common ironweed	Wet				x		x	
Vernonia missurica	Missouri ironweed	Medium							
Vernonia novaboracencis									
Veronicastrum virginicum	Culver's root	Medium	x						
Viola lanceolata	Lance-leaved violet	Wet							
Viola pedata lineariloba	Bird's foot violet	Dry							
Zizania aquatica	Wild rice	Wet					x		x
Zizia aptera	Heart-leaved meadow parsnip	Dry							
Zizia aurea	Golden alexanders	Medium	x						x

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
WOODY MATERIAL - Native Ohio Trees and Shrubs									
Acer negundo	Box elder	Medium							
Acer rubrum	Red maple	Medium						x	
Acer saccharinum	Silver maple	Medium							
Acer saccharum	Sugar maple	Dry							
Aesculus flava	Yellow Buckey	Dry							
Aesculus glabra	Ohio Buckeye	Dry							
Alnus incana	Black Alder								
Alnus serrulata	Smooth Alder	Wet							
Amelanchier arborea	Serviceberry	Medium							
Amelanchier laevis	Smooth Serviceberry								
Aronia arbutifolia	Red Chokeberry								
Aronia melanocarpa	Black chokeberry	Medium							
Asimina triloba	Pawpaw	Wet							
Betula alleghaniensis	Yellow Birch	Medium							
Betula lenta	Sweet birch	Medium							
Betula nigra	River birch	Wet							x
Betula populifolia	Gray birch	Medium							
Carpinus caroliniana	Blue beech	Medium							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Carya glabra	Pignut hickory	Dry							
Carya laciniosa	Kingnut hickory	Wet							
Carya ovata	Shagbark hickory	Medium							x
Ceanothus americanus	New Jersey tea	Dry							
Celtis occidentalis	Hackberry	Medium						x	
Cephalanthus occidentalis	Buttonbush	Wet						x	
Cercis canadensis	Redbud	Dry							
Chionanthus virginicus	Fringe tree	Medium							
Clethra alnifolia									
Cornus alternifolia	Alternate lf dogwood	Dry							
Cornus amomum	Silky dogwood	Wet							
Cornus florida	Flowering dogwood	Dry							
Cornus racemosa	Grey dogwood	Medium						x	
Cornus sericea	Red-osier dogwood	Wet						x	
Cratageus crus-galli	Cockcpur	Medium							
Diospyros virginiana	Persimmon	Medium							
Fagus grandifolia	American beech	Medium							
Fraxinus americana	White ash	Medium							

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Fraxinus pennsylvanica	Green ash	Medium						x	x
Fraxinus quadrangulata	Blue ash								
Gymnocladus dioicus	KY coffee tree								
Hamamelis virginiana	Witchhazel	Dry							
Ilex verticillata	Winterberry	Medium							
Juglans nigra	Black Walnut	Medium							
Juniperus virginiana	Eastern red cedar								
Lindera benzoin	Spicebush	Medium							
Liquidambar styraciflua	Sweet gum	Dry							x
Liriodendron tulipifera	Tulip tree	Medium							
Nyssa sylvatica	Black gum	Medium							x
Parthenocissus quinquefolia	Virginia creeper	Medium							
Physocarpus opulifolius	Ninebark	Medium							
Platanus occidentalis	Sycamore	Wet							x

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Populus deltoides	Eastern cottonwood	Wet							
Populus tremuloides	Quaking aspen	Medium							
Prunus serotina	Black cherry	Medium							
Prunus virginiana	Choke cherry	Medium							
Quercus alba	White oak	Medium							x
Quercus bicolor	Swamp white oak	Wet						x	x
Quercus coccinea	Scarlet oak	Dry							
Quercus imbricaria	Shingle Oak	Dry							
Quercus macrocarpa	Bur oak	Medium						x	x
Quercus muhlenbergii	Chinquapin oak	Dry							
Quercus palustris	Pin oak	Wet						x	x
Quercus rubra	Red oak	Dry							x
Quercus shumardii	Shumard oak	Medium							
Quercus velutina	Black oak	Dry							
Rhus aromatica	Fragrant sumac	Dry							
Rhus copallina	Winged sumac	Medium							
Rhus typhina	Staghorn sumac	Dry							
Salix amygdaloides	Peachleaf willow	Medium						x	
Salix discolor	Pussy willow	Medium							
Salix nigra	Black willow	Medium						x	

Table B-2
Approved Native Plant Species[2]

Botanical Name	Common Name	Soil Moisture	Upland Buffer	Meadow	Wooded Wetland	Edge	Emergent	Stormwater Basin	Salt Tolerant
				Saturated	Shallow	Shallow	Deep	Tested[3]	
Salix sericea	Silky willow	Wet							
Sambucus canadensis	Elderberry	Medium							x
Sassafras albidum	Sassafras	Medium							
Spiraea alba	Meadowsweet	Wet							x
Spiraea tomentosa	Steeple bush	Wet							x
Staphylea trifolia	Bladdernut	Medium							
Taxodium distichum	Bald cypress	Wet							x
Thuja occidentalis	Arborvitae	Medium							
Tilia americana	American basswood	Medium							
Viburnum cassinoides	With-rod	Medium							
Viburnum dentatum	Arrow wood	Medium						x	
Viburnum lentago	Nannyberry	Medium						x	x
Viburnum prunifolium	Black haw	Medium							x
Viburnum recognitum	Northern arrow-wood	Medium							
Viburnum trilobum	American highbush cranberry	Wet							x

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Stormwater Drainage Manual

Appendix C

Calculation Worksheets

PROJECT: DATE:

BY: CHECKED BY: CONSULTANT: RETURN INTERVAL:

M.H. or C.B. No.	Sta.	Drainage Area					Time		Rainfall Intensity (in/hr)	Discharge Q (cfs)	Length of pipe (feet)	Slope of pipe (ft/ft)	Size of pipe (in)	Mean velocity (ft/sec)	Capacity flowing full (cfs)	Remarks
		Δ A (acres)	ε A (acres)	C	Δ CA (acres)	ε CA (acres)	Δ t (minutes)	ε t (minutes)								

PROJECT: DATE:

BY: CHECKED BY: CONSULTANT: RETURN INTERVAL:

M.H. or C.B. No.	Sta.	ε CA (acres)	ε t (minutes)	Rainfall Intensity (in/hr)	Discharge Q (cfs)	Length of pipe (ft)	Size of pipe (inches)	Slope of pipe, S (ft/ft)	Minor losses H_m f(t)	S_f (ft/ft)	$Hf=S_f L$ (feet)	TW or 0.8 D Elev.	HW Elev.	Crit. Elev.	Remarks

DITCH INFORMATION

MANNING'S "n" FOR:

Calculated by: _____ **Date:** _____

Checked by: _____ **Date:** _____

Seeded Lining: _____

Sod or Jute Mat Lining: _____

Paved Lining: _____

Dumped Rock Channel Protection: _____

ALLOWABLE VELOCITY FOR (in f.p.s.)

Seeded Lining: _____

Sod or Jute Mat Lining: _____

Design Frequency For:

Velocity _____ Yrs

Depth _____ Yrs

DITCH CALCULATIONS

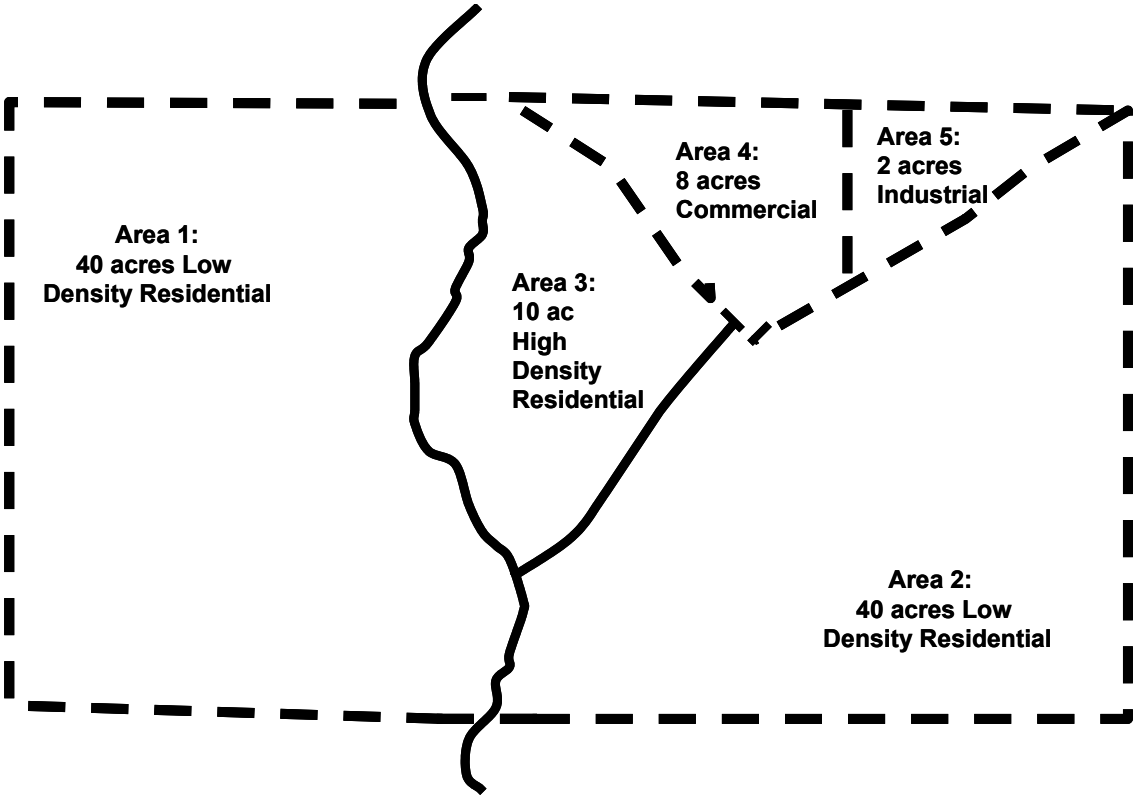
Ref. No	Station: High Point	Station: Point of Solution	Side	Drainage Area: Δ A (acres)	Drainage Area: ε A (acres)	Time: Overland	Time: Ditch	Time: ε t	Intensity: Velocity	Intensity: Depth	Runoff Coef	Coe. X A: Δ CA	Coe. X A: ε CA	CiA: Qv	CiA: Qd	Critical depth dc (ft.)	Slope ft./ft.	Velocity in f.p.s	Depth in ft.	Ditch Time Check	Treatment: Lining	Treatment: Station From	Treatment: Station To

Stormwater Drainage Manual

Appendix D

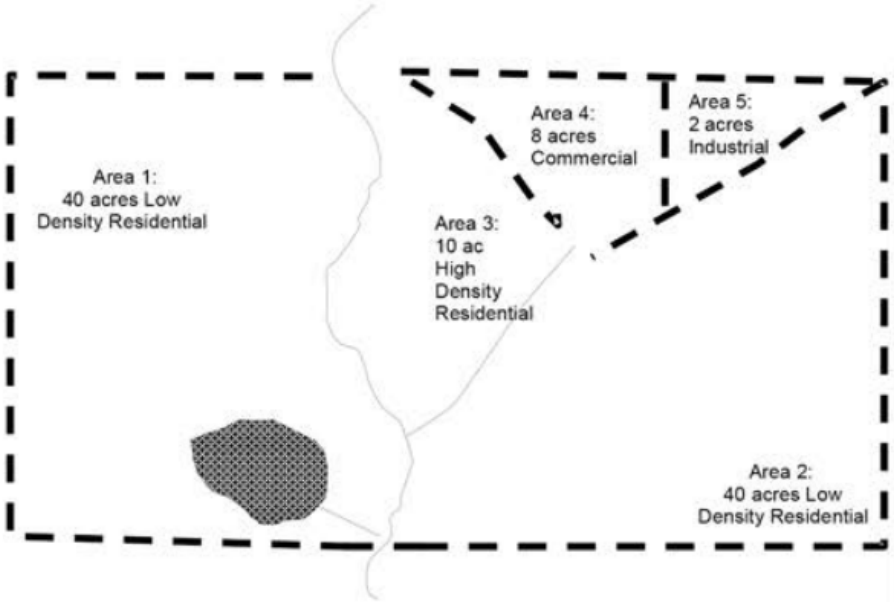
Examples for Stormwater Quality Control

Example 110 Acre Development Site: Area Details



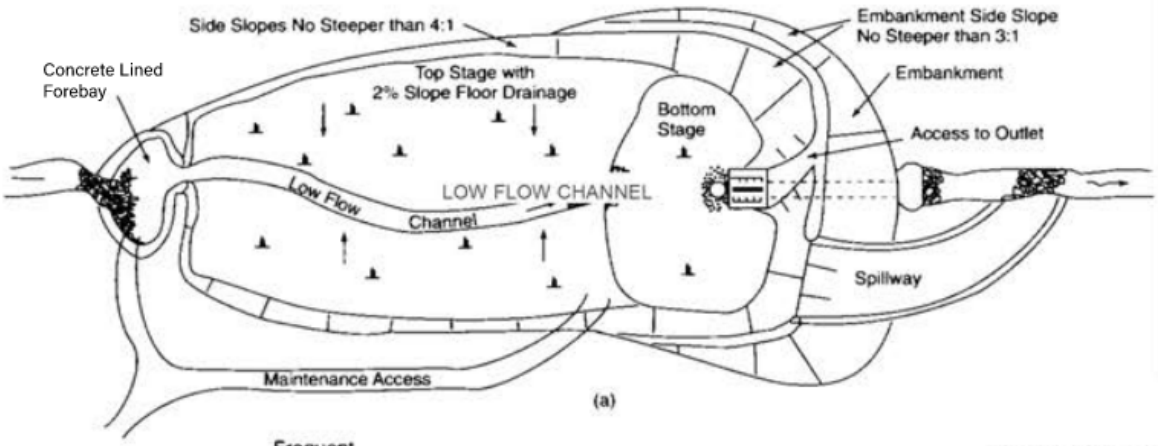
Area Identifier	Size (ac)	Equivalent Land Use (Table 3-5: Runoff Coefficients for Determining WQv)	Runoff Coefficient for WQv
Area 1: Low Density Residential	40	½ acre lots	0.3
Area 2: Low Density Residential	40	½ acre lots	0.3
Area 3: High Density Residential	10	1/8 acre lots	0.5
Area 4: Commercial	8	Commercial/Business and Industrial	0.8
Area 5: Industrial	2	Commercial/Business and Industrial	0.8

Example 110 Acre Development Site: Dry Extended Detention Basin Sizing for Area 1

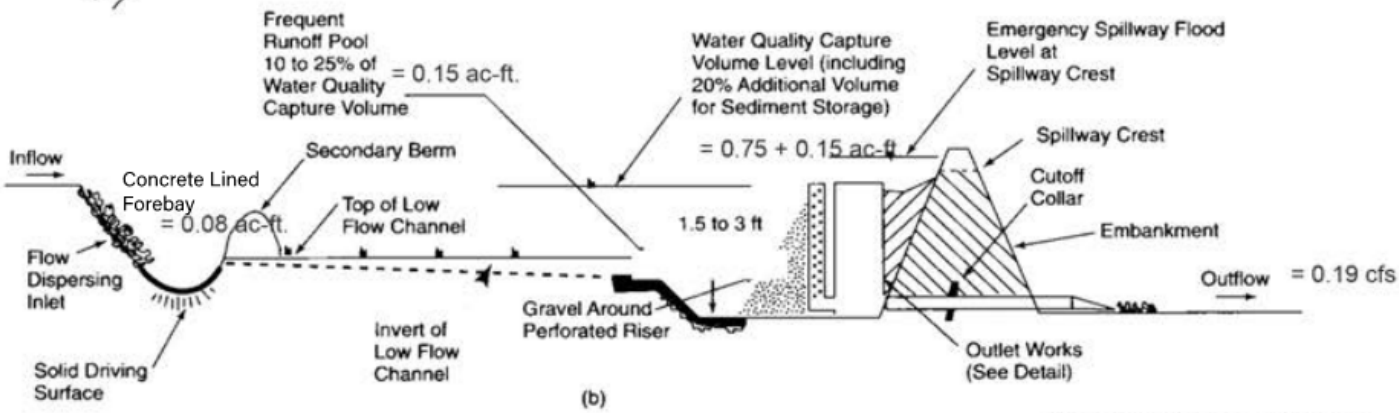


Area 1:
Extended Dry Detention Pond
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75" * 0.3 * 40 ac) / 12
= .75 ac-ft
Extended Detention = WQV (Sec. 3.3.4)
= .75 ac-ft
Sediment Storage = 0.2 * WQV (Sec. 3.3.4)
= .15 ac-ft
Forebay = 0.1 * WQV (Sec. 3.3.4.1)
= 0.08 ac-ft
Micropool = 0.2 * WQV (Sec. 3.3.4.1)
= 0.15 ac-ft
Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.4)
= (.75 ac-ft / 48 hrs) * (43560sf/ac)(1h/3600s)
= .19 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 cfs
Number of perforations (Sec. 3.3.4.1)
= 0.19 cfs / 0.005 cfs
= 38 (Use 5 rows with 8 perforations per row with each row 4 inches apart)

Extended Dry Detention Basin Site



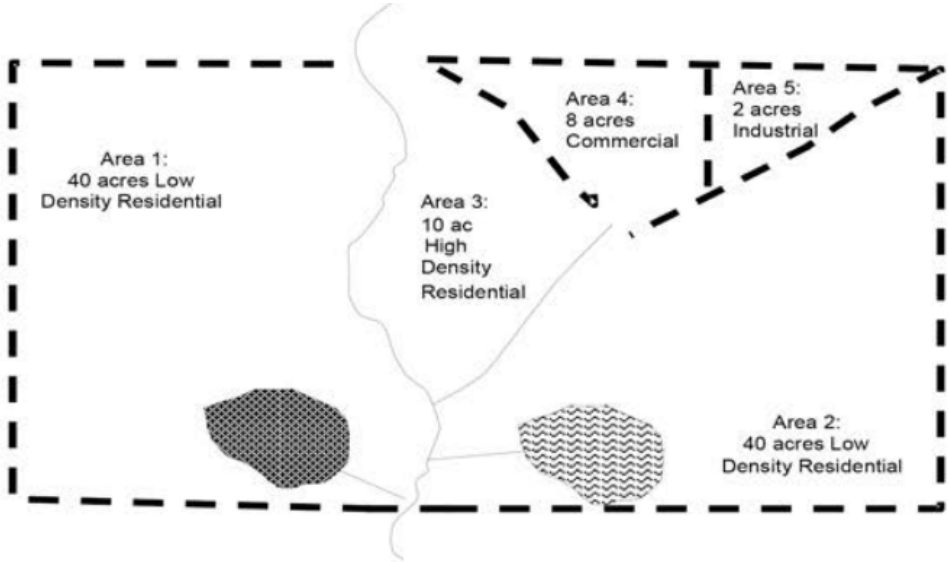
(a)



(b)

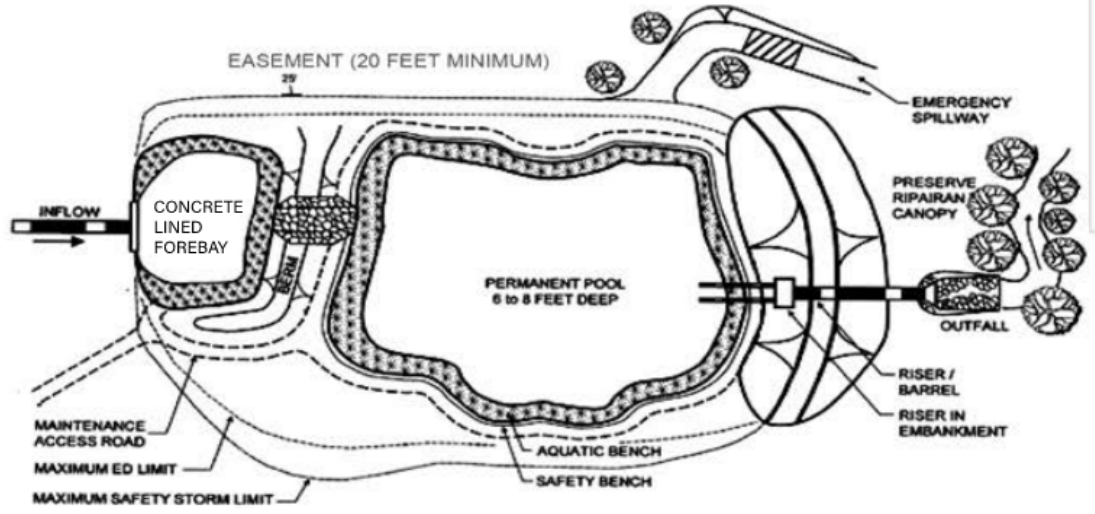
Note: The water quality capture volume plus sediment storage volume includes the forebay volume and micropool volume.

Example 110 Acre Development Site: Wet Detention Basin Sizing for Area 2

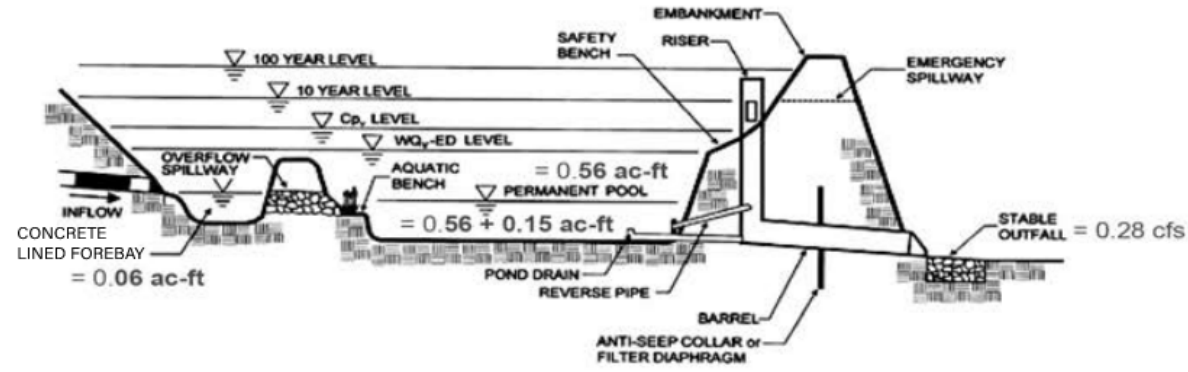


Area 2:
Wet Detention Pond
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75" * 0.3 * 40 ac) / 12
= .75 ac-ft
Extended Detention = 0.75 * WQV (Sec. 3.3.4)
= .56 ac-ft
Permanent Pool = 0.75 * WQV (Sec. 3.3.4)
= .56 ac-ft
Sediment Storage = 0.2 * WQV (Sec. 3.3.4)
= .15 ac-ft
Forebay = 0.1 * WQV (Sec. 3.3.4.1)
= 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)
$Q = AC(64.4\ H)^{1/2}$
$0.28 = A*0.66(64.4*5)^{1/2}$
$A = 0.024\ ft^2$
$= \pi * D^2/4$
$D = (4*0.024\ ft^2/\pi)^{1/2} * 12$
= 2 inches

Extended Dry Detention Basin Site
Wet Detention Basin Site

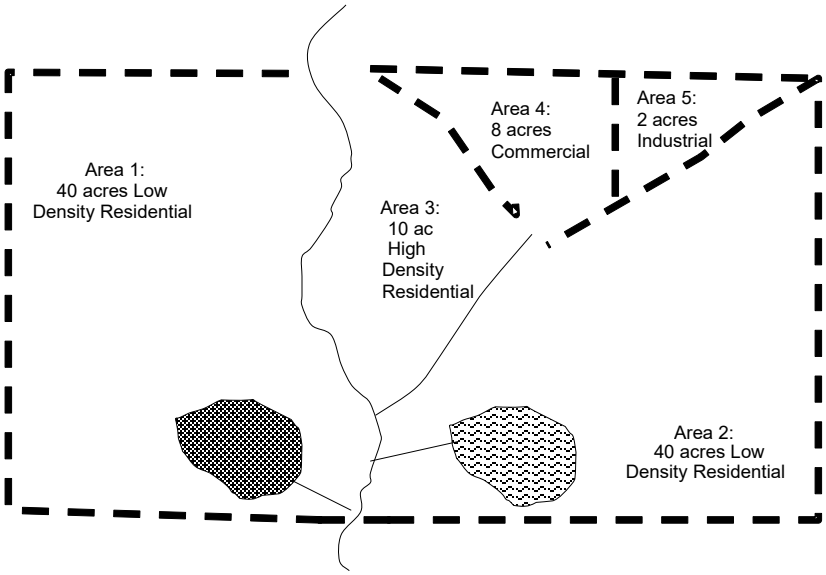


PLAN VIEW



PROFILE

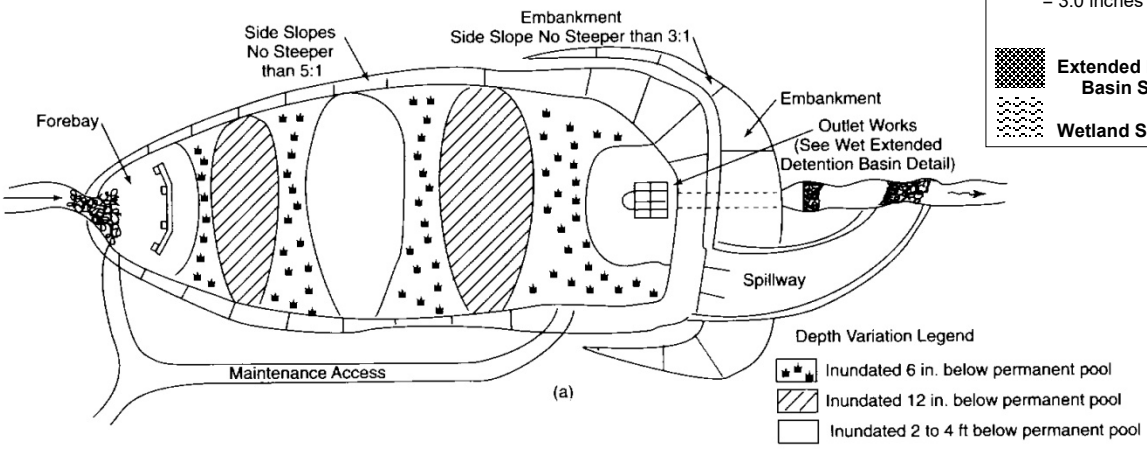
Example 110 Acre Development Site: Wetlands Sizing for Area 2 (Alternative to Wet Detention Basin)

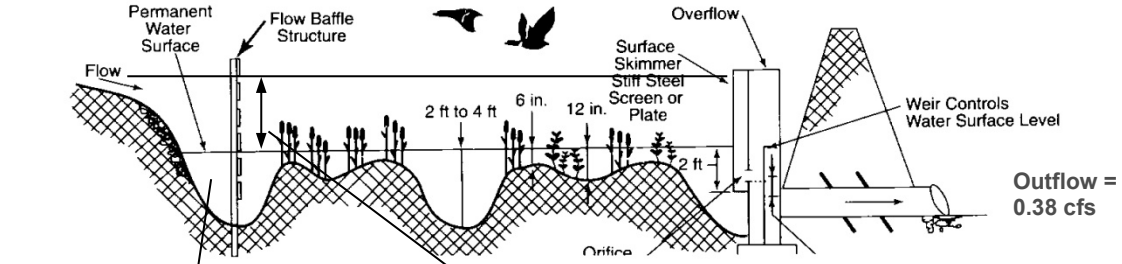


Area 2 (Alternative):
Wetland
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75" * 0.3 * 40 ac) / 12
= .75 ac-ft
Extended Detention = WQV (Sec. 3.3.4)
= .75 ac-ft
Sediment Storage = 0.2 * WQV (Sec. 3.3.4)
= .15 ac-ft
Forebay = 0.1*WQV (Sec. 3.3.4.1)
= 0.08 ac-ft
Max depth = 2 ft
Surface Area = .75 ac-ft / 2 ft
= .38 ac
Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.4)
= (.75 ac-ft / 24 hrs)*(43560sf/ac)(1h/3600s)
= .38 cfs
Outlet orifice size (Sec. 3.3.4.1):
$Q = AC(64.4\ H)^{1/2}$
$0.38 = A*0.66(64.4*2)^{1/2}$
$A = 0.05\ ft^2$
$= \pi * D^2/4$
$D = (4*0.05ft^2/\pi)^{1/2}*12$
= 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 County 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 0.75WQv, whichever is greater.

The change in water storage is given by:

ΔV = Inflows – 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 rate[5]
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:

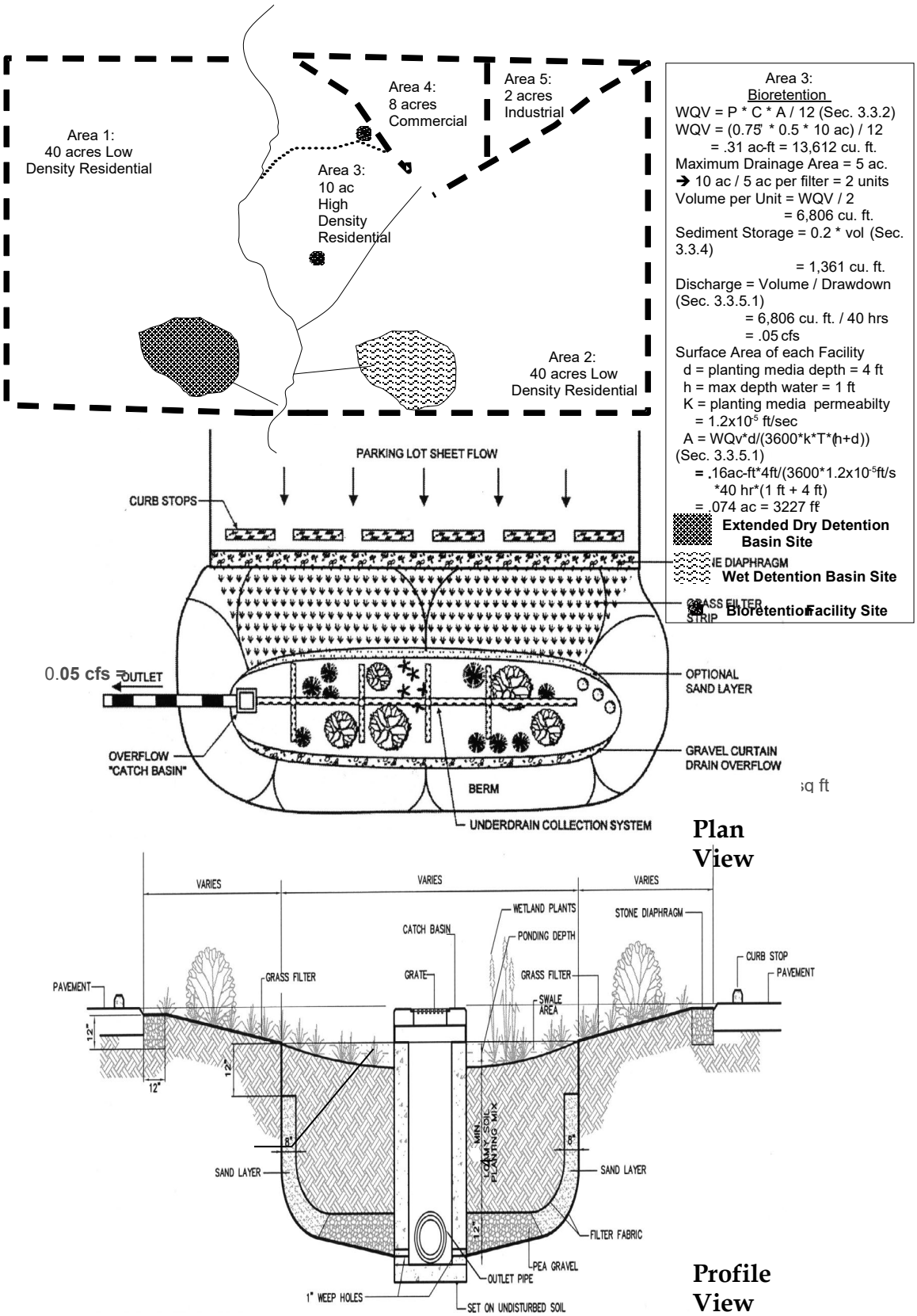
$$\Delta V = -(0.75*0.2 \text{ inches / day}) * A *30 \text{ days} *1 \text{ foot}/12 \text{ inches}$$

$$= -0.375 * A \text{ ac-ft}$$

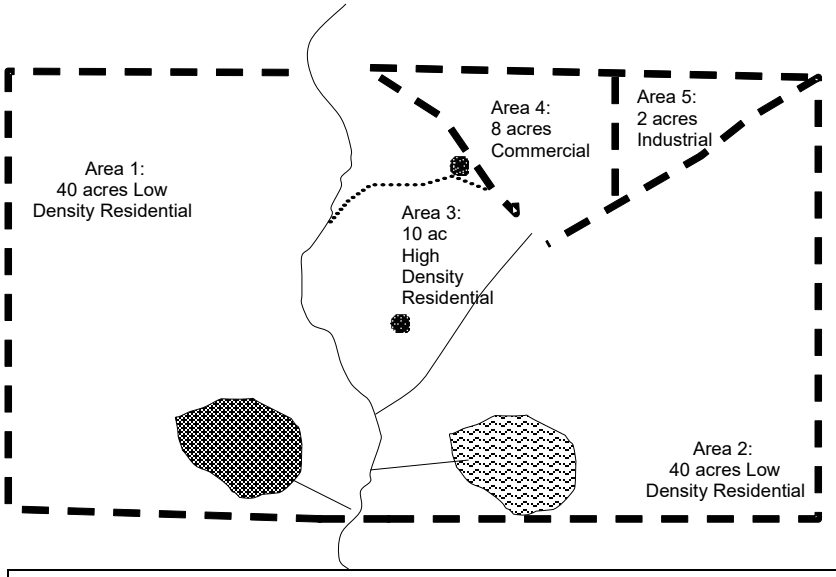
In other words, the volume of water lost to evapotranspiration in the wetlands will be 0.375 times the area of the wetland, and the permanent pool depth will decrease approximately 0.375 ft (4 inches) during a one-month drought where no rainfall occurs. The permanent pool volume must be twice the evapotranspiration 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.

[5] *Treatment Wetlands*, pg. 192.

Example 110 Acre Development Site: Bioretention Facility Sizing for Area 3



Example 110 Acre Development Site: Extended Dry Detention Swale for Area 4



Extended Dry Detention Swales:

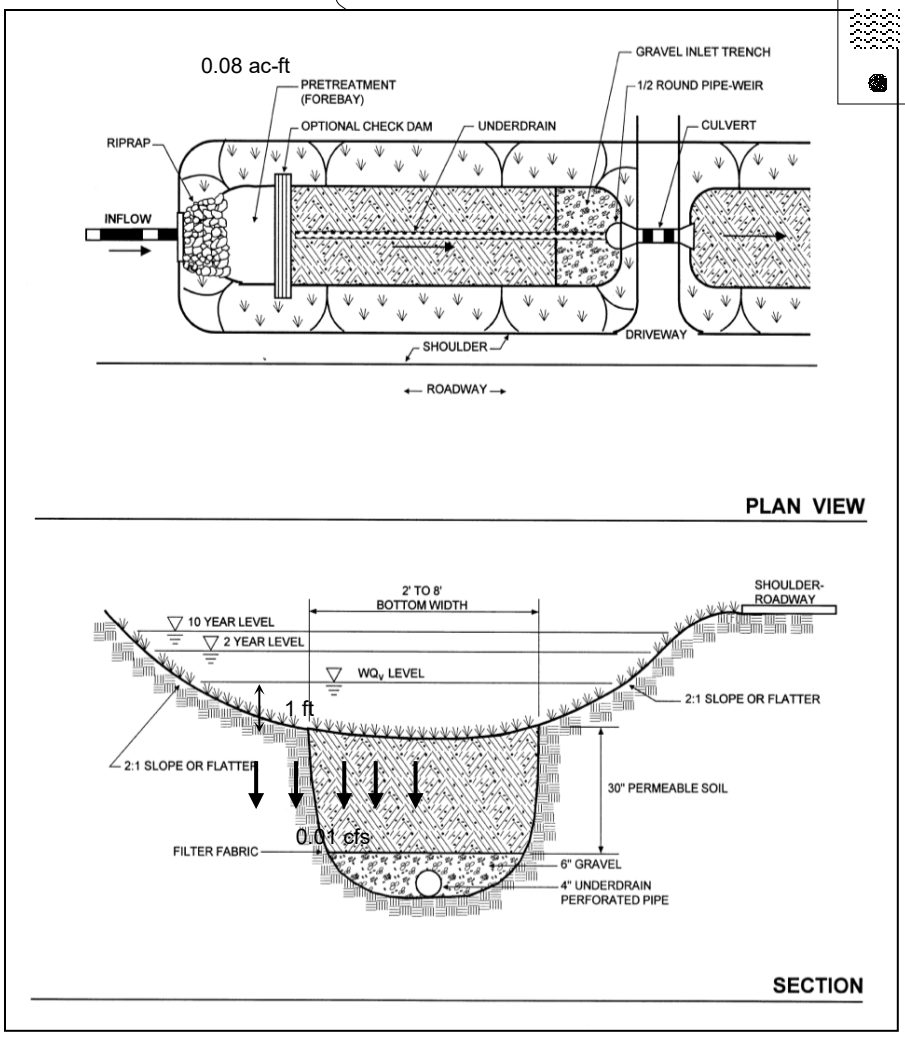
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75 * 0.**75 * 8 ac) / 12**
= .3**8 ac**-ft = **16,335 cu. ft.**
Extended Detention = WQV
= **0.38 ac-ft**
Sediment Storage = 0.2 * WQV
= **0.08 ac-ft.**
Discharge = Volume / Drawdown Time
= **0.38 ac-ft / 40 hrs**
= .0**1** cfs

Assume Max depth **= 1 ft**
Surface Area = 0.38 ac-ft / 1 ft
= **0.38 Acres**
Assume: Swale length = 600 ft
Swale Width = 28 ft

Extended Dry Detention Basin Site

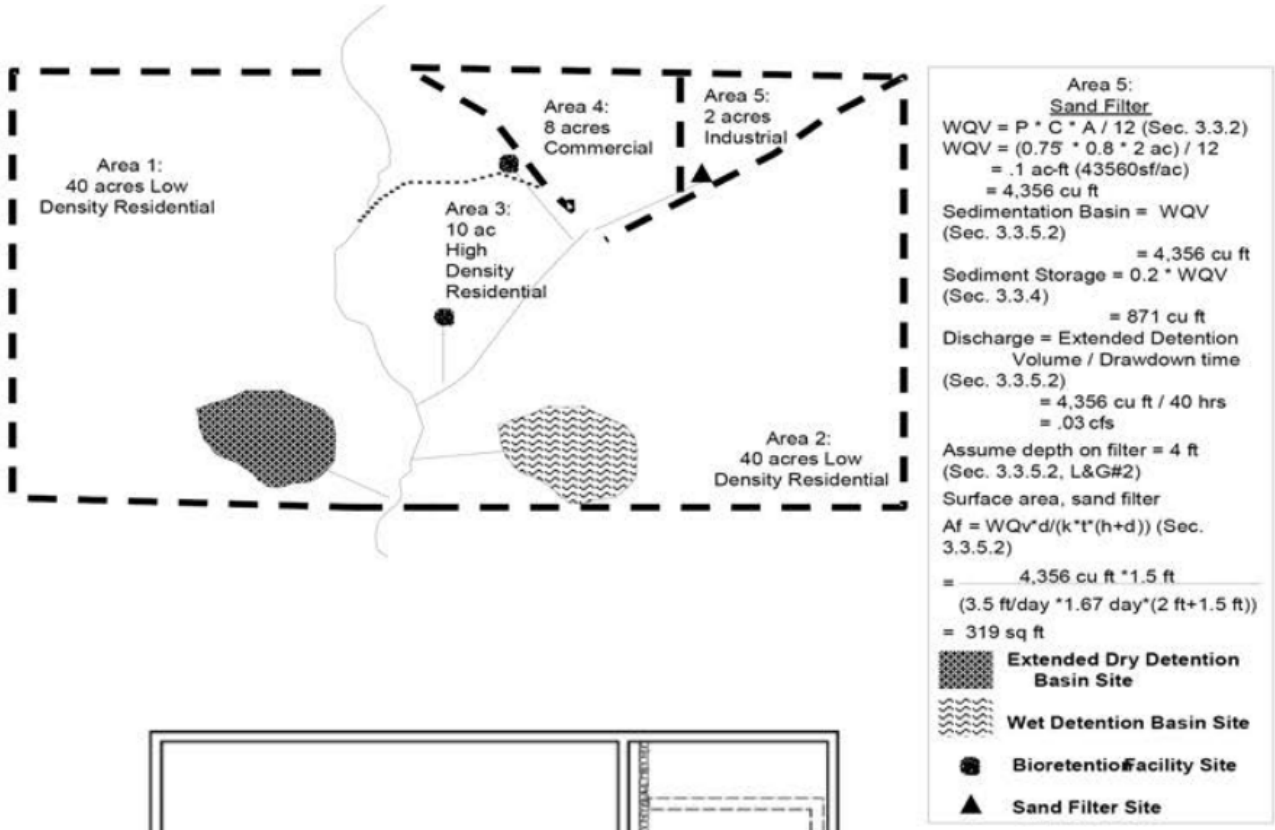
Wet Detention Basin Site

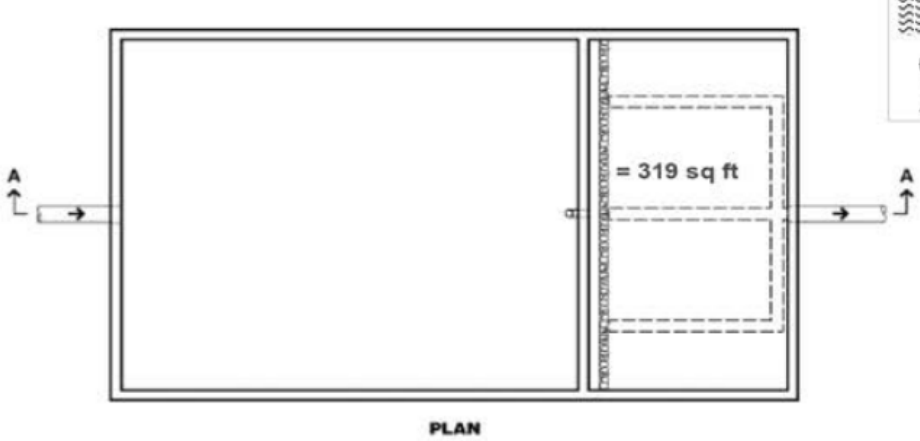
Bioretention Facility Site



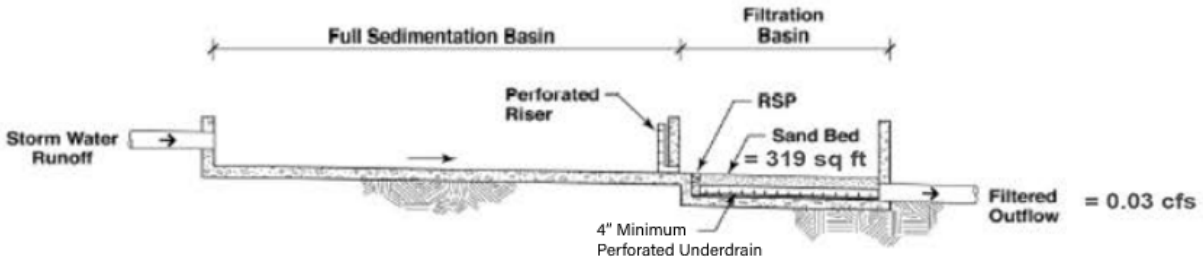
Example 110 Acre Development Site: Sand Filter Water Quality Treatment for Area 5

Example < 5 Acre Development Site:





PLAN

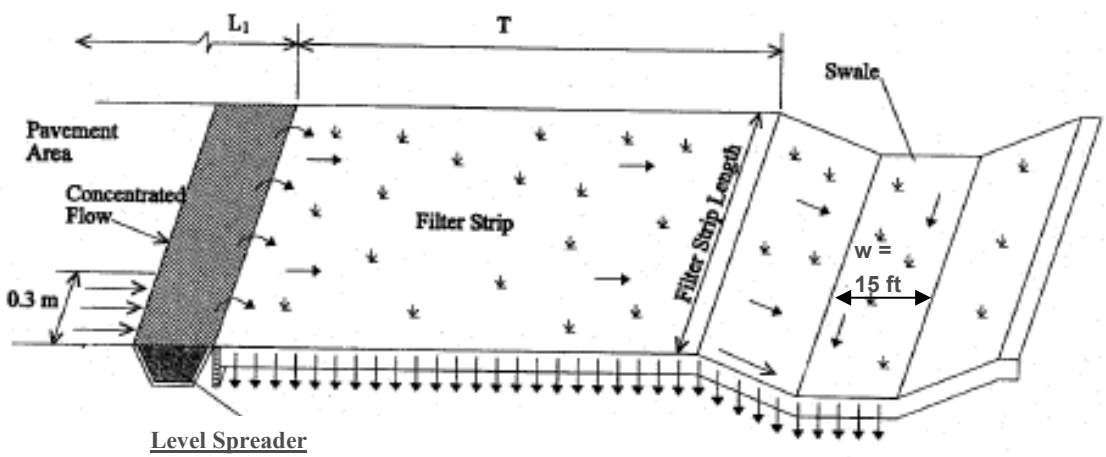


SECTION A-A

Vegetated Swale for 4 acre Development Site

Vegetated Swales

WQV = P*C*A/12
WQV = (0.75"*0.75*4ac)/12
= 0.19 ac-ft = 8,168 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 minutes
Using Figure 2-1, intensity = 1.1 in/hr
Qp = C*I*A = 0.75*1.1"/hr*4 ac
= 3.3 cfs (Peak flow)
Since Qp >1 cfs, 4 swales should serve the 4 ac site, with Qp=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
$0.79 = w*(0.17)^{5/3}$
w = 15 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

Stormwater Management Plan Checklist

SWMS Plan Review Checklist

Plans

____ **Registered Engineer signature and seal**
____ **22" x 34" paper size**
____ **22" x 34" mylar (final plans only)**
____ **Digital submittal on disk/CD**
____ **1 reduced set 11" x 17"**
____ **Easement Descriptions and Exhibits**
____ **Seven (5) 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**
____ **Proposed stormwater facilities**
____ **Existing field tile locations**
____ **Lines designating the phases of multiphase development projects**
____ **Lot lines, streets, right-of-way, setbacks, and easements**
____ **Flood Hazard limits and classifications**
____ **Regulated wetlands**
____ **All outfalls identified with major outfalls clearly labeled**

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 SCPs**
- ____ **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)**
- ____ **SCP 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**

____ **Stormwater facilities size, types, and location**
- ____ **Water quality SCPs**
- ____ **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 SCP details**
  - ____ **Plan view**
  - ____ **Elevation view**
  - ____ **Volume and drawdown data**
  - ____ **Planting list**
- ____ **Detention Ponds**
  - ____ **Cross section(s)**
  - ____ **Elevation information**
  - ____ **Forebay details**
  - ____ **Outlet structure details**

Stormwater Drainage Manual

Appendix F

As–Built Location Forms

Franklin County
Franklin County Drainage Engineer
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:

Franklin County Drainage Engineer
970 Dublin Rd.
Columbus, Ohio 43215

<u>Stormwater Outfall As-built Location</u>

Date of field location:_____

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: Work Manager asset no. assigned _____
Maintenance responsibility: _____ Franklin County or _____Township or_____
Private property owner/Home Owners Association

Franklin County
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:

Franklin County Drainage Engineer
970 Dublin Rd.
Columbus, Ohio 43215

Stormwater Control Structure As-built Location

Date of field location: _____

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 SCP 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: Work Manager asset no. assigned _____
Maintenance responsibility: _____ Franklin County or _____Township or _____ Private property owner/Home Owners Association

Stormwater Drainage Manual

Appendix G

Alternative Manufactured SCP Approval Guidelines

Alternative Manufactured Best Management Practices Policy (SCPs)

Type of Development	Site Disturbance Greater than 1 acre less than 5 Acres	Site Disturbance Greater than or equal to 5 Acres [1]
New Development	1.) Use Group 1, 2 or 3 SCPs SWDM* 2.) Applicant must adequately explain why the use of Group 1, 2, or 3 SCPs are infeasible before an alternative stormwater treatment device will be considered for approval. 3.) Must provide justification if not providing drawdown per OEPA[2].	1.) Use Group 1, 2 or 3 SCPs from the Franklin County SWDM.* 2.) Must provide drawdown time.
Redevelopment	1.) Reduce impervious area by 20%. 2.) Use Group 1, 2, or 3 SCPs from the Franklin County SWDM*. 3.) May use combination of 1 and 2 to result in 20% water quality treatment 4.) Applicant must first adequately explain why the use of Group 1, 2, or 3 SCPs are infeasible before an alternative stormwater treatment device will be considered for approval.[2] 5.) Must provide justification if not providing drawdown per OEPA[2].	1.) Reduce impervious area by 20%. 2.) Use Group 1, 2 or 3 SCPs from the Franklin County SWDM*. 3.) May use combination of 1 and 2 to result in 20% water quality treatment 4.) Applicant must first adequately explain why the use of Group 1, 2, or 3 SCPs are infeasible and obtain approval from OEPA before an alternative stormwater treatment device will be considered by the County.[2] 5.) Must provide drawdown time.

* Group 1 SCPs stormwater basins, Group 2 media filters, Group 3 vegetated swales and filter strips, Section 3 of the Franklin County Stormwater Drainage Manual; see also OEPA Construction General Permit.

[1] Stand-alone stormwater practices proposed for sites 5 acres and greater must be capable of providing the drawdown times stipulated in Table 1 in Part III.G.2.e of OEPA's Construction General Permit.

[2] See OEPA Post Construction Q&A Document for guidance.

SITES 1 to 5 ACRES

1. Applicants may use SCP technologies listed as approved under the Ohio Department of Transportation's Qualified Products List under Supplemental Specification 995.

   http://www.odotonline.org/materialsmanagement/qpl.asp?specref=SS-995

   Device is expected to deliver minimum removal efficiency 80% TSS greater than or equal to the design Water Quality Flow.

2. Device must be designed and installed off-line according to ODOT's Location and Design Manual, Volume 2, current edition. Device may be placed "in line" where flow through the device is restricted to equal to or less than the WQf amount for all storms up to and including the 100-year event (i.e., where bypass will not occur).

SITES GREATER THAN 5 ACRES

1. As documented in the OEPA CGP (Construction General Permit) applicants wishing to use Alternative SCPs on sites greater than 5 acres ***must*** explain to the OEPA why other SCPs are infeasible and obtain written OEPA approval.
2. Applicant must provide test results showing 80% TSS removal efficiency at the design flow using a particle size distribution equivalent to Sil-co-Sil 106; median (D_{50}) particle size from 20 to 25 micron.
3. The County will only allow the use of stand-alone technologies that have been successfully verified by either the New Jersey Department of Environmental Protection (Conditional Interim Certification) or Washington Department of Ecology (Conditional Use Level Designation), using the referenced median (D_{50}) particle size distribution at influent concentrations ranging from 100 mg/l to 300 mg/l in accordance with one of the following acceptance protocols:
   a. Technology Acceptance Protocol – Ecology (TAPE)

      http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html

   b. Technology Acceptance Reciprocity Partnership (TARP)

      http://www.state.nj.us/dep/dsr/bscit/Stormwater%20Protocol.pdf

ENGINEERS SUBMITTAL

The Applicant's professional engineer must ensure that the operating flow rate(s), runoff capture volumes, and drawdown times at which any manufactured technology has been certified are commensurate with the design flow rates, runoff capture volumes, and drawdown times determined for the site using the County's stormwater quality treatment criteria contained in the Stormwater Drainage Manual.

Final approval for the use of manufactured stormwater control technologies in Franklin County shall be at the discretion of the Franklin County Drainage Engineer; however, per the OEPA documents, justification to and approval of OEPA is necessary ***prior*** to submittal of an NOI. Regardless of whether the performance and testing criteria are met, the County reserves the right to deny approval for any device for reasons other than pollutant removal performance. Such reasons may include, but are not limited to, challenges associated with maintaining the performance of the unit in the field, hydraulic performance of the system and its effect on the stormwater drainage system, and the potential of the device to become a source for mosquito breeding and associated vector borne disease.

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